UNIVERSITY OF AGRICULTURAL SCIENCES
BANGALORE

COURSE SYLLABUS
FOR
MASTER'S DEGREE PROGRAMME

2022-23

DIRECTORATE OF POST GRADUATE STUDIES
UNIVERSITY OF AGRICULTURAL SCIENCES
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CONTENTS

* Stand-alone Programme

M.Sc. (Agri.) in Agricultural Economics

Course Code	Course Title	Credit Hours
AEC 501	Micro Economic Theory and Applications	3 (3+0)
AEC 502	Agricultural Production Economics	2 (1+1)
AEC 503	Agricultural Marketing and Price Analysis	3 (2+1)
AEC 504	Macro Economics and Policy	2 (2+0)
AEC 505	Econometrics	3 (2+1)
AEC 506	Agricultural Development and Policy Analysis	2 (2+0)
AEC 507	Agricultural Finance and Project Management	3 (2+1)
AEC 508	Linear Programming	2 (1+1)
AEC 509	Research Methodology for Social Sciences	2 (1+1)
AEC 510	Indian Economy: History and Contemporary Issues	2 (2+0)
AEC 511	International Economics	2 (1+1)
AEC 512	Institutional Economics	1 (1+0)
AEC 513	Natural Resource and Environmental Economics	2 (1+1)
AEC514	Commodity Future Trading	2 (2+0)
AEC 515	Development Economics	2 (2+0)
AEC 516	Rural Marketing	2 (2+0)
AEC 517	Evolution of Economic Thought	1 (1+0)
	Total	**36 (28+8)**
AEC 580	Qualifying Examination	2 (0+2)
AEC 581	Seminar-I	1 (0+1)
AEC 582	Seminar-II	1 (0+1)
AEC 591	Research-I	13 (0+13)
AEC 592	Research-II	14 (0+14)

AEC 501 MICRO ECONOMIC THEORY AND APPLICATIONS (3+0)

Objective

The course envisages the concepts and principles embodying micro-economics. The economic problems, functioning of price mechanism, theory of house hold behavior and consumer's demand function. Theory of firm, supply determinants, determination of price under different market structures and factor pricing. (Micro economic components).

Theory

Block 1: Introduction to micro-economics

Unit 1: Basic Concepts: A review

Scarcity and Choice; Production possibility frontier, Positive and normative economics; concepts of opportunity cost, Demand and Supply: determinants of individual demand/supply; demand/ supply schedule and demand/ supply curve; market versus individual demand/ supply; shifts in the demand/ supply curve.

Block 2- Insight of consumer, production and cost involved

Unit 1: Consumer Choice

Cardinal Utility Approach – Ordinal Utility Approach -Budget sets and Preferences under different situations – Hicks and Slutsky income and substitution effects – Applications of Indifference curve approach – Revealed Preference Hypothesis – Consumer surplus – Derivation of Demand curve – Elasticity of demand – Demand and supply together; how prices allocate resources; controls on prices – price floor and price ceiling – applications in agriculture.

Unit 2: Production and Cost

Production functions: single variable - average and marginal product, variable proportions, stages of production. Two variables – isoquants, returns to scale and to a factor; factor prices; Technical progress; cost minimization and output maximization; Elasticity of substitution. Expansion path and the cost function

Concept of economic cost; Short run and long run cost curves; increasing and decreasing cost industries; envelope curve; L-shaped cost curves; economies of scale; revenue and expenditure, elasticity and marginal revenue; Firm equilibrium and profit.

Block 3: Overview of market

Unit 1: Market Forms

Behavior of profit maximizing firms and the production process-Perfect competition: Equilibrium of the market. Long run industry supply, applications: effects of taxes and subsidies; Monopoly: Equilibrium; supply; multi plant firm; monopoly power; deadweight loss; price discrimination; Monopolistic Competition: Product differentiation; equilibrium of the firm in the industry-with entry of new firms and with price competition. Comparison with pure competition. Duoploy: Cournot model and reaction curves; Stackelberg‘s model, Bertrand model; Oligopoly.

Unit 2: Factor Markets

Labour and land markets - basic concepts (derived demand, productivity of an input, marginal productivity of labour, marginal revenue product); demand for labour; input demand curves; shifts in input demand curves; competitive labour markets; Economic rent and quasi rent.

References

- KOUTSOYIANNIS, A. *Modern Micro Economics.* Macmillan Press Ltd
- RICHARD, A. Bilas, *Micro Economic Theory*.
- LEFTWICH RICHARD, H. *The Price System and Resources Allocation*
- ALLEN C. L. *A Frame Work of Theory*.

AEC 502 AGRICULTURAL PRODUCTION ECONOMICS (1+1)

Objective

To expose the students to develop the concept, significance and uses of production economics. To understand the relationships between factors and output. To learn how to decide the combination of inputs to be used as per the resources available. Ensure that the production process works efficiently.

Theory

Block 1: Introduction to Production Economics

Unit 1: Concepts of production economics

Nature, scope and significance of agricultural production economics- Agricultural Production processes, character and dimensions- spatial, temporal - Centrality of production functions, assumptions of production functions, commonly used forms - Properties, limitations, specification, estimation and interpretation of commonly used production functions.

Block 2: Factors and costs

Unit 1: Factors and theory of production

Factors of production, classification, interdependence, and factor substitution -Determination of optimal levels of production and factor application -Optimal factor combination and least cost combination of production - Theory of product choice; selection of optimal product combination.

Unit 2: Concepts of cost

Cost functions and cost curves, components, and cost minimization -Duality theory – cost and production functions and its applications - Derivation of firm's input demand and output supply functions - Economies and diseconomies of scale.

Block 3: Assessment

Unit 1: Dynamics of economic assessment

Technology in agricultural production, nature and effects and measurement - Measuring efficiency in agricultural production; technical,

allocative and economic efficiencies - Yield gap analysis –concepts-types and measurement - Nature and sources of risk, modeling and coping strategies.

Practical

- Different forms of production functions
- Specification, estimation and interpretation of production functions
- Returns to scale, factor shares, elasticity of production
- Physical optima-economic optima
- Least cost combination
- Optimal product choice
- Cost function estimation, interpretation
- Yield gap analysis
- Incorporation of technology in production functions
- Measuring returns to scale
- Risk analysis
- Estimation of cost of production - Annuals and perennials.

References

- E. O. HEADY. *Economics of Agricultural Production and resources use*.
- JOHNP DOLL AND FRANK ORAZEM. *Production Economics: Theory with application*
- HEADYEO & DILLON, J. L. 1961.*Agricultural Production functions.* Kalyani Publishers, Ludhiana, India.667p.
- BAUMOLW, G. 1973. *Economic theory and operations analysis*. Practice Hall of India Private Limited, NewDehli.626p.
- GARDNER, B. L. & RAUSSER, G. C. 2001. *Handbook of Agricultural Economics* Vol. I Agricultural Production. Elsevier.

AEC 503 AGRICULTURAL MARKETING AND PRICE ANALYSIS (2+1)

Objective

The course is designed to acquaint the students about the basics of dynamics of agricultural marketing. The content includes supply, demand and marketing of farm production, marketing functions and channels, marketing costs, margins and efficiency, agricultural prices, new marketing formats like e-marketing, e-NAM future trading, supply chain management, market intelligence *etc.*

Theory

Block 1: Introduction to Agricultural Marketing

Unit 1: Introduction to agricultural marketing

New Concepts in Agricultural Marketing – Characteristic of Agricultural product and Production – Problems in Agricultural Marketing from Demand and Supply and Institutions sides. Market intermediaries and their role – Need for regulation in the present context– Marketable & Marketed surplus estimation. Marketing Efficiency – Structure Conduct and Performance analysis – Vertical and Horizontal integration – Integration over space, time and form-Vertical co-ordination.

Block 2: Agricultural Markets

Unit 1: Aspects of agricultural marketing

Different Forms of marketing: Co-operatives Marketing – APMC Regulated Marketing – Direct marketing, Farmer Producer Companies, e-NAM and marketing under e-NAM, e-marketing Contract farming and Retailing, Organized retailing – Supply Chain Management – State trading, Warehousing and other Government agencies –Performance and Strategies –Market infrastructure needs, performance and Government role – Value Chain Finance.

Unit 2: Future marketing and government

Introduction to Commodities markets and future trading – Basics of commodity futures – Operation Mechanism of Commodity markets – Price discovery – Hedging and Basis – Fundamental analysis –

Technical Analysis – Role of Government/SEBI in promoting commodity trading and regulatory measures.

Block 3: Advances in Agricultural Marketing

Unit 1: Use of Information Technology

Role of information technology and Market intelligence in marketing of agricultural commodities, Market research and market information service, spatial and temporal price relationship-electronic auctions (e-bay), e-Chaupals, Agmarknet and Domestic and Export market Intelligence Cell (DEMIC).

Unit 2: Dynamics of price

Price forecasting – time series analysis – time series models – spectral analysis. Price policy and economic development – non-price instruments.

Practical

- Supply and demand elasticities in relation to problems in agricultural marketing.
- Price spread and marketing efficiency analysis.
- Marketing structure analysis through concentration ratios.
- Performance analysis of Regulated market and marketing societies. Analysis on contract Farming and supply chain management of different agricultural commodities, milk and Poultry products.
- Supply Chain Analysis – quantitative estimation of supply chain efficiency.
- Market Intelligence – Characters, Accessibility, and Availability Price forecasting.
- Online searches for market information sources and interpretation of market intelligence reports – commodity outlook.
- Technical Analysis for important agricultural commodities.
- Fundamental Analysis for important agricultural commodities.
- Presentation of the survey results and wrap-up discussion.

References

- ACHARYA SS & AGARAWAL NL. 2004. *Agricultural Marketing in India*. Oxford and IBH Publishing company Pvt. Ltd. New Delhi.
- ACHARYA SS & AGARAWAL NL.1994.*Agricultural Prices-Analysis and Policy*. Oxford and IBH Publishing company Pvt. Ltd. New Delhi.
- RICHARD HK OHLS AND JOSEPH N. Uhl: *Marketing of Agricultural products* by Collier Mac Millan International.

AEC 504 MACRO ECONOMICS AND POLICY (2+0)

Objective

The course envisages the concepts and principles of macroeconomics from classical to Keynesian theories. The other component deals with the monetary system-money, credit and banking system, value of money and economic activities, national income accounting and approaches to estimate national income theory of income and employment determination and inflation.

Theory

Block 1: Conceptualizing Macro Economics

Unit 1: Introduction: Measurement and Concepts

Basic concepts and scope of Macro-economics, National Income Accounting: Methods of measurement of key macro-economic aggregates, relationship of national income and other aggregates (with numerical exercises), real and nominal income.

Block 2: Theories of macroeconomics

Unit 1: Classical Macroeconomics

Say's Law, Quantity Theory of Money, aggregate labour supply and demand of labour, Classical theory of determining output, wages and prices.

Unit 2. Income and Spending: Keynesian Framework

Simple Keynesian model of income determination; Keynesian Multiplier– aggregate spending, taxation, transfer payments, foreign spending, balanced budget; budget surplus (with numerical exercises).

Block 3: Money, Consumption and Inflation

Unit 1: Money, Interest and Income

Goods market equilibrium-IS curve; Demand for Money, the Liquidity Preference Theory – Liquidity Trap; asset market equilibrium-LM curve; simultaneous equilibrium in goods and asset market- effect of fiscal and monetary policy.

Unit 2: Theories of Aggregate Consumption and Investment

Absolute Income Hypothesis, Relative Income Hypothesis, Fisher's Inter-temporal Choice Model, Life-Cycle and Permanent Income Hypotheses; Profits and Accelerator Theory.

Unit 3: Inflation and Unemployment

Inflation: Nature, Effects and control; Types of inflation – demand pull, cost push-stagflation, core inflation, hyperinflation. Unemployment-types of unemployment, Phillips curve.

References

- STONIER & HEGUE. *A Text Book of Economic Theory*
- SAMUELSON PA. 1948. *Foundation of Economic Analysis*. Harvard University Press
- MC VAISH ALLID.1983. *Macro–Economics Theory*
- GARDNER ACKLEY.1961.*Macro–EconomicsTheory*:Macmillan, NewYork.
- TF DERNBURG & DM MCDOUGALI- *Macro Economics*
- G. SIRKIN – *Introduction to Macro–Economics Theory*
- RL HEIBROKER- *Understanding Macro–Economics*
- JK MEHTA– *Macro Economics*
- MICHAEL RE dgemand–*Macro-Economics: Theory & Policy*
- DAVID'W Pearce–*The dictionary of modern Economics*

AEC 505 ECONOMETRICS (2+1)

Objective

The course provides knowledge of the econometric methods like time series analysis, line arregression models and their application in economic analysis. The course provides an insight into the econometric problems in analyzing time series and cross section data.

Theory

Block 1:Introduction to Econometrics

Unit 1: Introduction

Relationship between economic theory, mathematical economics, models and econometrics, methodology of econometrics-regression analysis.

Block 2: Classical Regression

Unit 1: Classical Linear Regression

Basic two variable regression – assumptions estimation and interpretation approaches to estimation – OLS,MLE and their properties – extensions to Multi-variable models-multiple regression estimation and interpretation.

Unit 2: Breaking down of Classical assumptions

Violation of assumptions – identification, consequences and remedies for Multicollinearity, heteroscedasticity, autocorrelation – data problems and remedial approaches – model misspecification.

Block 3: Qualitative Variables

Unit 1: Qualitative variables and simultaneous equation models

Use of dummy variables- limited dependent variable – specification and its estimation. Introduction to simultaneous equations- identification problem, structural equations, reduced form equations, identification and approaches to estimation.

Practical

- Single equation two variable model specifications and estimation

- Hypothesis testing transformations of functional forms and OLS application
- Estimation of multiple regression models
- Testing and correcting specification errors
- Testing and managing Multicollinearity
- Testing and managing autocorrelation
- Estimation of regressions with dummy variables.
- Estimation of regression with limited dependent variable.
- Identification of equations in simultaneous equation systems.

References

- DORFMAN R.1996. *Linear Programming and Economic Analysis*. Mc Graw Hill.
- GREENE WH. 2002. *Econometric Analysis*. Pearson Education
- JOHNSTON J AND DINARDO J. 2000. *Econometric Methods*. Mc Graw-Hill
- KOUTSEYIANIS, A.1997. *Theory of Econometrics*. Barner & Noble
- MADDALA GS. 2002. *Econometrics*. Mc Graw-Hill
- PINNDYCK RS AND RUBINFELD DL. 1990. *Econometric Models and Econometric Forecasts*. Mc Graw Hill.

AEC 506 AGRICULTURAL DEVELOPMENT AND POLICY ANALYSIS (2+0)

Objective

Concept of economic development and policy, theories of development, performance of Indian agriculture. The process and implementation of policies over a period of time.

Theory

Block 1: Introduction

Unit 1: Introduction

Role of agriculture in economic/ rural development – Evolution of thinking on agriculture and development; Agricultural development – meaning, stages and determinants – Population and food supply – need for sound agricultural policies.

Block 2: Theoretical Concepts

Unit 1: Theories of Agricultural Development

Resource exploitation model- Conservation model- Location (Urban impact) model- Diffusion model- High pay-off input model-Induced Innovation Model- Agricultural R&D and Linkages.

Block 3: Performance and policies

Unit 1: Performance of Indian Agriculture

Agrarian structure and land relations; trends in performance and productivity; agrarian structure and technology; credit, commerce and technology; capital formation; subsidies; pricing and procurement; Post Green Revolution agriculture; Production and productivity crisis in agriculture; Regional differences; Food Security, PDS system and Malnutrition.

Unit 2: Agricultural Policy: Process and Implementation

Instruments of Agricultural Policy; Process of agricultural policy formulation, implementation, Monitoring and Evaluation in India; Global experiences in participatory approach to Agricultural policy process; critical review of various elements of Indian agricultural policy-resource policies – credit policies – input and product marketing policies – price policies – promotion of agricultural trade; WTO – Agreement on Agriculture; Planning models. Planning for utilization of resources and Indian Five-Year Plans.

References

- ALBERT O. HIRSCHMAN 1958. *Strategy of Economic Development.* New Man Yale University
- SIMON KUZNETS1965.*Economic Growth and Structures.* Oxford New Delhi.

- DAS GUPTA AK. 1965. *Planning and Economic Growth.* George Allen and Unwin London
- ROBERT E .BALDWIN 1966. *Economic Development and Growth*. John Willey, NewYork

AEC 507 AGRICULTURAL FINANCE AND PROJECT MANAGEMENT (2+1)

Objective

This course is designed with an objective to deliver knowledge of the principles, procedures, problems and policies relating to financing agricultural firms. In addition to this the students are also given knowledge about the research developments in the subject. The approach is analytic.

Theory

Block 1: Introduction to Agricultural Finance

Unit 1: Basic concepts: A Review

Role and Importance of Agricultural Finance. Financial Institutions and credit flow to rural/priority sector. Agricultural lending – Direct and Indirect Financing – Financing through Co-operatives, NABARD and Commercial Banks and RRBs. District Credit Plan and lending to agriculture/priority sector. Micro-Financing and Role of MFI's – NGO's, and SHG's. Capital in Agriculture: Role of Capital in Agriculture; Sources of Capital in Agriculture.

Block 2: Credit and Financial Analysis

Unit 1: Credit and its aspects

Lending to farmers – The concept of 3 C's, 7 P's and 3 R's of credit. Estimation of Technical feasibility, Economic viability and repaying capacity of borrowers and appraisal of credit proposals. Understanding lenders and developing better working relationship and supervisory credit system. Credit inclusions – credit widening and credit deepening.

Unit 2: Financial analysis

Financial Decisions – Investment, Financing, Liquidity and Solvency. Preparation of financial statements – Balance Sheet, Cash Flow Statement and Profit and Loss Account. Ratio Analysis and assessing the performance of farm/ firm.

Block 3- Project and Risk Management

Unit 1: Project Overview

Project Approach in financing agriculture. Financial, economic and environmental appraisal of investment projects. Identification, preparation, appraisal, financing and implementation of projects. Project Appraisal techniques – Undiscounted measures. Time value of money – Use of discounted measures – B-C ratio, NPV and IRR. Agreements, supervision, monitoring and evaluation phases in appraising agricultural investment projects. Network Techniques – PERT and CPM.

Unit 2: Risk and its Management

Risks in financing agriculture. Risk management strategies and coping mechanism. Crop Insurance programmes – review of different crop insurance schemes – yield loss and weather based insurance and their applications.

Practical

- Development of Rural Institutional Lending;
- Branch expansion, demand and supply of institutional agricultural credit and over dues and Loan Waiving;
- An overview, Rural Lending Programmes of Commercial Banks, Lead Bank Scheme;
- Preparation of District Credit Plan, Rural Lending Programmes of Co-operative Lending Institutions;
- Preparation of financial statements using farm/firm level data, Farm credit appraisal techniques and farm financial analysis through financial statements;
- Performance of Micro Financing Institutions;

- NGO's and Self-Help Groups, Identification and formulation of investment projects;
- Principle of Increasing Risk: Statement and Illustrations under different farm conditions.
- Project appraisal techniques – Undiscounted Measures and their limitations;
- Time Value of Money: Compounding, discounting techniques; Sinking Fund, capital recovery factor.
- Project appraisal techniques – Discounted Measures;
- Interest Rate: Different types, Effective Rate of Interest.
- Network techniques – PERT and CPM for project management
- Analysis of Risk and Uncertainty: types and measures to quantify risk
- Case Study Analysis of an Agricultural project;
- Project preparation: Preparing bankable projects involving agri-project consultants.
- Financial Risk and risk management strategies – crop insurance schemes;
- Financial instruments and methods – E banking, Kisan Cards and core banking.

References

- EDIESOLLEMH AND HEADY EO. (Ed.). *Capital and Credit Needs in Changing Agriculture*, Bauman
- HOPKINS A BARRY, PETER JOAND BAKER CB. *Financial Management in Agriculture*.
- MURRAY WG AND NELSON AG.1960. *Agricultural Finance.* Iowa State University
- CHANONAC.1969.*Agricultural Finance in India: Role of Commercial Banks*. Marketing and Economics Research Bureau, New Delhi.
- GITTINGER JP.1972. *Economic analysis of agricultural projects*, John Hopkins Univ. Press, Baltimore

- LITTLE IMD AND JA MIRRLESS. 1974, *Project appraisal and planning for developing countries*, Oxford and IBH publishing Co. New Delhi.
- ARNOLDCH.1972. *Project Evaluation, collected papers*, Macmillan.

AEC 508 LINEAR PROGRAMMING (1+1)

Objective

To optimize the farms returns by allocating the available farm resources optimally and to determine the best combinations of crop and livestock enterprise on the farms.

Theory

Unit 1

Decision Making- Concepts of decision making, introduction to quantitative tools, introduction to linear programming, uses of LP in different fields, graphic solution to problems, formulation of problems.

Unit 2

Simplex Method: Concept of behavior Method, solving profit maximization and cost minimizations problems. Formulation of farms and non-farm problems as linear programming models and solutions.

Unit 3

Extension of Linear Programming models: Variable resource and price programming, transportation problems, recursive programming, dynamic programming.

Unit 4

Game Theory- Concepts of game theory, two person constant sum, zero sum game, saddle point, solution to mixed strategies, the rectangular game as Linear Programming.

Practical

- Graphical and algebraic formulation of linear programming models.
- Solving of maximization and minimization problems by simplex method.

- Formulation of the simplex matrices for typical farm situations.

References

- Introduction to Linear Programming by D.C. SANYAL, K. DAS by U.N. Dhur& Sons Private Ltd.
- Linear Programming by G. HADLEY by Narosa Publishing House.
- Linear Programming and Theory of Games by P.K. GUPTA by New Central Book Agency, New Delhi.
- Operation Research, Theory and Practices by DR. MANOJ GARG by Savera Publishing House.
- *Linear Programming and Economic Analysis*. DORFMAN R.1996, Mc Graw Hill.

AEC 509 RESEARCH METHODOLOGY FOR SOCIAL SCIENCES (1+1)

Objective

The course deals with scientific methods of research, the initiation of an inquiry, formulation of research problems and hypotheses, the role of induction and deduction in research, collection and analysis of date and interpretation of results.

Theory

Block 1: Concepts of research methodology

Unit 1: Concepts of research methodology

Importance and scope of research in agricultural economics. Types of research – Fundamental vs. Applied. Concept of researchable problem – research prioritization– selection of research problem. Approach to research – research process.

Block 2- Building up hypothesis and sample selection

Unit 1: Hypothesis: Framing and Testing

Hypothesis – meaning – characteristics – types of hypothesis – review of literature – setting of Course Objective and hypotheses – testing of hypothesis.

Unit 2: Sampling

Sampling theory and sampling design – sampling error – methods of sampling – probability and non-probability sampling methods – criteria to choose. Project proposals – contents and scope – different types of projects to meet different needs – trade-off between scope and cost of the study. Research design and techniques – Types of research design.

Block 3- Data Collection and Analysis

Unit 1: Data Collection

Data collection – assessment of data needs – sources of data collection – discussion of different situations. Mailed questionnaire and interview schedule – structured, unstructured, open ended and closed-ended questions. Scaling Techniques. Preparation of schedule – problems in measurement of variables in agriculture. Interviewing techniques and field problems – methods of conducting survey – Reconnaissance survey and Pre testing.

Unit 2: Data Analysis

Data coding, tabulation and cleaning, Multivariate analysis: Factor analysis, PCA, Cluster analysis.

Guidelines in the preparation of research report or thesis, Universal procedures for preparation of bibliography writing of research articles.

Practical

- Exercises in problem identification.
- Project proposals – contents and scope.
- Formulation of Objective and hypotheses.
- Assessment of data needs – sources of data – methods of collection of data.
- Methods of sampling – criteria to choose – discussion on sampling under different Situations.
- Scaling Techniques – measurement of scales.
- Preparation of interview schedule.
- Field testing. Method of conducting survey.

- Exercise on coding, editing, tabulation and validation of data.
- Preparing for data entry into computer.
- Hypothesis testing – Parametric and Non-Parametric Tests.
- Exercises on format for Thesis/ Report writing.
- Presentation of the results.

References

- BAKER CB. *Research Methodology in Agricultural Economics*
- Cohen Mr And Nagel R. *An Introduction to Logic and Scientific Method*
- DEVEYJ Logic. *The Theory of Enquiry*
- DHONDHYAL SP. *Social Science Research and Thesis Writing*
- EZEKIELM. *Correlation Analysis*
- HEADY EO. *Linear Programming Methods*
- Willson Er. *An Introduction to Scientific Research*
- KUMARA.2008. *Research Methodology: A Survey.* Alts, New Delhi.

AEC 510 INDIAN ECONOMY: HISTORY AND CONTEMPORARY ISSUES (2+0)

Objective

To introduce the students to the economic history over a period of time. It also highlights the contemporary issues of Indian economy.

Theory

Block 1- History of Indian Economy

Unit 1: India from Independence to Liberalization

An overview of the economic developments during the period 1947-1980; Objectives and strategies of planned economic development and the role of the State; Sectoral growth performance; savings and investment; Demographic trends and issues; education; health and malnutrition; Trends and policies in poverty; inequality and

unemployment.

Unit 2: India Since 1980's (Liberalization and Beyond): Overview

Policy Changes since 1980s.The 1990 Crisis. Causes and Effects of liberalization. Regional differences: infrastructure, primary, secondary and tertiary sector.

Unit 3: Macro Trends Since 1990

Growth; Savings and Investment, Employment; productivity; diversification; Agro- based industries; competition policy; foreign investment, Regional differences.

Block 2- Contemporary Issues

Unit 1: Contemporary Issues

Monetary and Financial trends- areas of government spending in India, Capital expenditure, revenue expenditure, plan expenditure, non-plan expenditure, Deficits (fiscal, primary, revenue), impact of fiscal deficit on economy, Capital receipts, revenue receipts, tax and non-tax revenue, direct and indirect taxes, need to rationalize tax structure. Goods and Services Tax (GST). Union Budget, Zero base budgeting, Gender budgeting, Fiscal devolution and centre state financial relations in India, WPI, CPI implicit deflators. Foreign Trade policy.

Reference

- DUTT AND SUNDARAM. *Indian Economy*

AEC 511 INTERNATIONAL ECONOMICS (1+1)

Objective

The major objective of this course is to give an insight of the interactions between national economies. What are the theories governing the trade across national boundaries. The methods involved to regulate the international trade and institutions involved.

Theory

Block 1- Introduction

Unit 1: Concepts of International Economics

Scope and Significance of International Economics – The role of trade- General Equilibrium in a Closed Economy (Autarky Equilibrium) – Equilibrium in a Simple Open Economy – Possibility of World Trade – Trade gains and Trade Equilibrium.

Block 2- Models, Rate and Terms of Trade

Unit 1: Barriers to trade Tariff & Non-Tariff Barriers to Trade, Producer Subsidy, Export Subsidy, Import Quota and Export Voluntary Restraints – The Case of Small Country and Large Country Case.

Unit 2: Models of trade

Ricardian Model of Trade- Specific Factors Model- Heckscher–Ohlin Model – Trade Creation and Trade Diversion – Offer Curve – Export Supply Elasticity and Import Demand Elasticity – Comparative Advantage and Absolute Advantage.

Unit 3: Rates and Terms of trade

Official Exchange Rate and Shadow Exchange Rate –Walra's Law and Terms of Trade – Trade Blocks.

Block 3- Institutions

Unit 1: Trades Institutions

IMF, World Bank, IDA, IFC, ADB & UNCTAD – International Trade agreements – Uruguay Round – GATT – WTO. Directorate General of Foreign Trade (DGFT), Export Promotion Councils, Central Board of Indirect Taxes and Customs (CBIC).

Practical

- Producer's Surplus, Consumer's Surplus, National Welfare under Autarky and Free Trade Equilibrium with small and large country assumption.
- Estimation of Trade Gains
- Estimation of competitive and comparative measures like NPC, EPC, ERP and DRC
- Estimation of Offer Curve Elasticity

- Estimation of Effect of Tariff, Export Subsidy, Producer Subsidy, Import Quota and Export Voluntary Restraints on National Welfare
- Estimation of Ricardian Model
- Estimation of Effect of Trade under Specific Factor Model
- Estimation of trade Equilibrium under Heckscher–Ohlin model
- Trade Creation and Diversion.
- Export Procedures, Documentations, International Commercial Terms (FOB, CIF).
- Harmonized system code (HS code).

References

- KINDELBERGERAND JOSHIPK. 2016. *International Economics* AITBS Delhi-110051
- BROUWER F. *International Trade and Food Security*. LEI-Wageningen UR, The Netherlands

AEC 512 INSTITUTIONAL ECONOMICS (1+0)

Objective

To develop critical and informed understanding about institutions, their role in the working of economy. Exposure of issues, policies & regulations and its application in agricultural system.

Theory

Block 1: Introduction

Unit 1: Basics of Institutional Economics

Old and New Institutional Economics – Institutional Economics vs Neo-classical Economics. Definition of institutions – Distinction between institutions and organizations – Institutional evolution.

Block 2: Approaches

Unit 1: Institutional changes & Resource allocation

Institutional change and economic performance – national and international economic institutions. Transaction cost economics –

Transaction costs and the allocation of resources. Transaction costs and efficiency. Asymmetric information – Moral hazard and Principal-Agent problem.

Unit 2: Group and collective Approach

Free rider problem – path dependency – Interlinked transactions. Collective action and the elimination of free-rider problem – The logic of collective action and its role in reducing free rider problem – theory of Groups. Rent seeking – interest groups and policy formulation.

Block 3: Law Protection and Institutions

Unit 1: Property rights

Economic analysis of property rights- property rights regimes – private property – State Property – Common Property Resources (CPRs) – public goods and club goods.

Unit 2: Agrarian Institutions

Special features of institutional arrangements in agriculture – Transaction costs in agriculture – Case Studies – Theories of agrarian institutions – tenancy institutions.

Reference

- PEARCE DW– *The dictionary of modern Economics*

AEC 513 NATURAL RESOURCE AND ENVIRONMENTAL ECONOMICS (1+1)

Objective

To understand about economics of environment and social costs incurred due to economic development. Work out methods to maintain environment quality and reduce social costs.

Theory

Block 1- Introduction to natural resource and environmental economics

Unit 1: Basic Foundation

Concepts, Classification and Problems of Natural Resource Economics – Economy Environment interaction – The Material Balance

principle, Entropy law-Resources Scarcity – Limits to Growth – Measuring and mitigating natural resource scarcity – Malthusian and Recardian scarcity – scarcity indices – Resource Scarcity and Technical Change.

Block 2- Insights of the subject

Unit 1- Theories and economics of natural resources

Theory of optimal extraction renewable resources –economic models of oil extraction efficiency – time path of prices and extraction – Theory of mine – Gray's model Hotelling's rule, Solow-Harwick's Rule Theory of optimal extraction exhaustible resources – economic models of forestry and fishery.

Unit 2: Functioning of Market

Efficiency and markets – market failures – externalities – types – property rights – transaction costs – Coase's theorem and its critique – public goods – common property and open access resource management – Collective action.

Tragedy of commons: Characteristics of property rights, emergence of different forms of property rights to Natural Resources, Land use and rent under private property and disappearance of rent under common property; Hardin's Tragedy of Commons.

Block 3- Dealing with the issues and sustainability

Unit 1: Environmental Issues

Environmental perspectives – biocentrism, sustainability, anthropocentrism – Environmental problems and quality of environment – Sources and types of pollution – air, water, solid waste, land degradation – environmental and economic impacts – Economics of pollution control – efficient reduction in environmental pollution.

Unit 2: Regulations

Environmental regulation – economic instruments – pollution charges – Pigoviantax– tradable permits – indirect instruments – environmental legislations in India.

Unit 3: Sustainability aspects

Concept of sustainable development – Economic Perspective – Indicators of sustainability Relation between development and environment stress-Environmental Kuznet's curve Environmental Accounting–resource accounting methods – International Environmental Issues – climate change – likely impacts – mitigation efforts and international treaties.

Practical

- Exhaustible resource management – optimum rate of oil extraction.
- Theory of mine – Gray's model, Hotelling's rule.
- Renewable resource management – optimum harvest of Forestry/ fishery.
- Exercise on pollution abatement-I.
- Exercise on pollution abatement-II.
- Costing of irrigation water: Surface and ground water for irrigation using natural resource cost concepts.
- Estimation of Externalities: Positive and negative externalities
- Concepts in valuing the environment.
- Taxonomy of valuation techniques.
- Productivity change method – substitute cost method – Hedonic price method – Travel cost method – Contingent valuation methods.
- Discount rate in natural resource management.
- Environment impact assessment
- Visit to Pollution Control Board.

References

- PEARCE DW AND TURNER RK. *Economics of Natural Resource and Environment*
- KWAK J. *Economism: Bad Economics and the Rise of Inequality*
- TIETENBERG T AND LEWIS L. *Environmental and Natural Resource Economics*
- SCHWARZ PM. *Energy Economics*

AEC 514 COMMODITY FUTURE TRADING (2+0)

Objective

To disseminate the knowledge about risk mitigating measures especially future trading. The future trading in agricultural commodities is increasing day by day therefore the role of SEBI, functioning of commodity exchanges is discussed.

Theory

Block 1- Introduction to commodity market

Unit 1: Concepts of commodity future trading

History and Evolution of commodity markets – Terms and concepts: spot, forward and futures Markets – factors influencing spot and future markets. Speculator mechanism in commodity futures.

Block 2- Techniques and Risks in Commodity Market

Unit 1: Technical aspects

Transaction and settlement – delivery mechanism – role of different agents – trading strategies –potential impact of interest rate, Foreign Exchange, FDI in Commodity Markets.

Unit 2: Risk and its Management

Risk in commodity trading, importance and need for risk management measures - Managing market price risk: hedging, speculation, arbitrage, swaps – pricing and their features.

Block 3- Commodity exchange and market analysis

Unit 1: Commodity Exchange – A review

Important global and Indian commodity exchanges– contracts traded – special Features–Regulation of Indian commodity exchanges– FMC and its role.

Unit 2: Analysis of commodity market

Fundamental v/s Technical analysis – construction and interpretation of charts and chart patterns for analyzing the market trend – Market indicators – back testing. Introduction to technical analysis software – analyzing trading pattern of different commodity groups.

References

- KAUFMAN PJ. *The Concise Handbook of Futures Markets*: Jhon Wiley & Sons
- PURCELL WD. *Agricultural Futures and Options: Principles and Strategies*: Mac Millan Publications
- WASENDORF RR & MC CAFFERY *All About Commodities from the Inside Out.* Mc Graw Hill

AEC 515 DEVELOPMENT ECONOMICS (2+0)

Objective

To develop concept of growth and development. Methods and theories of measuring development. Study of different developed economies will give exposure towards measures to create economic upliftment.

Theory

Block 1- Introduction to Development Economics

Unit 1: Conceptions of Development

Development Economics – Scope and Importance – Economic development and economic growth – divergence in concept and approach – Objectives of economic development, Sustainable Development Goals (SDGs). Indicators and Measurement of Economic Development –GNP as a measure of economic growth – New Measures of Welfare – NEW and MEW – PQLI – HDI – Green GNP, GNH – Criteria for under development – Obstacles to economic development –Economic and Non-Economic factors of economic growth- Development issues, poverty, inequality, unemployment and environmental degradation.

Block 2- Theories and comparison

Unit 1: Theories of Economic growth and development

Classical theories- Adam smith – Ricardo- Malthus, Marx's theory of economic development; Schumpeter's theory, Approaches to development- low income equilibrium trap – critical minimum effort- The Strategy of economic development- Balanced v/s. Unbalanced

growth, choice of technique, investment criteria, big push theory, Rostow's stages of Economic Growth, unlimited supply of labour; social and technological dualisms; roles of capital accumulation, human capital and technological change in economic development, Models of economic growth Harrod- Domar, Kaldor, Mahalanobis, Lewis, FeiRanis, Input-Output, multisectoral models.

Unit 2: Comparative Economic Development

Countries selected for case studies –USA, Japan, China and India; Overview of economic development is selected countries; agrarian surplus and the role of the peasantry in economic development; industrial revolution; division of labour, organization of work and industrial production, the role of the State in developmental transition.

References

- BLAUGM.1986. *Economic History and the History of Economic Thought*
- CHENERY HB AND TN SRINIVASAN. *Handbook of Development Economics*
- BALDWIN RE. *Economic Development and Growth*. John Willey, New York

AEC 516 RURAL MARKETING (2+0)

Objective

To explore the possibilities and potential of the rural market. It aims at critically analyzing the market opportunities, consumer trends and patterns and development of better marketing strategies for the rural areas.

Theory

Block 1: Rural Marketing Environment

Unit 1: Rural Markets

Concept, Definition and Scope of rural marketing, nature and characteristics of rural markets, potential of rural markets in India, rural V/S urban market.

Unit 2: Factors influencing rural markets

Environmental factors: Socio-cultural, economic, demographic, technological and other environmental factors affecting rural marketing.

Unit 3: Rural finance

Concept, demand, banking model; Finance Schemes of NABARD, Other Schemes of State Govt, Central Govt.

Unit 4: Rural consumer's Behavior

Behavior of rural consumers and farmers; buyer characteristics and buying behaviorP; customer relationship management, rural market research.

Block 2: Rural Marketing Strategy

Unit 1: Rural Product strategy

Marketing of consumer durable and non-durable goods and services in the rural markets with special reference to product planning; marketing mix, product mix.

Unit 2: Pricing Strategy

Pricing policy and pricing strategy, distribution strategy, Rural retailing and modern store formats in rural areas.

Unit 3: Promotion Strategy

Media Planning, Distribution channels, personal selling strategies in rural markets, innovations in rural marketing.

References

- KRISHNAMACHARYULU AND RAMAKRISHNAN. 2010. *Rural Marketing: Text and Cases*: Pearson Education. 2nd edition
- SINGH S. 2004. *Rural Marketing: Focus on Agricultural Inputs,* Vikas Publishing
- KASHYAP P. 2011. *Rural Marketing*. Pearson Education
- KUMAR D AND GUPTA P. 2017. *Rural Marketing: Challenges and Opportunities*. Sage Publications.

AEC 517 EVOLUTION OF ECONOMIC THOUGHT (1+0)

Objective

To solve various mathematical problems in economic research. Calculations are integral part of research analysis therefore it has wide application in economic studies.

Theory

Block 1: Introduction and Approaches

Unit 1: Introduction and Approaches for the study of evolution of economic thought – Absolutist vs. Relativist approaches – Evolution of Economic Thought v/s Economic History.

Unit 2: History

Ancient economic thought –medieval economic thought– mercantilism – physiocracy.

Block 2: Approaches

Unit 1: Classical Thought

Forerunners of Classical Political Economy. Development of Classical Thoughts (Adam Smith, Robert Malthus and David Ricardo)

Unit 2: Critical analysis of classical thought

Critics of Classical Thoughts- Socialist critics – Socialist and Marxian Economic Ideas – Austrian School of Thought.

Block 3: Neo-classism

Unit 1: Development of micro economic analysis

Origins of Formal Microeconomic Analysis – William Stanley Jevons, Cournot and Dupuit.

References

- BATIA, H.L (1978), History of Economic Thought.
- HAJELA, T.N (1978), History of Economic Thought (6thEdn.)
- HARRY H. LANDRETH AND DAVID COLANDER (1994), History of Economic Thought

M.Sc. (Agri.) in Agricultural Extension Education

Course Code	Course Title	Credit Hours
AEE 501	Extension Landscape	2 (2+0)
AEE 502	Applied Behaviour Change	3 (2+1)
AEE 503	Organisational Behaviour and Development	3 (2+1)
AEE 504	Research Methodology in Agriculture Extension	3 (2+1)
AEE 505	Capacity Development	3 (2+1)
AEE 506	ICTs for Agricultural Extension and Advisory Services	3 (2+1)
AEE 507	Evaluation and Impact Assessment	3 (2+1)
AEE 508	Management of Extension Organizations	3 (2+1)
AEE 509	Enabling Agricultural innovation	2 (1+1)
AEE 510	Gender Mainstreaming	3 (2+1)
AEE 511	Diffusion and Adoption of Innovations	2 (1+1)
	Total	**30 (20+10)**
AEE 580	Qualifying Examination	2 (0+2)
AEE 581	Seminar - I	1 (0+1)
AEE 582	Seminar - II	1 (0+1)
AEE 591	Research - I	13 (0+13)
AEE 592	Research - II	14 (0+14)

AEE 501 EXTENSION LANDSCAPE (2+0)

Objective

To introduce the challenges of extension, approaches and policies evolved globally to meet the needed capacities of EAS providers and orienting students with studies on new insights of communication and innovation studies, process and impact of reforms implemented.

Theory

Block 1: Globally, What Is New In Extension?

Unit 1: Challenges before Extension and Advisory Services (EAS)

Extension and Advisory Services (EAS)- Meaning (embracing pluralism and new functions) New Challenges before farmers and extension professionals: Natural Resource Management-Supporting farmers to manage the declining/deteriorating water and soil for farming; Gender Mainstreaming- How extension can enhanceaccess to new knowledge among women farmers; Nutrition- Role of extension in supporting communities with growing nutritious crop and eating healthy food; Linking farmers to markets- Value chain extension including organizing farmers, strengthen value chain and supporting farmers to respond to new standards and regulations in agri-food systems; Adaptation to climate changes-How extension cancontribute to up-scaling Climate Smart Agriculture; Supporting family farms strengthening the capacities of family farms; Migration-Advising farmers to better respond to opportunities that emerge from increasing mobility and also supporting migrants in enhancing their knowledge and skills; Attracting and Retaining Youth in Agriculture including promotion of agripreneurship and agri-tourism; Urban and peri-urban farming- How to support and address issues associated with urban and peri-urban agriculture; Farmer distress, suicides- Supporting farmers in tackling farm distress.

Unit 2: New Functions and New Capacities

Beyond transfer of technology: Performing new functions to deal with new challenges; Organising producers into groups-dealing with problems that need collective decision making such as Natural Resource Management (NRM) and access to markets; Mediating conflicts and building consensus to strengthen collective decision making; Facilitating access to credit, inputs and services-including development of service providers; Influencing policies to promote new knowledge at a scale Networking and partnership development including convening multi-stakeholder platforms/innovation platforms. New Capacities needed by extension and advisory services at different levels –at the individual (lower, middle management and senior management levels),organizational and enabling environment levels; –Core competencies at the individual level; Varied mechanisms for capacity development (beyond training).

Unit 3: Pluralism in EAS

Pluralism in Extension Delivery: Role of private sector (input firms, agri-business companies, consultant firms and individual consultants)- Trends in the development of private extension and advisory services in India and other countries; challenges faced by private extension providers; Role of Non-Governmental Organizations (National/ international)/ Civil Society Organizations (CSOs) in providing extension-Experiences from India and other countries; Producer Organizations- Role in strengthening demand and supply of extension services; their strength and weaknesses-experiences from different sectors; Role of Media and ICT advisory service providers; global experiences with use of media and ICTs in advisory services provision.

Block 2: Insights From Innovation Studies and New Extension Approaches

Unit 1: From the Linear Paradigm to Systems Paradigm

Diffusion of Innovations paradigm- strengths and limitations; multiple sources of innovation-farmer innovation, institutional innovation; farmer participation in technology generation and promotion; strength and limitations; Agricultural Knowledge and Information Systems (AKIS); strength and limitations; Agricultural Innovation Systems (AIS); Redefining Innovation- Role of Extension and Advisory Services in AIS-From information delivery to intermediation across multiple nodes; Role of brokering; Innovation Platforms, Innovation Management; Strength and weaknesses of AIS. Rethinking Communication in the Innovation Process – Network building, support social learning, dealing with dynamics of power and conflict.

Unit 2: Evolving Extension Approaches

Evolution and features of extension approaches: Transfer of technology approach; educational approach, farmer participatory extension approach, demand-driven extension, market led extension (value chain extension), extension for climate smart agriculture, gender sensitive extension, extension for entrepreneurship Extension systems in different regions: Asia-Pacific, Europe, Latin America, Australia,

North America Networking for Strengthening EAS: GFRAS (Global Forum for Rural Advisory Services) and its regional networks.

Block 3: Extension Reforms and Policy Challenges

Unit 1: Changes in Governance, Funding and Delivery

Reduction in public funding: public withdrawal from extension provision (partial/full); Examples/Cases; Privatization: Public funding and private delivery; cost sharing and cost recovery; Examples/Cases; Decentralisation of extension services; Examples/Cases; Lessons from extension reforms in different countries; Extension and Sustainable Development Goals (SDGs).

Unit 2: Challenges in Managing Pluralistic Extension Systems

Pluralism: Managing pluralism and Co-ordination of pluralistic extension provision; Public private partnerships in extension (including the role of local governments/panchayats and producer organisations); Examples, challenges in co-ordination; Achieving convergence in extension planning and delivery, Financing Extension:

Mobilising resources for extension: public investments, donor support (grants/loans); Monitoring and Evaluation of Extension: Generating appropriate data for Assessment and Evaluation of pluralistic extension; Strengthening extension policy interface; generating evidence on impact of extension and policy relevant communication.

References

- ADOLPH, B., 2011, Rural Advisory Services World wide: A Synthesis of Actors and Issues. GFRAS: Lindau, Switzerland. https://www.g-fras.org/en/knowledge/gfras-publications.html?download=6: rural- advisory-services-world wide & start=40
- BINGEN, R. J. AND SIMPSON, B. M., 2015, Farmer Organizations and Modernizing Extension and Advisory Services. MEAS Discussion Paper. http://meas.illinois.edu/wp-content/uploads/2015/04/Bingen- Simpson-2014-FarmerOrganizations-MEAS-Discussion-Paper.pdf

- BITZER, V., WONGTSCHOWSKI, M., HANI, M. AND BLUM, M., 2016, New direction for inclusive Pluralistic Service Systems. In New Directions for Inclusive Pluralistic Service Systems Rome (Italy). FAO.http://www.fao.org/3/a-i6104e.pdf
- BURTON, E. S. AND KRISTIN, D., 2014, Status of Agricultural Extension and Rural Advisory Services Worldwide. GFRAS: Lindau, Switzerland. http://www.g-fras.org/en/knowledge/gfraspublications. html? download=391: status-of-agricultural-extension-and-rural- advisoryservices-worldwide
- DAVIS, K. AND HEEMSKERK, W., 2012, Coordination and Collective Action for Agricultural Innovation Overview Module 1 Investment in Extension and Advisory Services as Part of Agricultural Innovation Systems. In Agricultural Innovation Systems: An Investment Sourcebook. Agricultural and Rural Development. World Bank. © World Bank.http://siteresources.worldbank.org/INTARD/Resources/335807 1330620492317/9780821386842 ch3.pdf
- MANFRE, C., RUBIN, D. AND NORDEHN, C., 2017, Assessing How Agricultural Technologies can Change Gender Dynamics and Food Security Outcomes. A three part toolkit. Integrating Gender and Nutrition within Agricultural Extension Services (INGENAES). http://www.culturalpractice.com/wp-content/uploads/Introduction-to-the-Toolkit-Final-10_17.pdf
- RIVERA, W. AND ZIJP, W., 2002, Contracting for Agricultural Extension- International Case Studies and Emerging Practices. CABI Publishing.
- SULAIMAN, R. V. AND DAVIS, K., 2012, The New Extensionist: Roles, strategies, and capacities to strengthen extension and advisory services. In Lindau, Switzerland: Global Forum for Rural Advisory Services. http://www.g-fras.org/en/157-thenew-extensionist
- SWANSON, B. E., 2008, Global Review of Good Agricultural Extension and Advisory Service Practices. Food and Agriculture Organization of the United Nations. Rome. http://www.fao.org/docrep/pdf/011/ i0261e/i0261e00.pdf

• WORLD BANK. 2006. Enhancing Agricultural Innovation: How to Go Beyond the Strengthening of Research Systems. Washington, DC: World Bank. © World Bank. https://openknowledge.worldbank.org/handle/10986/7184

AEE 502 APPLIED BEHAVIOUR CHANGE (2+1)

Objective

To build capacities of students to understand the fundamental psychological processes in guiding human behaviour at different levels / contexts and to develop sound extension strategies.

Theory

Block 1: Foundations of Behaviour Change

Unit 1: Foundations of Human Behaviour

Human behaviour – Meaning, importance and factors influencing human behaviour; Biological bases of human behaviour – Nervous system, brain, endocrine system and genes; Individual variations – intelligence, ability and creativity– foundations and theories, personality and temperament - foundations, approaches, theories of personality, measuring personality (traits, locus of control, self-efficacy; Personal, social and moral development – meaning, concepts – self-concept, self-esteem and self-worth and theories. Motivation – foundations, approaches, theories, managing human needs and motivations; perceiving others – impression, attitude, opinions; Emotions - foundations, types and functions, measuring emotional intelligence.

Block 2: Cognitive Processes And Learning

Unit 1: Cognitive Processes affecting Human Behaviour

Sensory organs and their role cognition; Cognitive processes – Attention, perception, remembering and forgetting, knowledge and expertise – foundations and theories; Principles and processes of perception; Consciousness – meaning, types, sleep and dreams; Learning and Memory – Memory - meaning, types and mechanisms of storage and retrieval of memories in the Human brain; Complex cognitive processes - Concept formation, Thinking, Problem solving and transfer – foundations, theories and approaches.

Unit 2: Information Processing

Information processing – meaning, principles; Models of information processing - Waugh and Norman model of primary and secondary memory; Atkinson and Shiffrin's stage model of memory; other models including blooms taxonomy and Sternberg's Information Processing Approach; Attention and perception – meaning, types, theories and models; Consciousness.

Unit 3: Learning

Learning – foundations, approaches and theories; Cognitive approaches of learning – meaning, principles theories and models; Memory – foundations, types; Behavioural approaches of learning – foundations and theories - classical conditioning, operant conditioning, applied behaviour analysis; Social cognitive and constructivist approaches to learning – foundations and theories – social cognitive theory, Self-regulated learning; learning styles – meaning, types and applications in learning.

Unit 4: Judgement, Choice and Decision-making

Human judgement – meaning, nature, randomness of situations, theories and models; Choice – meaning, criteria for evaluating options; theories and models of human choice; Choice architecture; Decision-making – Meaning, problem analysis; steps and techniques of decision-making under different contexts.

Block 3: Human Behaviour in the Society

Unit 1: Attitudes and Influence

Attitudes - meaning, assumptions, types, theories and models of attitude formation; methods of changing attitudes, Relating to others - liking, attraction, helping behaviour, prejudice, discrimination and aggression; Liking/ affect – meaning, types and theories; Attraction – meaning, types and theories; Persuasion – meaning, theories and techniques; Social influence and groups – conformity, compliance and obedience.

Unit 2: Social Judgement, Social Identity and Inter-Group Relations

Social judgement – meaning, frame of reference, stereotyping; The judgement of attitude models; Attribution – meaning, theories; Rational decision making; Social identify – meaning, types; assessment; Groups – meaning, types, group processes; sustainability of groups; Inter group processes and theories social learning.

Practicals

- Understanding perception – Attentional Blink and Repetition Blindness exercise
- Understanding attention - Testing selective attention capacity and skills and processing speed ability through Stroop test
- Hands-on experience in the techniques for assessing creative thinking – divergent and convergent thinking
- Lab exercise in applying Maslow's need hierarchy to assess motivation
- Learning - Classical conditioning and operant conditioning
- Assessing learning styles through Barsch and Kolb inventories
- Practical experience in building self-esteem
- Assessment of emotional intelligence
- Exercises in problem solving
- Exercises in visual perception
- Measuring self-concept using psychometric tools
- Experiment on factors influencing information processing
- Assessment of attitudes
- Hands on experience in methods of persuasion
- Field experience in assessing social judgement
- Simulation exercise to understand decision-making under different situations
- Exercise in rational decision-making.

References

- EISER, J., RICHARD, 2011, Social Psychology: Attitudes, Cognition and Social Behaviour. Cambridge University Press. (First Edition, 1986)), Cambridge.
- EYSENCK, M. W. AND KEANE, M. T., 2010, Cognitive psychology: A student's handbook. Sixth Edition, Hove: Psychology Press.
- FELDMAN, R. S., 2008, Essentials of understanding psychology (7th ed.). McGraw-Hill, Boston.
- GILOVICH, T., KELTNER, D., AND NISBETT, R. E., 2011, Social psychology. New York: W.W. Norton & Co.
- MORENO, R., 2010, Educational Psychology. John Wiley & Sons Inc., Hoboken, New Jersey.
- NEVID, J. S., 2012, Essentials of psychology: Concepts and applications Belmont, CA: Wadsworth, Cengage Learning.
- RACHLIN, H., 1989. Judgment, decision, and choice: A cognitive / behavioral synthesis. New York: W.H. Freeman.

AEE 503 ORGANISATIONAL BEHAVIOR AND DEVELOPMENT (2+1)

Objective

To understand organizational behavior development, theories and practices and imparting skills in diagnosing, initiating and facilitating organizational change interventions

Theory

Block 1: Organizational Behavior

Unit 1: Basics of Organization

Introduction to organizations-concept and characteristics of organizations; Typology of organizations; Theories of organizations: nature of organizational theory, Classical theories, Modern management theories, System Theory - Criticisms and lessons learnt/ analysis.

Unit 2: Basics of Organizational Behaviour

Concepts of Organisational Behaviour, Scope, Importance, **Nature, characteristics, objective, principles of organizational behaviour** and Models of OB.

Unit 3: Individual Behaviour in Organizations

Introduction, Self-awareness, Perception and Attribution, Learning, Systems approach to studying organization needs and motives – attitude, values and ethical behavior, Personality,

Motivation-Concept & Theories, Managing motivation in organizations, **Task performance and evaluation**

Unit 4: Group Behaviour in Organization

Foundations of group, group behaviour and group dynamics, **Advantages, Types of group behaviour, difference between group and team, Culture and group behaviour,** Group Development and Cohesiveness, Group Performance and Decision Making, Intergroup Relations; Teams in Organizations-Team building experiential exercises, Interpersonal Communication and Group; Leadership: Meaning, types, Theories and Perspectives on Effective Leadership, Power and Influence, managing Conflict and Negotiation skills, Job/ stress management, decision-making, problem-solving techniques.

Unit 5: Productive Behaviour and Occupational Stress

Productive behaviour - Meaning, dimension; Job analysis and Job performance – meaning, dimensions, determinants and measurement; Job satisfaction and organizational commitment - meaning, dimensions and measures roles and role clarity; Occupational stress – meaning, sources, theories and models, effects, coping mechanism, effects and management; Occupational stress in farming, farmer groups/ organizations, research and extension organizations.

Unit 6: Organizational System

Organizations Structure- Need and Types, Line & staff, functional, committee, project structure organizations, centralization &

decentralization, Different stages of growth and designing the organizational structure; Organizational Design-Parameters of Organizational Design, Organization and Environment, Organizational Strategy, Organization and Technology, Power and Conflicts in Organizations, Organizational Decision-Making; Organizational Culture vs Climate; Organizational Change; Organizational Learning and Transformation.

Block 2: Organisational Development

Unit 1: Overview of Organizational Development

Concept of OD, Importance and Characteristics, Objectives of OD, History and Evolution of OD, Implications of OD Values.

Unit 2: Managing the Organizational Development Process

Basic Component of OD Program-Diagnosis-contracting and diagnosing the problem, Diagnostic models, open systems, individual level group level and organizational level diagnosis; Action-collection and analysis for diagnostic information, feeding back the diagnosed information and interventions; Program Management- entering OD relationship, contracting, diagnosis, feedback, planned change, intervention, evaluation.

Unit 3: Organizational Development Interventions

Meaning, Importance, Characteristics of Organization development Interventions, Classification of OD Interventions-Interpersonal interventions, Team Interventions, Structural Interventions, Comprehensive Interventions.

Unit 4: Organizational Development Practitioner or Consultant

Who is OD consultant? Types of OD consultants and their advantages, qualifications, Comparison of traditional consultants Vs. OD consultants, Organizational Development process by the practitioners skills and activities.

Practicals

- Case Analysis of organization in terms of process – attitudes and values, motivation, leadership.

- Simulation exercises on problem-solving – study of organizational climate in different organizations.
- Study of organizational structure of development departments, study of departmentalization, span of control, delegation of authority, decision-making patterns.
- Study of individual and group behaviour at work in an organization.
- Conflicts and their management in an organization. Comparative study of functional and non functional organizations and drawing factors for organizational effectiveness.
- Exercise on OD interventions (Interpersonal, Team, Structural, Comprehensive) with its procedure to conduct in an organization

References

- BHATTACHARYYA, D. K., 2011, Organizational Change and Development, Oxford University Press.
- HELLRIEGEL, D., SLOCCUM, J. W. AND WOODMAN, 2001, Organizational Behaviour. Cincinnati, Ohio:South-Western College Pub.
- LUTHANS, F., 2002, Organizational Behaviour. Tata McGraw-Hill, New York
- NEWSTROM, J. W. AND DAVIS, K., 2002, Organizational Behaviour: Human behaviour at Work. Tata-McGraw Hill, New Delhi.
- PETER, M. S., 1998, The Fifth Discipline: The Art and Practice of Learning Organization. Random House, London.
- PRADIP, N. K., 1992, Organizational Designs for Excellence. Tata McGraw Hill, New Delhi.
- SHUKLA, MADHUKAR, 1996, Understanding Organizations. Prentice Hall of India, New Delhi.
- STEPHENS, P. R. AND TIMOTHY, A. J., 2006., Organizational Behaviour, 12th Edition. Prentice Hall Pub.
- THOMAS, G. C. AND CHRISTOPHER, G. W., 2013, Organizational development and change, 10th edition, South-Western college publishing.

• WENDELL, L. F. AND CECIL, H. B., 1999, Organizational Development: Behavioural science interventions for organization improvement, Pearson. pp :368.

AEE 504 RESEARCH METHODOLOGY IN AGRICULTURE EXTENSION (2+1)

Objective

To create a workforce with sound fundamental knowledge and critical competencies in planning, conducting and applying behavioural research for developing quality extension models, methods and tools.

Theory

Block 1: Introduction to Behavioural Research

Unit 1: Nature of Behavioural Research

Methods of knowing; Science and scientific method; Behavioural research – Concept, aim, goals and objectives; Characteristics and Paradigms of research; Types of behavioural research based on applications, objectives and inquiry; Types of knowledge generated through research – historical, axiological, theoretical and conceptual knowledge, prior research studies, reviews and academic debate; Role of behavioural research in extension; Careers in behavioural research.

Unit 2: The Behavioural Research Process

Basic steps in behavioural research – Formulating a Research Problem; Reviewing the Literature; Identifying the variables and hypotheses; Formulating research designs, methods and tools; Selecting sample; Collecting data; Analyzing and Interpreting the Data; Reporting and Evaluating Research; Skills needed to design and conduct research; Writing research proposals.

Block 2: Steps in Behavioural Research Process

Unit 1: Formulating a Research Problem

The research problem and research topic - definitions; Importance of formulating a research problem; Sources of research problems; Characteristics of a good research problem; Research problems in quantitative and qualitative research; Steps in formulating a research

problem; Strategies for writing research problem statement; Research purpose statement; Research questions – Types, Criteria for selecting research questions, techniques for narrowing a problem into a research question; Objectives - Meaning, types and criteria for judging the objectives.

Unit 2: Reviewing the Literature

Review-meaning and importance; Types of literature review – Context, Historical, Integrative, methodological, self-study and theoretical; Literature review for quantitative and qualitative studies; Steps in conducting literature review – Identify key terms, locate literature, critical evaluation and selection; organising literature and writing literature review.

Unit 3: Identifying Variables and Hypotheses

Developing theoretical, conceptual, empirical frameworks; Approaches for identifying concepts, constructs and variables; Role of theory in behavioural research; Steps in identifying variables – Domain, Concepts, Constructs, Dimensions; Indicators; Variables, Definitions, premises, propositions and hypotheses; Techniques of identifying concepts, constructs and variables - Types of concepts; Types of variables –causal relationship, the study design; and the unit of measurement; Types of definitions-Types of propositions and hypotheses. Characteristics of good hypotheses; Measurement – Meaning, levels of measurement – nominal, ordinal, interval andratio; Criteria for choosing measurement levels for variables.

Unit 4: Formulating Research Designs, Methods and Tools

Research designs – Definition, purpose and functions; Research Design as Variance Control - MAXMINCON Principle; Criteria for selecting a suitable Research Design; Classification of research designs: Quantitative designs - experimental, descriptive, comparative, correlational, survey, ex-post facto and secondary data analysis; Qualitative designs - ethnographic, grounded theory, phenomenological and Narrative research; Mixed method designs – Action research design; Translational research; Elements of research design - Research strategies,

Extent of researcher interference, Study setting, Unit of analysis and Time horizon. Sources of errors while specifying research designs. Internal and external validity; Choosing right research design; Triangulation - Importance in behavioural research, Types of triangulation. Research methods: Designing research Instruments – questionnaires, interview schedules; tests – knowledge tests, behaviour performance tests; scales – scales and indexes, checklists, focus groups; Steps in developing and using research methods and tools; participatory rural appraisal.

Unit 5: Selecting Sample

Sampling - population, element, sample, sampling unit, and subject; Sampling strategies for quantitative and qualitative research; Principles of sampling; Factors affecting the inferences drawn from a sample; Types of sampling, Methods of drawing a random sample, Sampling with or without replacement, Types of sampling - Probability Sampling - Simple random sampling, Cluster sampling, Systematic sampling, Stratified random sampling and Unequal probability Sampling; Non probability Sampling - Reliance of available subjects, Purposive or judgmental sampling, accidental sampling, expert sampling, Snowball sampling, and Quota sampling; Sample size requirements for quantitative and qualitative studies. Methods for estimating sample size; Generalisation – Importance, Types of generalisations.

Unit 6: Collecting Data

The process of collecting data – Selection, training, supervision, and evaluation of field investigators; Online data collection; Errors and biases during data collection. Testing goodness of measures through item analysis - Reliability and validity;

Types of validity – Content validity: Face and content validity, Criterion-related validity: concurrent and predictive validity, Construct validity: convergent, and discriminant validity, factorial validity, and nomological validity; Types of reliability – Test-Retest, Parallel forms, Inter-item consistency reliability, Split-half reliability. Factors affecting the validity and reliability of research instruments, Strategies for

enhancing validity and reliability of measures. Validity and reliability in qualitative research.

Unit 7: Analyzing and Interpreting the Data

Data coding, exploration and editing; Methods of data processing in quantitative and qualitative studies; Quantitative data analysis - parametric and non-parametric statistical analyses; Parametric analysis – Descriptive and inferential statistics, Hypothesis testing - Type I and Type II errors. Concepts in hypothesis testing - Effect Size, á, â, and Power, P Value; Multivariate data analysis – regression, factor analysis, cluster analysis, logistic regression and structural equation modelling. Guidelines for choosing appropriate statistical analysis; Statistical packages for data analysis; Methods of interpreting data and drawing inferences - The Ladder of Inference; Methods of communicating and displaying analysed data.

Unit 8: Reporting and Evaluating Research

Writing reports and research publications; Evaluation Methodology.

Practicals

- Selecting a research problem and writing problem statement
- Narrowing down research problem to purpose, research questions and objectives
- Choosing, evaluating and reviewing research literature
- Selection of variables through construct conceptualisation and defining variables
- Choosing research design based on research problem
- Choosing right sampling method and estimating sample size
- Developing research methods and tools – questionnaires, interview schedule, checklists and focus group guides
- Writing a research proposal
- Field data collection using research methods and tools
- Testing reliability and validity of research instruments
- Hands on experience in using SPSS for coding, data exploration,

editing, analysis and interpretation Formulation of secondary tables based on objectives of research

- Writing report, writing of thesis and research articles
- Presentation of reports

References

- CRESWELL, J. W., 2012, Educational research: Planning, conducting, and evaluating quantitative and qualitative research. Fourth edition. Boston, MA: Pearson.
- KERLINGER, F. N. AND LEE, H. B., 2000, Foundations of Behavioral Research. FL: Harcourt College Publishers, Orlando.
- NEUMAN, W. L., 2006. Social Research Methods: Qualitative and Quantitative Approaches. Toronto: Pearson.
- SEKARAN, U. AND BOUGIE, R., 2013, Research Methods for Business A Skill-Building Approach. 6th Edition, Wiley, New York.
- SENDHIL, R., KUMAR, A., SINGH, S., VERMA, A., VENKATESH, K. AND GUPTA, V., 2017, Data Analysis Tools and Approaches (DATA) in Agricultural Sciences. Proc. e-Compendium of Training-cum-Workshop, ICAR-IIWBR, pp: 1-126.
- SIVAKUMAR, P. S. AND SULAIMAN, R. V., 2015, Extension Research in India- Current Status and Future Strategies. AESA Working Paper 2. Agricultural Extension in South Asia.http://www.aesanetwork.org/ aesa-working-paper-2 -on-extension-research-in-india- currentstatus-and-future-strategies-p-sethurman-sivakumar-and- rasheed-sulaiman-v-december-2015/

AEE 505 CAPACITY DEVELOPMENT (2+1)

Objective

To understand the concepts, approaches, methods and strategies of training, capacity building and human resource development and imparting skills in devising, organizing, implementing and evaluating capacity development programmes.

Theory

Block 1: Introduction to Capacity Development

Unit 1: Capacity Development–An Overview

Training, capacity building, capacity development and HRD- Meaning and differences; Need and principles of capacity development; Types and levels of capacities -Institutional capacities (include the rules, regulations and practices that set the overarching contextual environment), Organisational capacities (how various actors come together to perform given tasks), Individual capacities (technical, functional and leadership skills). Types of capacity building - Based on structure (structured, semi-structured &unstructured), Based on context (orientation, induction and refresher), and other categories (online, Webinar, distance etc.).Components of capacity development; Capacity development cycle.

Unit 2: Capacity Development- Approaches and Strategies

Capacity Development Dilemma- Theory versus Practice, Trainee versus Task, Structured versus Unstructured, Generic and Specific; Approaches in Capacity Development -Informative approach, Participatory approach, Experimental approach/ Experiential, Performance based approach; Capacity Development Strategies - Academic strategy, Laboratory strategy, Activity strategy, Action strategy, Personal development strategy, Organizational development strategy.

Unit 3: Planning and Organization of Capacity Development Programmes

Steps in Designing and Planning of Capacity Development- Step 1. Select the participants, Step 2. Determine the participants' needs, Step 3. Formulate goal and objectives, Step 4. Outline the content, Step 5. Develop instructional activities, Step 6. Prepare the design, Step 7. Prepare evaluation form, Step 8. Determine follow-up activities; Organising capacity development programme; Operational arrangements at different stages- Before the programme, During the programme, Middle of the programme, At the end of the programme, After the programme, Follow up; Stakeholders' responsibilities.

Block 2: Capacity Development Needs Assessment

Unit 1: Planning and Organization of Capacity Development Programmes

Concept of Need Assessment; Approaches in Need Analysis- Performance Analysis, Task Analysis, Competency Study; Needs Survey.

Unit 2: Capacity Development Needs Assessment Methods

Data Collection Methods in Identifying Needs - Rational Methods (Observation, Informal talks, Complaints, Comparison, Analysis of report, Opinion poll, Buzz session, Analysis of the new programme), Empirical Methods (Job analysis, Performance evaluation, Checklist or Questionnaire Method, Tests, Critical Incident Technique, Card Sort Method, Focus Group Discussion, Interview, SWOT Analysis); Information and Skills required in Need Analysis; Identification of Needs through Task Analysis - Task identification, Task Analysis, Gap Analysis.

Block 3: Capacity Development Institutions and Management

Unit 1: Capacity Development Institutions

Capacity Developer (Trainer): Meaning and concept; Types of Capacity Developers (regular, *ad-hoc*, part time, guest and consultants); Roles of Capacity Developer (explainer, clarifier, supporter, confronter, role model, linker, motivator, translator/interpreter, change agent); Good Capacity Developer – Qualities, skills and roles Qualities, Skills (Intrapersonal & Inter personal), Roles (Manager, Strategist, Task Analyst, Media Specialist, Instructional Writer, Marketer, Facilitator, Instructor, Counsellor, Transfer Agent, Evaluator); Capacity Development Centres and Locations; Organisation's Role in Capacity Development.

Unit 2: Capacity Development Project Formulation

Project Proposal: Concept and Meaning; Steps in Project Formulation- Review of past proposals, Consulting experts, consultants, and previous organizers, Reviewpast project evaluation reports, Interact with the prospective beneficiaries; Format for Writing Project Proposal (LFA).

Block 4: Capacity Development Process and HRD

Unit 1: Capacity Development Methods and Tools

Capacity Development Methods –Lecture, Discussion, Syndicate, Seminars, Conference, Symposium, Role Play, Case study, Programmed Instruction, T - group/ Laboratory methods; Factors Determining Selection of Methods – Capacity development objectives, subject matter, categories of participants, and the available resources like time, location, budget; Capacity Development Aids.

Unit 2: Evaluation

Capacity Development Programme Evaluation - Meaning & Importance; Purpose of Evaluation; Principles of Evaluation; Types of Evaluation – Formative, Summative, Kirkpatrick's four levels of evaluation; Process of Evaluation- Evaluation the beginning, Evaluation during the programme, Evaluation at the end; Use of evaluation findings; Statistical Tools for evaluation.

Unit 3: Impact Assessment

Impact Assessment- Meaning, Need, Features, Benefits, Concepts; Indicators for Impact Assessment - Direct indicators, Indirect or proxy indicators, Quantitative indicators, Qualitative indicators, Result chain / hierarchy of indicators; Methods of Impact Evaluation- Learning retention of participants (KOSA), Impact on the job performance, Impact on organizational effectiveness, Impact on stakeholder's competency.

Unit 4: Human Resource Development

HRD: Meaning, Importance and Benefits; Types of HRD Systems & Sub-systems Career system (Manpower planning, Recruitment, Career planning, Succession planning, Retention), Work system (Role analysis, Role efficacy, Performance plan, Performance feedback and guidance, Performance appraisal, Promotion, Job rotation, Reward), Development system (Induction, Training, Job enrichment, Self-learning mechanisms, Potential appraisal, Succession development, Counselling, Mentor system), Self-renewal system (Survey, Action research, Organisational development interventions), Culture system (Vision, mission and goals, Values, Communication, Get together and celebrations, Task force, Small

groups); Components of HRD System - Performance Appraisal, Potential Appraisal, Task System, Development System, Socialisation System, Governance; Functions of HRD-Organisational Development, Career Development, Capacity Development.

Practicals

- Capacity development needs assessment exercise
- Capacity development project formulation exercise
- Planning organizing and conducting an extension capacity development programme
- Designing a programme
- Writing learning objectives
- Developing objectives into curriculum
- Training plan
- Organizing capacity development workshop
- Evaluation with pre- and post-training tests
- Training methods – Practicing each method mentioned in contents as group exercise

References

- ANNONYMOUS, 2010, FAO Capacity Assessment Approach and Supporting Tools - Discussion Draft, Food and Agriculture Organisation of the United Nations
- ANNONYMOUS, 2012.Capacity Development: Learning Module 2. FAO Approaches to Capacity Development in Programming. Processes and Tools, Food and Agriculture Organisation of the United Nations
- ANNONYMOUS, 2013.Capacity Development: Learning Module 4. Organization Analysis and Development Food and Agriculture Organisation of the United Nations
- SIDA, 2000, Capacity Development. SIDA Working Paper No. 4. Analysis of Needs for Capacity Development.

- ANNONYMOUS, 2013, Capacity Development for Agricultural Innovation Systems - Key Concepts and Definitions. Tropical Agricultural Platform
- UNDP, 2008, Capacity Assessment Methodology. User's Guide. Capacity Development Group. Bureau for Development Policy.
- WAC, 2013, Assessing Capacity Needs and Strategy Development for Grassroots Rural Institutions: A Guide for Facilitators. World Agroforestry Centre (WAC)

AEE 506 ICTs FOR AGRICULTURAL EXTENSION AND ADVISORY SERVICES (2+1)

Objective

To orient ICT initiatives, smart/ disruptive technologies, data analytics, knowledge management process and application aspects and providing hands on experience in navigating ICTs.

Theory

Block 1: Introduction to Information and Communication Technologies (ICTs) and E-extension

Unit 1: ICTs- Concepts and Status

ICTs- meaning, concepts, basics of ICTs, global and national status, types and functions of ICTs, innovations, meaning of e-Governance, e-learning, mLearning, advantages and limitations of ICTs.

Unit 2: ICTs in Knowledge Management

Knowledge management-meaning, approaches and tools. Role of ICTs in Agricultural Knowledge Management.

Unit 3: e-Extension initiatives in Agriculture and allied sectors

e-Extension, overview on Global and national e-extension initiatives, Inventory of e-Extension initiatives in Agriculture and allied sectors from Central and State governments, ICAR, SAUs, private sector and NGO initiatives in India.

Block 2: Application of ICTs in Extension and Advisory Services

Unit 1: ICT Applications

Knowledge centres (tele centres), digital kiosks, websites and web portals, community radio, farmers call centres, mobile phone based advisory services and mobile applications (mExtension, mLearning), Self-learning CDs on Package of practices, social media, digital videos, Market Intelligence and Information Systems- ICT enabled Supply-Chains and Value-Chains/ e-Marketing (e-NAM, Agmarknet, *etc*.).

Unit 2: ICT Expert Systems

Expert System/ Decision Support System/ Management Information Systems, Farm Health Management & Intelligence System for Plant Health, Animal Health, Soil Health, Fishery, Water, Weather, etc.

Unit 3: ICT Networks

Global and regional knowledge networks, international information management systems, e-Learning platforms (MOOCS, Course CCRA, EduEx, *etc*), e-Governance Systems; digital networks among extension personnel, Farmer Producers Organisations (FPOs)/ SHGs/ Farmers Groups.

Block 3: Knowledge Management and Standards

Unit 1: Policies in Knowledge Management

Global policy/ Standards on e-Governance, National policy on e-governance, Open Data / Open Gov Standards and Open Source etc; Language Technology Applications; National e-Agriculture policy/ Strategies/ guidelines.

Unit 2: Web Standards

Web standards, creating and writing for web portals, development of mobile applications, developing digital videos- story board- video recording- video editing, types of blogs and writing guidelines.

Unit 3: Social Media Applications to engage audience

Video conference, live streaming and webinars, types and functions of social media applications, guidelines for preparing social media content, engaging audience and data-analytics.

Block 4: Smart and Disruptive Technologies and Advanced Analytics for Agricultural Extension

Unit 1: Smart Technologies

Open technology computing facilities, System for data analytics/ mining/ modelling/Development of Agricultural simulations; Remote Sensing, GIS, GPS, Information Utility (AIU); disruptive technologies-Analysis; Internet of Things (IoTs), Drones, Artificial intelligence (AI), block chain technology, social media and Big Data analytics for extension.

Unit 2: Human Computer Interactions

Human Centered Learning/Ergonomics/ Human Computer Interactions-Meaning; Theories of multimedia learning - Sweller's cognitive load theory, Mayer's cognitive theory of multimedia learning, Schnotz's integrative model of text and picture comprehension, van Merriënboer's four-component instructional design model for multimedia learning; Basic Principles of Multimedia Learning - Split-attention, Modality, Redundancy, Coherence, Signaling, segmenting, pre-training, personalisation, voice embodiment; Advanced principles - Guided discovery, worked examples, Self-explanation, drawing, feedback, multiple representation, Learner control, animation, collaboration, prior knowledge, and working memory. Designing ICT gadgets based on human interaction principles - Interactive design-Meaning, importance; Approaches of interactive design - user-centered design, activity centered design, systems design, and genius design; Methods of interactive design - Usability testing methods.

Practicals

- Content and client engagement analysis
- Designing extension content for ICTs
- Creating and designing web portals, blogs, social media pages
- Developing digital videos
- Live streaming extension programmes and organising webinars
- Working with Farmers call centres

- Engaging with professional digital networks
- Writing for digital media

References

- BARBER, J., MANGNUS, E. AND BITZER, V., 2016, Harnessing ICT for agricultural extension. KIT Working Paper 2016: 4. https:/ / 213ou636sh0ptphd141fqei1-wpengine.netdna-ssl.com/sed/wp-content/uploads/sites/2/2016/11/KIT_WP2016-4_Harnessing-ICT-for-agricultural-extension.pdf
- ANNONYMOUS, 2011, E-learning methodologies a guide for designing and developing e-learning courses. Food and Agriculture Organization of the United Nations.http://www.fao.org/docrep/015/ i2516e/ i2516e.pdf
- HEIKE BAUMÜLLER, 2018, The little we know: An exploratory literature review on the utility of mobile phone enabled services for smallholder farmers. J. Int. Dev., 30: 134-154.
- MAYER, R. E., 2005, The Cambridge handbook of multimedia learning. University of Cambridge, New York.
- MEERA, S. N., 2017, Disruptive Technologies - Big Data and Internet of Things in Strengthening Extension & Advisory Services. Blog 68.Agricultural Extension in South Asia. http:// www.aesanetwork.org/disruptive-technologies-big-data-and-internet-of-things-instrengthening-extension-advisory-services/
- PREECE, J., ROGERS, Y., AND PREECE, J., 2007, Interaction design: Beyond human-computer interaction. Chichester: Wiley.
- SARAVANAN, R., KATHIRESAN, C., AND INDRA, D. T. 2011, (Eds.) Information and Communication Technology for Agriculture and Rural Development, New India Publishing Agency (NIPA), New Delhi.
- ANNONYMOUS, 2017, ICT in Agriculture (Updated Edition): Connecting Smallholders to Knowledge, Networks, and Institutions. Washington, DC: World Bank. https://openknowledge. worldbank. org/handle/10986/27526

AEE 507 EVALUATION AND IMPACT ASSESSMENT (2+1)

Objective

To orient the students on the importance, methods of evaluations and impact assessments and imparting capacities for conducting evaluations and impact assessments.

Theory

Block 1: Programme Evaluation

Unit 1: Introduction to Evaluation

Concept of Evaluation: Meaning and concept in different contexts; Why Evaluation is Done and When? Programme planning, analyse programme effectiveness, decisionmaking, accountability, impact assessment, policy advocacy; Objectives, types, criteria and approaches of programme evaluation, evaluation principles; the contextof program evaluation in agricultural extension; Role and Credibility of Evaluator: Role as educator, facilitator, consultant, interpreter, mediator and change agent. Competency and credibility of evaluator.

Unit 2: Evaluation Theories

Evaluation theory vs. practice – synergistic role between practice and theory in evaluation; Evaluation theories - Three broad categories of theories that evaluators use in their works - programme theory, social science theory, and evaluation theory(other theories/ approaches - Utilization-Focused Evaluation & Utilization-Focused Evaluation (U-FE) Checklist, Values Engaged Evaluation, Empowerment Evaluation, Theory-Driven Evaluation). Integration between theory and practice of evaluation: –evaluation forums, workshops, conferences and apprenticeship/ internship.

Block 2: Evaluation Process

Unit 1: How to Conduct Evaluation

Ten Steps in programme evaluation: (1) Identify and describe programme you want to evaluate (2) Identify the phase of the programme(design, start-up, ongoing,wrap-up, follow-up) and type of

evaluation study needed (needs assessment, baseline, formative, summative, follow-up) (3) Assess the feasibility of implementing an evaluation (4) Identify and consult key stakeholders (5) Identify approaches todata collection (quantitative, qualitative, mixed) (6) Select data collection techniques (survey interviews and questionnaires with different types) (7) Identify population and select sample (sampling for evaluation, sample size, errors, sampling techniques (8) Collect, analyse and interpret data (qualitative and quantitative evaluation data analysis) (9) Communicate findings (reporting plan, evaluation report types,reporting results, reporting tips, reporting negative findings (10) Apply and use findings (programme continuation/ discontinuation, improve on-going programme, plan future programmes and inform programme stakeholders).

Unit 2: Evaluating the Evaluation

Evaluating the Evaluation - 10 Steps as above with focus on conceptual clarity, representation of programme components and stakeholders, sensitivity, representativeness of needs, sample and data, technical adequacy, methods used for data collection and analysis, costs, recommendations and reports.

Block 3: Programme Management Techniques

Unit 1: SWOT Analysis and Bar Charts

SWOT Analysis – Concept, origin and evolution; SWOT As a Programme Management Tool; Conducting SWOT Analysis - Common Questions in SWOT Analysis; Advantages and Disadvantages of SWOT; Bar Charts (Gantt Charts and Milestone Charts) - Characteristics, advantages and limitations.

Unit 2: Networks

Networks – Introduction, origin and widely used networks (Programme Evaluation and Review Technique (PERT) and Critical Path Method (CPM), differences betweenPERT and CPM, advantages and disadvantages. Networks Terminology – Activity, Dummy activity, Event (predecessor event, successor event, burst event, mergeevent, critical

event), Earliest Start Time (EST), Latest Start Time (LST), Critical Path, Critical Activity, Optimistic time (To), Pessimistic time (Po), Most likely time (TM), Expected time (TE), Float or Slack, Event Slack, Lead time, Lag time, Fast tracking, Crashing critical path, Acclivity Table, Danglers, Normal Time. Rules for Preparation of Networks and Steps in Network Preparation with example.

Block 4: Programme Evaluation Tools

Unit 1: Bennett's Hierarchy of Evaluation

Introduction to Bennett's hierarchy – Background and description; Relation between programme objectives & outcomes at 7 levels of Bennett's hierarchy – Inputs,activities, participation, reactions, KASA changes, practice and behaviour changes, end results. Advantages and Disadvantages of Bennett's hierarchy.

Unit 2: Logic Framework Approach (LFA)

Introduction to LFA – Background and description; Variations of LFA - Goal Oriented Project Planning (GOPP) or Objectives Oriented Project Planning (OOPP); LFA Four-by-Four Grid – Rows from bottom to top (Activities, Outputs, Purpose andGoal & Columns representing types of information about the events (Narrative description, Objectively Verifiable Indicators (OVIs) of these events taking place, Means of Verification (MoV) where information will be available on the OVIs, and Assumptions).Advantages and Disadvantages of LFA.

Block 5: Impact Assessment

Unit 1: Introduction to Impact Assessment

Concept of Impact Assessment: Meaning, concept and purpose in different contexts; Impact Assessment Framework: Meaning of inputs, outputs, outcomes, impacts and their relation with monitoring, evaluation and impact assessment.

Unit 2: Impact Assessment Indicators

Indicators for impact assessment – meaning and concept; Selecting impact indicators; Types of impact indicators for technology and

extension advisory services - social andbehavioral indicators, socio-cultural indicators, technology level indicators, environmental impact assessment indicators and institutional impact assessment indicators.

Unit 3: Approaches for Impact Assessment

Impact assessment approaches–Quantitative, qualitative, participatory and mixed methods with their advantages and disadvantages; Quantitative Impact Assessment Types – Based on Time of Assessment (Ex-ante and ex-post), Based on Research Design (Experimental, quasi experimental, Non-experimental). Econometric Impact Assessment: - (Partial Budgeting Technique, Net Present Value, Benefit Cost Ratio, Internal Rate of Return, Adoption Quotient, *etc*). Qualitative and Participatory Impact Assessment Methods.

Unit 4: Environment Impact Assessment (EIA)

Concept of EIA – Introduction, What it is? Who does it? Why it is conducted? How it is done?; Benefits and important aspects of EIA-risk assessment, environmental management and post product monitoring. Environmental Components of EIA –air, noise, water, biological, land; Composition of the expert committees and Steps in EIA process - screening, scoping, collection of baseline data, impact prediction, mitigation measures and EIA report, public hearing, decision making, monitoring and implementation of environmental management plan, assessment of alternatives, delineation of mitigation measures and EIA report; Salient Features of 2006 Amendment to EIA Notification - Environmental Clearance/Rejection, participants of EIA; Shortcomings of EIA and How to improve EIA process?

Practicals

- Search the literature using web / printed resources and identify evaluation indicators for the following:
  - – Utilization-Focused Evaluation
  - – Values Engaged Evaluation
  - – Empowerment Evaluation
  - – Theory-Driven Evaluation

- Visit Directorate of Extension in your university and enquire about extension programmes being implemented / coordinated by Directorate. Develop an evaluation proposal of any one programme using 'Ten Steps in Programme Evaluation' discussed in the theory class.
- Review any comprehensive programme evaluation report from published sources. Evaluate the report and write your observations following the 'Evaluating the Evaluation' approach.
- Identify at least four agriculture development programmes and their objectives being implemented in your state. Write two attributes each on Strengths, Weaknesses, Opportunities and Threats related to the identified programme objectives in the SWOT grid.
- Identify an on-going development programme and make-out 6 activities from the programme.
- Draw a Gantt chart for 12 months programme activities.
- Write a report on evaluation hierarchy levels and indicators as per Bennett's hierarchy of evaluation for any development programme or project.
- Develop LFA four-by-four grid for any development programme or project with activities, outputs, purpose and goal and objectively verifiable indicators, means of verification & assumptions.
- Visit a nearby KVKs / ATIC. Select any agriculture technology with package of practices and extension advisory services promoted by KVK / ATIC. Identify impact assessment indicators for social and behavioral indicators, socio-cultural indicators, technology level indicators, environmental impact assessment indicators and institutional impact assessment indicators.
- Refer any Environment Impact Assessment report and analyse steps in EIA. Write your observations.

References

- ADRIENNE, M., GUNDEL, S., APENTENG, E. AND POUND, B., 2011, Review of Literature on Evaluation Methods Relevant to Extension. Lindau, Switzerland: Global Forum for Rural Advisory Services, Lindau, Switzerland

- MURRAY, P., 2000, Evaluating participatory extension programs: challenges and problems. Aust. J. of Exp. Agric., (40) 4: 519-526.
- NJUKI, J., MAPILA, M., KAARIA, S. AND MAGOMBO, T., 2008, Using community indicators for evaluating research and development programmes: Experiences from Malawi. Development in Practice, 18 (4): 633-642.
- ROSSI, P. H. AND FREEMAN, H. E., 1985, Evaluation: a systematic approach (third edition). Sage Publications, Inc., Beverly Hills.
- SANDERS, J., 1994, The program evaluation standards, 2nd edition. Joint committee on standards for educational evaluation. Sage Publications, Inc., Thousand Oak.
- SRINATH, L. S., 1975, PERT and CPM Principles and Applications, East-West Press, New Delhi.
- SUVEDI, M. AND KAPLOWITZ, M. D., 2016, Process skills and competency tools - what every extension worker should know - Core Competency Handbook. Urbana, IL: USAID-MEAS.

AEE 508 MANAGEMENT OF EXTENSION ORGANIZATIONS (2+1)

Objective

To orient students on the importance of knowledge and skills on various management functions of extension organizations and ways of running extension services, and developing capacities for becoming effective managers of agri-ventures.

Theory

Block 1: Basics of Management

Unit 1: Management- An Over view

Management and Extension management – Meaning, concept, nature and importance; and theories of management. Management, administration and supervision -meaning, definition and scope; Approaches to management, Principles, functions and levels of

management; Qualities and skills of a manager; Interpersonal relations in the organization; Reporting and budgeting

Block 2: Management in different types of Extension Organizations

Unit 1: Extension Management in public, private sector and other sectors

Extension management (POSDCORB) in public sector, Department of Agriculture, Agricultural Technology Management Agency (ATMA), Krishi Vigyan Kendra (KVK), SAUs, ICAR Institutes, Private sector, Cooperatives, NGOs, FPOs etc. Organisational Structure, Relations between different units- Challenges in management.

Unit 2: Concepts in Management

Decision making – Concept, Types of decisions, Styles and techniques of decision making, Steps in DM Process, Guidelines for making effective decisions; Human Resource Management: Manpower planning, Recruitment, Selection, Placement and Orientation, Training and Development; Dealing with fund and staff shortages in different extension organizations (KVK, ATMA etc.); Leadership – Concept, Characteristics, Functions, Approaches to leadership, Leadership styles; Authority and responsibility, Delegation and decentralization, line and staff relations; Challenges of co-ordination in extension organizations; Managing interdepartmental coordination and convergence between KVK, ATMA and line departments; Coordinating pluralism in extension services; Challenges in managing public-private partnerships (PPPs) at different levels in agricultural development in general and extension in particular; Performance appraisal – Meaning, Concept, Methods.

Block 3: Motivation and Organizational Communication

Unit 1: Motivation and Communication

Managing work motivation – Concept, Motivation and Performance, Approaches to motivation, **Theories of Motivation**, team building; Organizational Communication – Concept, Process, Types, Networks, Barriers to Communication; Mentoring, Time management, Team work and team-building strategies; Modernization of information handling.

Unit 2: Supervision and Control

Supervision – Meaning, Responsibilities, Qualities and functions of supervision, Essentials of effective supervision; **performance appraisal in Extension organization** Managerial Control – Nature, Process, Types, Techniques of Control, Observation, PERT and CPM, Management Information Systems (MIS): Concept, tools and techniques, MIS in extension organizations.

Practicals

- Simulated exercises on techniques of decision making
- Study the structure and function of agro-enterprises, Designing organizational structure/organograms.
- Group activity on leadership development skills
- Simulated exercise to understand management processes
- Field visit to extension organizations (ATARI, KVKs, NGOs), FPOs, dairy cooperatives to understand the functions of management
- Practical exercises on PERT & CPM
- Group exercise on development of short term and long term plans for agroenterprises
- Developing model agriculture-based projects including feasibility study, financial planning and cost-benefit analysis

References

- BITZER, V., WENNIK, B. AND DE STEENHUIJSEN, B., 2016, The governance of agricultural extension systems, KIT Working Paper 2016-1Royal Tropical Institute, Amsterdam https:// www.kit.nl/wp-content/ uploads/2018/08/The-governance-of-agricultural-extension- systems.pdf
- DANIEL, R. G., JAMES, A. F. S., FREEMAN, R. E., 2003, Management (6th Edition).Pearson India.
- ANNONYMOUS, 2017, Module 3: Agricultural Extension Programme Management, The New Extensionist Learning Kit,

Global Forum for Rural Advisory Services (GFRAS) http://www.g-fras.org/fr/component/phocadownload/category/70-new-extensionist-learning- kitnelk. html? download=564: nelk-module-3-agricultural- extension-programme-managementtextbook

- GUPTA, C. B., 2001, Management Theory and Practice. Sultan Chand &Sons. New Delhi
- KOONTZ, H. AND WEIHRICH, H., 2015, Essentials of Management: An International, Innovation and Leadership perspective. McGraw Hill Education (India) Private Ltd.
- QAMAR, K. M., 2005, Modernizing National Agricultural Extension Systems: A Practical Guide for Policy-Makers of Developing Countries. Food and Agriculture Organization of the United Nations
- http://www.fao.org/uploads/media/modernizing%20national.pdf
- SWANSON, B. E., BENTZ, R. P., SOFRANKO, A. J., 1997, Improving Agricultural Extension. A Reference Manual. Food and Agriculture Organization of the United Nations, Rome.
- VAN DEN BAN A. W. AND HAWKINS, H. S., 1998, Agricultural extension- Chapter 10, BSL, CBS Publishers and Distributors.

AEE 509 ENABLING AGRICULTURAL INNOVATION (1+1)

Objective

To introduce the new perspectives and application of AIS framework and broaden the understanding on tools and approaches in scaling up knowledge and ways of exploring AIS in enabling innovation.

Theory

Block 1: Agricultural Innovation Systems

Unit 1: Agricultural Innovation Systems: Concepts and Elements

Origins of the innovation systems concept-Innovation vs Invention; **Idea generation and reinvention**; Agricultural Innovation System

(AIS) -ToT, FSR, AKIS and AIS compared, Key insights from AIS: How Innovation takes place; Role of different actors in AIS; Importance of interaction and knowledge flows among different actors, Role of Communication in Innovation Process; Role of Extension in AIS, Different views to analyze AIS: structural view, functional view, process view and capacity view.

Unit 2: Enabling Innovation

Role of enabling environment: Policies and institutions in enabling innovation; Role of Government-Innovation Policy: Achieving coordination and policy coherence; Innovation Platforms; Role of Innovation Brokers, Methodologies for AIS Diagnosis: Typologies of existing methodologies-strengths and limitations; Assessing Extension and Advisory Services within AIS; Capacity Development in AIS: Strengthening capacities to innovate.

Block 2: Scaling Up Knowledge for Innovation

Unit 1: Scaling Up: Tools, Approaches and Pathways

Scaling Up: Definitions; Changing views on scaling up: Approaches to Scaling Up: Push, pull, plant, probe: Scaling up pathways: Drivers and spaces for scaling up; Framework and Tools for Scaling up: Planning and implementing a scaling up pathways; Scalability assessment tools; Role of policies in scaling up: Influencing policies for scaling up; Innovation Management for scaling up knowledge and implications for Extension and Advisory Services; **SWOT Analysis.**

Practical

- Identify one crop/commodity sector and use AIS framework to diagnose actors and their roles, patterns of interaction, institutions determining interaction and the enabling policy environment and develop a AIS Diagnosis Report (Review and Key informant interviews)
- Undertake a case study on a successful case of scaling up knowledge and identify factors that contributed to its success

- Identify one specific knowledge (a technology, an approach) that has been recently introduced and develop an Up scaling Strategy

References

- BINSWANGER, H. P. AND AIYAR, S. S., 2003, Scaling Up Community Driven Development Theoretical Underpinnings and Program Design Implications. Mimeo. Washington, D.C.: World Bank. https:// openknowledge.worldbank.org/bitstream/handle/ 10986/18310/ multi0page.pdf?sequence=1&isAllowed=y
- BINSWANGER-MKHIZE, H. P., DE REGT, J. P. AND SPECTOR, S., 2009, Scaling Up Local and Community Driven Development: A Real World Guide to Its Theory and Practice. World Bank.
- http://siteresources.worldbank.org/EXTSOCIAL DEVELOPMENT/Resources/244362-1237844546330/ 59492181237844567860/ Scaling_Up_LCDD_Book_ rfillesize.pdf
- GROVERMANN, C., GAIJI, S., NICHTERLEIN, K., MOUSSA, A. S., DIAS, S., SONNINO, A. AND CHULUUNBAATAR, D., 2017, Chapter 2. The Potential of a Global Diagnostic Tool for Agricultural Innovation Systems. Global Innovation Index, Food and Agriculture Organization of the United Nations. http:// www.wipo.int/edocs/pubdocs/en/ wipo_pub_gii_2017-chapter2.pdf
- HARTMANN, A., JOHANNES, F., LINN, 2008, Scaling Up: A framework and lessons for development effectiveness from literature and practice. Working Papers 5.The Brookings Institution. https:// www.brookings.edu/wpcontent/uploads/2016/06/10_scaling_up_aid_linn.pdf
- LAURENS, K. AND PETER, G., 2012, The role of innovation brokers in agricultural innovationsystems
- 211-230.10.1787/9789264167445-19-en.http:// siteresources.worldbank.org/INTARD/Resources/ 335807-1330620492317/9780821386842_ch3.pdf
- SARAVANAN, R. AND SUCHIRADIPTA, B., 2017, Agricultural Innovation Systems: Fostering Convergence for Extension. Tech. Bull. No. 2, Extension Next. MANAGE. http:// www.manage.gov.in/ publications/extnnext/June2017.pdf

- TROPICAL AGRICULTURE PLATFORM. 2016. Common Framework on Capacity Development for Agricultural Innovation Systems. Guidance Note on Operationalization. CAB International, Wallingford, UK. https://www.cabi.org/Uploads/CABI/about-us/4.8.5-other-business-policies-and-strategies/tap-guidance-note.pdf
- ANNONYMOUS, 2012, Agricultural Innovation Systems: An Investment Sourcebook. Washington DC, World Bank. http://siteresources.worldbank.org/INTARD/Resources/335807-
- 1330620492317/9780821386842.pdf

AEE 510 GENDER MAINSTREAMING (2+1)

Objective

To orient students on the importance of Gender mainstreaming and related concepts, roles and responsibilities, techniques for conducting gender analysis & its prerequisites and to develop capacities in identifying and addressing gender implications in development programmes.

Theory

Block 1: Why Gender Matters?

Unit 1: Historical Perspective of Gender

Historical perspective of gender: Feminism and emergence of gender as a concept, Scope of gender studies in agriculture and rural development.

Unit 2: Agrarian Importance of Gender

Agrarian Importance of Gender: Understanding the importance of gender in national and global agriculture-Key gender issues and challenges in agriculture – Gender and value chain- Global actions to address gender-needs and strategies to address gender and women empowerment.

Block 2: Gender Related Concepts, Analysis, Gender and Technology

Unit 1: Gender Related Concepts and Divides

Gender related concepts and divides: Understanding of the concepts of gender, gender equality and equity, gender balance, gender blindness,

gender relations, gender neutrality, gender bias and discrimination, gender rights, gender roles and responsibilities. Gender budgeting, Gender divides and their implications such as gender digital divide, gender access to resources and inputs divide, gender mobility divide, gender wage divide, Gender needs: practical and strategic.

Unit 2: Gender Analysis

Gender analysis: Importance, usage, prerequisites, techniques of gender analysis-Tools for gender analysis.

Unit 3: Gender and Technology

Gender and technology: How gender and technology impact each other, Gender neutral technology, Gender sensitive technology, Gender supportive assistance in technology adoption-Gender in agricultural research and extension.

Block 3: Gender Mainstreaming and Women Empowerment

Unit 1: Gender Mainstreaming

Gender mainstreaming: Importance of gender mainstreaming in agriculture, Extension strategies to address gender issues such as gender and health, nutrition, gender in agricultural value chains, gender and climate change adaptation, gender and globalization& liberalization for mainstreaming gender concerns into the national programmes and policies.

Unit 2: Women Empowerment

Women Empowerment: Importance of women empowerment, Current national women empowerment and gender indices. Women empowerment approaches (technological, organizational, political, financial, social, legal and psychological), Case studies based on experiences and learning from various development and rural development programmes.

Unit 3: Global Best Practices, Policies and Frameworks

Global Best Practices, Policies and Frameworks: Global best practices, women empowerment and gender mainstreaming models and

frameworks for addressing gender concerns in agriculture, approaches of various organizations: gender main streaming and special women focused programmes in agriculture and rural development.

Unit 4: Entrepreneurship Development for Women

Entrepreneurship development for women: Women entrepreneurship development in agriculture and agro processing: current status, women led enterprises, supporting organizations and schemes, Govt. policies, entrepreneurship development programme and process for women in agriculture.

Practicals

- Visit to a village for understanding rural gender roles and responsibilities as groups, followed by class presentation by groups
- Exercise for capturing shifts in gender roles and responsibilities
- Conducting gender analysis in a village using gender analysis techniques
- Visit to agencies supporting women empowerment followed by report presentation. Each student to visit a different organization such as State Rural Livelihood Mission, Women Development Corporation, Department of Agriculture, ImportantNGOs working for women empowerment
- Exercise for identification and prioritization of issues affecting/ needs for women empowerment
- Interaction with a successful women entrepreneur/ SHG

References

- ANNONYMOUS, 2011, Gender and agricultural value chains A review of current knowledge and practice and their policy implications. ESA Working Paper No. 11-05 (March 2011) http://www.fao.org/docrep/ 013/am310e/am310e00.pdf
- ANNONYMOUS. Gender in Extension and Advisory Services, Module 12, GFRAS New Extensionist Learning Kit

(NELK).Global Forum for Rural Advisory Services. https://ingenaes.illinois.edu/wpcontent/uploads/GFRAS_NELK_Module12_Gender-Manual- 2.pdf

- GIZ. 2013. Gender and Agricultural Extension. https://www.giz.de/fachexpertise/downloads/giz2012-en-gender-and-gricultural extension.pdf
- JAISWAL, S., 2013, Research Methodology in Gender Studies. Maxford Dynamic Series: 1-296.
- PONNUSAMY, K. AND SHARMA, P., 2015, Gender Sensitization for Development. NDRI Publ.No.130/2015.
- PORTER, F., SMYTH, I. AND SWEETMAN, C., 1999, Gender works: Oxfarm Experience in Policy and Practice. Oxfarm Publ.
- SINHA, K., 2000, Empowerment of Women in South Asia. Association of Management Development Institute in South Asia, Hyderabad.

AEE 511 DIFFUSION AND ADOPTION OF INNOVATIONS (1+1)

Objective

- To understand the concept of adoption, diffusion, Phases of adoption, roles and responsibilities of extension agent in diffusion of technology.
- To discuss the adopter categories, their characteristics and factors affecting diffusion of innovation.
- To discuss the factors affecting adoption and adoption models in agriculture.

Theory

Block 1: Diffusion of an innovation

Unit 1: Diffusion of an agricultural innovation

Diffusion – concept and meaning, elements, innovation, communication channel, time social system; History of Diffusion

Research, traditions of research on diffusion, typology of diffusion research; criticism of diffusion research.

Unit 2: Innovation development process

Innovation development process, Socio-economic status, equality and innovation development; Tracing the innovation development process, converting research into practice; Perceived attributes of Innovation and their rate of adoption, factors influencing rate of adoption.

Unit 3: Innovation decision process

Model of innovation decision process, Communication channels by adopter categories; Innovation decision period, Types of innovation-decisions- Optional, Collective and Authority and contingent innovation decisions, Diffusion effect and concept of over adoption

Unit 4: Opinion leadership and diffusion networks

Models of mass communication flow, Opinion leadership measurement and characteristics of opinion leaders, monomorphic and polymorphic opinion leadership, multi-step flow of innovation; concepts of homophily and heterophily and their influence on flow of innovations; Diffusion network, measuring opinion leader and network links, social learning theory.

Unit 5: Models in adoption and diffusion of technology

ADOPT, Information flow conceptual model, Dynamic, risk – economic model, Task technology fit model, Technology acceptance model, Theory of planned behaviour, Satisfaction model.

Block 2: Adoption of an innovation

Unit 1

The adoption process – concept and stages, dynamic nature of stages, covert and overt processes at stages, the innovation-decision process – a critical appraisal of the new formulation.

Unit 2: Adopter categories of farmers

Innovativeness and adopter categories; adopter categories as ideal types, characteristics of adopter categories.

Unit 3: Consequences of innovation

Consequences of Innovation –Decisions –Desirable or Undesirable, direct or indirect, anticipated or unanticipated consequences

Block 3: Change agent and decision making

Unit 1: Decision making

Decision making – meaning, theories, process, steps, factors influencing decision making.

Unit 2: Change agent

Factors in change agent success: change agent effort, change agency v/s client orientation, compatibility with client needs; Change agent empathy, homophily and change agent contact; clients evaluating ability.

Unit 3: Centralized and Decentralised diffusion system

Classical models of diffusion, comparing centralized and decentralised diffusion system, advantages and disadvantages of centralized and decentralised diffusion system

Practicals

- Case studies in individual and community adoption process
- Content analysis of adoption studies
- Identification of adopter categories on a selected technology
- study of attributes of current farm technologies
- Identification of opinion leaders
- Sources of information at different stages of adoption on a selected technology
- Study of factors increasing or retarding the rate of adoption
- Presentation of reports on adoption and diffusion of innovations
- Empherical model preparation / adoption and diffusion of technology

References

- AJZEN, I., 2011, The theory of planned behaviour: reactions and reflections. Psychol. Health, 26 (9); 1113-1127

- BERETTA, E., FONTANA, M., GUERZONI, M., JORDAN, A., 2018, Cultural dissimilarity: boon or bane for technology diffusion? Technol. Forecast. Soc. Chang., 133: 95-103.
- LAMBERT, D. M., ENGLISH, B. C., HARPER, D. C., LARKIN, S. L., LARSON, J. A., MOONEY, D. F., ROBERTS, R. K., VELANDIA, M. AND REEVES, J. M., 2014, Adoption and frequency of precision soil testing in cotton production. J. Agric. Resour. Econ., 39 (1):106-123.
- LINDNER, R. K., PARDEY, P. G., JARRETT, F. G., 1982, Distance to information source and the time lag to early adoption of trace element fertilisers. Aust. J. Agric. Econ., 26: 98-113
- MONTES DE OCAMUNGUIA, O., LLEWELLYN, R., 2020, The Adopters versus the Technology: Which Matters More when Predicting or Explaining Adoption? Appl. Econ. Perspect. Policy, 42 :80- 91.
- MONTES DE OCA MUNGUIA, O., PANNELL, D. J., LLEWELLYN, R., 2021, Understanding the Adoption of Innovations in Agriculture: A Review of Selected Conceptual Models. Agronomy, 11: 139
- REICHARDT, M., JÜRGENS, C., 2009, Adoption and future perspective of precision farming in Germany: results of several surveys among different agricultural target groups. Precis. Agric., 10 (1): 73-94.
- REINKER, M., GRALLA, E., 2018, A system dynamics model of the adoption of improved agricultural inputs in Uganda, with insights for systems approaches to development. Systems, 6 (3) :31.
- ROBERTSON, M. J., LLEWELLYN, R. S., MANDEL, R., LAWES, R., BRAMLEY, R. G. V., SWIFT, L., METZ, N., O'CALLAGHAN, C., 2012, Adoption of variable rate fertiliser application in the Australian grains industry: status, issues and prospects. Precis. Agric., 13 (2): 181-199.

- ROGERS, E. M., 2003, Diffusion of Innovations, 5th ed.; The Free Press: New York, USA.
- ZHANG, H., VOROBEYCHIK, Y., 2019, Empirically grounded agent- based models of innovation diffusion: a critical review. Artif. Intell. Rev., 52 (1): 707-741.

M.Sc. (Agri.) in Agricultural Marketing and Co-operation

Course Code	Course Title	Credit Hours
AMC 501	Marketing Management and Strategy	2(2+0)
AMC 502	Techniques in Market Research	2(1+1)
AMC 503	Agricultural Marketing and Price Analysis	2(1+1)
AMC 504	Agricultural Trade Policy	2(1+1)
AMC 505	Agricultural Finance and Project Management	3(2+1)
AMC 506	Agricultural Business Management	2(1+1)
AMC 507	Econometrics	3(2+1)
AMC 508	Management of Cooperatives	2(2+0)
AMC 509	International Business	2(2+0)
AMC 510	Agricultural and Food Marketing	3(2+1)
AMC 511	Grading and Quality Control in Agricultural and Food Industry	2(1+1)
AMC 512	Optimization Techniques	2(1+1)
AMC 513	Commodity Futures Trading	2(2+0)
AMC 514	Rural Marketing	2(2+0)
	Total	**31(22+9)**
AMC 580	Qualifying Examination	2(0+2)
AMC 581	Seminar-I	1 (0+1)
AMC 582	Seminar-II	1 (0+1)
AMC 591	Research-I	13 (0+13)
AMC 592	Research-II	14 (0+14)

AMC 501 MARKETING MANAGEMENT AND STRATEGY (2+0)

Objective

Marketing management involves thorough research into the latest marketing trends and techniques, which allows you to stay relevant and updated on popular marketing techniques being used in the industry.

Marketing strategy helps in discovering the areas affected by organizational growth and thereby helps in creating an organizational plan to cater to the customer needs. It helps in fixing the right price for organization's goods and services based on information collected by market research. As majors in marketing management, students learn about the key aspects of marketing, a vital function of business. Topics they study inlude consumer behaviour, marketing research, professional selling, marketing strategies and marketing management.

Theory

Block I: Overview of Marketing Management

Unit 1: Marketing Management -meaning and definition, demand management is marketing management, guiding philosophies of marketing management – production concept, product concept, selling concept, marketing concept and social marketing concept. Basic terminologies in Marketing Management - Warranty, packaging and labelling,logistics, impulse purchase, horizontal marketing system, vertical marketing system, product line, steps in product development, product diversification, market research, life style, market penetration, backward integration, concentric diversification, skimming price, penetration pricing, market segmentation, data mining, organic growth, inorganic growth, parent brand etc.

Unit 2: Organizational Marketing Analysis - meaning, examples, organizational environment, task environment, competitive environment, public environment, macro environment. Market Segmentation - Bases of segmentation, advantages of segmentation, target market selection, market opportunity, analysis and market environment in the decade. Branding - meaning of brand, top brands in the world and India. Factors adding value to brand. Factors responsible for eroding of the brand, brand Franchising, private label brand, brand equity.

Product Promotion - Meaning, Promotion mix, advertising, public relations, personal selling, direct marketing, sales promotion, advertisement and publicity, ad agencies. Sales Forecasting - meaning, information needs of sales forecasting, methods of sales forecasting,

Executive Judgment, survey, time series analysis, correlation and regression, market tests, computerized sales forecasting.

Block II: Overview of Marketing Strategy

Unit 1: **Marketing strategy Strategic Management Process** - meaning, stages, company objectives and goals, company growth strategy, company portfolio plan. Distribution Strategy - meaning of distribution, channels of distribution, role of marketing channels, mercantile agents, merchant middlemen, selecting and appropriate channel, physical distribution tasks, direct marketing, wholesaling, retailing, and market logistics.

Unit 2: **Pricing strategies** - determinants of pricing, pricing objectives, role of costs in pricing, full cost pricing, cost plus pricing, marginal cost pricing, mark up pricing, real bid pricing, price cuts and price wars, skimming price, penetration pricing.

Block III: Product life Cycle

Unit 1: **Product life Cycle** - Meaning, Diagram, stages in product life cycle.

Unit 2: **Product Differentiation** - meaning, dimensions of product differentiation – product, services, personal, image. Product Positioning - meaning, scope for differentiating the offer perceptual mapping, case studies.

References

- PHILIP KOTLER, KEVINLANE KELLER, ABRAHAM KOSHY, AND M. JHA, 2009, Marketing Management – A south Asian Perspective. 13th edition.
- RAJAN SAXENA, 1997, Marketing Management, Tata McGraw – Hill Publishing Company Limited, New Delhi.
- TAPAN AND PANDA, 2007, Marketing Management – Test and cases Indian context, Excel Books, New Delhi.

AMC 502 TECHNIQUES IN MARKET RESEARCH (1+1)

Objective

To equip the students with techniques in marketing research through theory and practical. Hands on training in using quantitative tools like Linear programming model, Consumer behaviour models, Game theory and Markov chain using Excel, SPSS or R programming language. Provide insights to analytical and operational framework for solving problems of location, transportation, media selection, market segmentation, project scheduling and distribution of salesmen.

Theory

Block I: Optimization techniques

Unit1: **Maximization and minimization problem** - linear programming (LP), meaning, assumptions, formulation, graphical and simplex procedures to solve maximization and minimization problems. Using solver to find solutions to LP problems. Transportation and Assignment Models- meaning, formulation. Feasible and optimum solutions to transportation model. Solving Assignment model using Hungarian method. Game theory- meaning, pay-off, value of game, property of dominance, solution to game using graphical and algebraic method.

Unit 2: **Spatial equilibrium model** – meaning, application of Spatial equilibrium model to trade and markets.

Block II: Project Network analysis

Unit 1: Introduction to network analysis, Development of network analysis concept, methodology for project analysis, guidelines for network construction.

Unit 2: CPM / PERT, CPM (Critical Path Method) Meaning, iterative procedure of determining CPM. Earliest and latest event times, float and slack event, computation of total float, free float and independent float. Advantages and drawbacks of CPM. Programme Evaluation Review Technique (PERT) meaning. Difference between

CPM & PERT. Procedure for estimation of optimistic, pessimistic and most likely time in PERT. Advantages and drawbacks of PERT.

Block III: Consumer behavior model

Unit 1: Types of Consumer behavior models & factor influencing-Traditional Behavior Models- learning Model, Psychoanalytical Model, Sociological Model and Economic Model. Contemporary consumer behavior models. Factors influencing consumer behavior- Internal and external factors.

Unit 2: Howard Sheth Model, Nicosia Model and Webster and Wind Model – concepts and applications.

Block IV: Market segmentation techniques

Unit 1: Discriminant analysis- meaning, applications in marketing research, description of the model, data requirement. Factor analysis-meaning, applications in marketing research, description of the model, data requirement, Cluster analysis- meaning, applications in marketing research, description of the model, data requirement, Bayesian classificatory procedures-meaning and application in marketing research

Block V: Product pricing, market structure & system analysis

Unit 1: Inventory model, Break-even and Conjoint analysis.

Inventory- meaning, classification

Unit 2: Markov chain & simulation techniques- history and theory of Markov chain methodology. Construction of one period and multi period Markov models. Simulation analysis- meaning and application for market share and growth. Marketing system analysis- meaning and methods.

Practical

Maximization and problem formulation. Solving Linear programming problem using Simplex technique. Consumer behaviour models – Regression analysis. Discriminant, factor and cluster analysis using SPSS package. Game Theory problems. Market structure analysis method of determining optimum inventory using EOQ model. Pricing of

products using break-even analysis and conjoint analysis – Markov chain. Waiting line and Inventory Models.

Application of Markov model to study brand loyalty and prediction of market shares.

References

- NARESH K. MALHOTRA, AND DAVID F. BIRKS, 2007, Marketing Research- an applied approach, 3rd edition.
- V. K. KAPOOR, 2008, Operation Research-Quantitative techniques for Management, Sultan Chand & Sons publication.
- HAMDY A. TAHA, 2016, Operation Research – An Introduction, 10th Edition

AMC 503 AGRICULTURAL MARKETING AND PRICE ANALYSIS (1+1)

Objective

To provide an exposure to students about the fundamentals and recent developments in the field of agricultural marketing and price analysis. It also covers the role of Government and ICT in addressing pertinent issues and challenges related to agricultural marketing system.

Theory

Block I: Agricultural Marketing, and Role of Government in Agricultural Marketing

Unit 1: Problems in agricultural marketing, suggestions to improve agricultural marketing. Marketing agencies, marketing institutions and marketing channels. Dynamics of market structure – conduct and performance. Components of market structure and market conduct, criteria for measuring market performance. Marketing efficiency – meaning, approaches to assessment of marketing efficiency.

Unit 2: Government intervention and role in agricultural marketing. Regulation of agricultural marketing – meaning, objectives, history of market regulation, progress, important features of regulated markets,

market committee, functions of market committee, need for reorientation of market regulation.

Unit 3: Market information – meaning, importance, types of market information. Warehousing – meaning, functions, types of warehouses, warehousing in India, central warehousing corporation, state warehousing corporations, rural godowns and cold storages. State trading – meaning, objectives, types of state trading.

Block II: Contract Farming, Integration, Supply Chain Management, and Value Chain Management

Unit 1: Direct marketing channels, contract farming / contract marketing – meaning, advantages, disadvantages and weaknesses of contract farming, contract farming in India. Speculation – meaning, benefits of speculation. Hedging – meaning, benefits of hedging. Differences between speculation and hedging. Vertical co-ordination, horizontal integration, vertical integration – meaning, types of vertical integration. Supply chain management, value chain analysis, differences between supply chains and value chains.

Unit 2: Role of Information and Communication Technologies (ICT) in marketing of agricultural commodities. Agencies involved in agricultural marketing information network.

Block III: Price Analysis; Spot, Forward, and Futures Markets

Unit 1: Time series analysis – meaning, utility and components.

Unit 2: Meaning of derivative contract, examples of derivative instruments, significance of commodity futures markets, spot, forward and futures contracts, Forward Markets Commission, commodity exchanges in India, price discovery in futures markets.

Practical

Supply and demand elasticities for agricultural commodities. marketable & marketed surplus estimation, price spread and marketing efficiency. Market structure - Cononduct and perform once. Review of performance analysis of regulated markets and marketing societies, contract farming and supply chain management of different agricultural

commodities, milk and poultry Products. Review of advanced time series models having practical application, supply chain efficiency. Market intelligence, price forecasting. Online searches for market information sources and interpretation of market intelligence reports. Commodity outlook – analysis of important agricultural commodities.

References

- S. S. ACHARYA AND N.L. AGARWAL, 2019, Agricultural Marketing in India. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
- S. SUBBA REDDY, P. RAGHU RAM, T.V. NEELAKANTA SASTRY AND I. BHAVANI DEVI, 2019, Agricultural Economics. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.

AMC 504 AGRICULTURAL TRADE POLICY (1+1)

Objective

Provides students to understand the history, concepts and topics related to international trade in agricultural commodities, focusses on various trade theories including classical and modern trade theories that apply to international trade in agricultural commodities, also gives as insight into various domestic and international trade policies and regional economic relations that have transformed the relationship between the developed and developing world.

Theory

Block I: Development of international trade

Unit-1: History of international trade: A brief view of Mercantilism, aftermath of world wars establishment of GATT, economic integrations, history of India's international trade and its impact on Indian economy.

Unit–2: Theories of international trade – classical and new trade theories: Reasons of international trade, arguments for free trade, salient feature of foreign trade, advantages and disadvantages of international trade, review of classical and new trade theories.

Unit-3: Domestic and international trade: Differences between domestic and international trade, trade between developed and developing economies, prospects and problems of domestic and international trade.

Block II: Concepts of international trade

Unit-1: Tariffs and quotas: State interference in international trade through tariffs and quotas, difference between tariff and quota, types of quota and tariffs, tariff and non-tariff barriers to trade, impact of tariff and quota, tariffs and modern trade, protectionism, trade sanction and trade wars.

Unit-2: Balance of trade and balance of payments: meaning, definition and importance of trade and balance of payments in foreign trade, features and types of balance of trade, meaning of merchandise trade, service trade and foreign investment income, deficit and trade surpluses, difference between balance of trade and balance of payments.

Unit-3: Theory of commercial policy: Rules and regulations of trade followed by a firm or individuals to trade in other countries, features and instruments of commercial policy, GATT-WTO, EEC etc., and international commodity agreements.

Block II: Regional economic integration and trade policies:

Unit-1: Regional economic integration and cooperation: Meaning, types and features of regional economic integration, important regional economic integration and cooperation in the world - challenges and opportunities of regional integration and cooperation.

Unit-2: MNCs, Joint Ventures, State Trading and inter-government negotiation: Important multinational companies of the world, government intervention in trade of MNCs, types of intervention, foreign trade barriers and its impact on international trade, OECD guidelines for MNCs, MNCs and Indian policy framework.

Unit-3: Impact of international trade on Indian agriculture: Export opportunities for Indian agriculture, production, consumption and export surplus of agricultural commodities, food security and impact of trade liberalization on Indian agri-exports.

Practical

Important trade policies of India with special emphasis on WTO, visit to trade related institutions and organizations including KAPPEC, APEDA, Commodity Boards likeCoffee Board, Tobacco Board, Central Silk Board etc.,and discussion on the same.

References

- PORTER M. 1990. The Competitive Advantage of Nations, The Free Press, New York
- CETEORA P R. AND GRAHAM J L. 2002. International Marketing. Tata McGraw Hill, New Delhi.
- ACHARYA S S AND AGARWAL N L. 2004. Agricultural Marketing in India. Oxford & IBH Publishing Co. Pvt. Ltd.
- RAO P S. 2008. International Business: Text and cases. Himalaya Publishing House.
- JOSHI RM. 2011. International Business. Oxford University Press.

AMC 505 AGRICULTURAL FINANCE AND PROJECT MANAGEMENT (2+1)

Objective

This course is designed with an objective to deliver knowledge of the principles, procedures, problems and policies relating to financing agricultural firms.

Theory

Block I: Introduction to Agricultural Finance

Unit 1: Basic concepts: A Review

Role and Importance of Agricultural Finance. Financial Institutions and credit flow to rural/priority sector. Agricultural lending – Direct and Indirect Financing – Financing through Co-operatives, NABARD and Commercial Banks and RRBs. District Credit Plan and lending to agriculture/priority sector. Micro-Financing and Role of MFI's – NGO's, and SHG's. Capital in Agriculture: Role of Capital in Agriculture; Sources of Capital in Agriculture.

Block II: Credit and Financial Analysis

Unit 1: Credit and its aspects

Lending to farmers – The concept of 3 C's, 7 P's and 3 R's of credit. Estimation of Technical feasibility, Economic viability and repaying capacity of borrowers and appraisal of credit proposals. Understanding lenders and developing better working relationship and supervisory credit system. Credit inclusions – credit widening and credit deepening.

Unit 2: Financial analysis

Financial Decisions – Investment, Financing, Liquidity and Solvency. Preparation of financial statements – Balance Sheet, Cash Flow Statement and Profit and Loss Account. Ratio Analysis and assessing the performance of farm/ firm.

Block III- Project and Risk Management

Unit 1: Project Overview

Project Approach in financing agriculture. Financial, economic and environmental appraisal of investment projects. Identification, preparation, appraisal, financing and implementation of projects. Project Appraisal techniques – Undiscounted measures. Time value of money – Use of discounted measures – B-C ratio, NPV and IRR. Agreements, supervision, monitoring and evaluation phases in appraising agricultural investment projects. Network Techniques – PERT and CPM.

Unit 2: Risk and its Management

Risks in financing agriculture. Risk management strategies and coping mechanism. Crop Insurance programmes – review of different crop insurance schemes – yield loss and weather-based insurance and their applications.

Practical

Demand and supply of institutional agricultural credit. Over dues and Loan waiving. An overview, Rural Lending Programmes of Commercial Banks, Lead Bank Scheme-Preparation of District Credit Plan, Rural Lending Programmes of Co-operative Lending Institutions, Farm credit appraisal techniques and farm financial analysis through

financial statements. Performance of Micro Financing Institutions-NGO's and Self-Help Groups, Identification and formulation of investment projects, Project appraisal techniques for project management. Case Study Analysis of an Agricultural project, Financial instruments and methods –E- banking, Kisan Cards and core banking.

References

- EDIE SOLLEM HAND HEADY EO .(E d.). *Capital and Credit Needs in Changing Agriculture*, Bauman
- HOPKINS A BARRY, PETER J O AND BAKER C B. *Financial Management in Agriculture*.
- MURRAY W G AND NELSON A G. 1960. *Agricultural Finance.* Iow a State University
- CHANONA C. 1969. *Agricultural Finance in India: Role of Commercial Banks*. Marketing and Economics Research Bureau, New Delhi.
- GITTINGER J P. 1972. *Economic analysis of agricultural projects*, John Hopkins Univ. Press, Baltimore
- LITTLE I M D AND J A MIRRLESS.1974, *Project appraisal and planning for developing countries*, Oxford and IBH publishing Co. New Delhi.
- ARNOLDCH.1972. *Project Evaluation, collected papers*, Macmillan.

AMC 506 AGRICULTURAL BUSINESS MANAGEMENT (1+1)

Objective

The programme curriculum has a solid managerial foundation, with focus on food and agribusiness marketplace, and is designed to build and enhance a global perspective amongst the participants. Agribusiness is a large and diverse industry which is growing as the economy expands. It is an industry that brings together within the food chain, the supply of inputs to agriculture, agricultural production, the processing of outputs - of food and industrial products, its distribution, marketing and retailing.

The course aims to enhance the students career in international Agribusiness by giving a clear understanding of the principles and practice of management.

Theory

Block I: Basic Concepts of Management

Unit–1: Management: Meaning/Definitions, Importance & Scope of management, Characteristics/salient features of management, Difference between management and administration. Principles of management.

Unit–2: Functions of management :i) **Planning:** Meaning/ Definitions, Significance & Importance of planning, Features of good plan, Steps in planning, Advantages of planning, **ii) Organizing:** Meaning/Definitions, Importance of organization, Steps in organization, Organizing functions, Characteristics of organization, Principles of organization, Types of organization: Formal and informal, **iii) Directing:** Meaning/Definitions, Functions of directing-Supervision, Guiding, Leading, Motivation & Communication, Staffing & its advantages, Co-ordination-meaning, importance, types of coordination, iv) **Controlling:** Meaning/Definitions, Need for controlling, Steps in controlling, Essentials of effective control, Control techniques/tools.

Block II: Fundamentals of Agribusiness Management

Unit 1: Agribusiness management: Meaning and definitions, Importance of agrobased industries, Important characteristics of agribusiness firms, Need for Agrobased industries (ABI), Types of Agro based industries, Institutional arrangements for promotion of Agrobased industries, Procedure followed to set up ABI, Constraints in establishing ABI.

Unit 2: Structure of agribusiness sector-input, farm and product sectors (flow chart).

Block III: Agribusiness production and marketing management

Unit 1: Production management: Meaning, **Issues in production planning:** location of plant, Plant size, Plant layout, Purchasing & its

methods namely Forward, tender, blanket order, speculative and zero stock purchasing, Inventory management, production control, forecasting – kinds and methods

Unit 2: Marketing management: Meaning and definitions, Market segmentation: Meaning, Criteria for segmentation of markets, Marketing mix and 5 P's of marketing namely, Product, Price, Place, Promotion and People.

Product life cycle: introduction stage, market growth stage, maturity stage and declining stage.

Pricing policy: meaning and methods: Rebates, geographical pricing, odd and evenpricing, psychological pricing.

Practical

Problem solving relating to management of raw materials, processing, storage transportation, domestic marketing and export trade. Model building. Visits to processing and agri-business enterprises.

References

- BROADWAY AC & BROADWAY ARIF A. 2016. A Text Book of Agri-Business Management. Kalyani Pub.
- S.S. ACHARYA AND N.L. AGARWAL, 2019, Agricultural Marketing in India. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
- S. SUBBA REDDY, P. RAGHU RAM, T.V. NEELAKANTA SASTRY AND I. BHAVANI DEVI, 2019, Agricultural Economics. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.

AMC 507 ECONOMETRICS (2+1)

Objective

The course provides knowledge of the econometric methods like time series analysis, line arregression models and their application in economic analysis. The course provides an insight into the econometric problems in analyzing time series and cross section data.

Theory

Block I: Introduction to Econometrics

Unit 1: Introduction

Relationship between economic theory, mathematical economics, models and econometrics, methodology of econometrics-regression analysis.

Block II: Classical Regression

Unit 1: Classical Linear Regression

Basic two variable regression – assumptions estimation and interpretation approaches to estimation – OLS, MLE and their properties – extensions to Multi-variable models-multiple regression estimation and interpretation.

Unit 2: Breaking down of Classical assumptions

Violation of assumptions – identification, consequences and remedies for Multicollinearity, heteroscedasticity, autocorrelation – data problems and remedial approaches – model misspecification.

Block III: Qualitative Variables

Unit 1: Qualitative variables and simultaneous equation models

Use of dummy variables- limited dependent variable – specification and its estimation. Introduction to simultaneous equations- identification problem, structural equations, reduced form equations, identification and approaches to estimation.

Practical

- Single equation two variable model specifications and estimation
- Hypothesis testing transformations of functional forms and OLS application
- Estimation of multiple regression models
- Testing and correcting specification errors
- Testing and managing Multi collinearity
- Testing and managing autocorrelation

- Estimation of regressions with dummy variables.
- Estimation of regression with limited dependent variable.
- Identification of equations in simultaneous equation systems.

References

- DORFMANR. 1996. *Linear Programming and Economic Analysis*. McGraw Hill.
- GREENE WH.2002.*EconometricAnalysis*.PearsonEducation
- JOHNSTON J AND DINARDO J. 2000. *Econometric Methods*. McGraw-Hill
- KOUTSEYIANIS,A.1997.*TheoryofEconometrics*.Barner&Noble
- MADDALAGS. 2002. *Econometrics*. McGraw-Hill
- PINNDYCK RS AND RUBINFELD DL.1990. *Econometric Models and Econometric Forecasts*. McGraw Hill.

AMC 508 MANAGEMENT OF COOPERATIVES (2+0)

Objective

This course aims to develop the understanding on the concept of evolution of cooperative and cooperative laws, development of cooperatives in India. Acquainting the students about management of cooperatives and the legal system involved in the management of cooperatives.

Theory

Block I: Evolution of Cooperatives and Cooperatives Law

Unit 1: Concept of cooperation – Origin of cooperative ideology-Nature of Cooperatives-Distinctive Features of Co-operative Ownership. Principles of cooperation – Reformulation of cooperative principles by ICA in 1966 and 1995.

Unit 2: Evolution and development cooperatives in India-1904, 1912 Act, committees- AIRCSC, 1954, ACRC, 1986, Task force on cooperatives, 2004 - Recent trends. Cooperatives, state and political economy – Current political environment and its effects on cooperatives.

Block II: Cooperative development

Unit 1: Role of cooperative development agencies - RBI, NABARD, NCDC– A role review.

Unit 2: Sectors of cooperative development – Agricultural and non-agricultural sectors – The Concept of Agricultural Cooperatives -Typology of Agricultural cooperatives, classification – redesigning cooperatives-emergence of new cooperatives- Current trends and new directions.

Block III: Cooperative Management

Unit 1: Management of cooperative enterprises – Issues in cooperative management – Cooperative governance, Human resource development in cooperatives- Professionalization of cooperatives. Capital and cooperatives – Common Cooperative Financing Methods-Equity in a Cooperative-Equity Management Considerations-Equity Types.

Unit 2: Cooperative legal system – Review of important provisions of state cooperative societies Act and Rules, KCSAct, 1959, KSS Act, 1997, Multistate Cooperative Societies Act, 2002.Cooperatives in India – Perspectives and challenges, Performance and Impact of Cooperatives-The agenda for the future.

References

- KAMAT GS. 2011. *New Dimensions of Cooperative Management*. Himalaya Publ. House.
- ANSARI AA. 1990. *Cooperative Management Patterns*. Anmol Publ.
- RAVI CHANDRAN AND NAKKIRAN. 2009. *Cooperation* (*Theory & Practice*) Neha Publishers &Distributors;
- SAH AK. 1984. *Professional Management for the Cooperatives*. Vikas Publ. House.
- Anwar SA. *HRM Practise in Cooperative Sector*. Idea Publishing.

AMC 509 INTERNATIONAL BUSINESS (2+0)

Objective

The main objective of the course is to provide the students an exposition of the theory and principles of international business economics that are essential for understanding, evaluating and give solutions to the problems of international trade. The course tries to explain the strategies and structures of international businesses, explain the network and flows that makes globalization challenging task for international firms.

Theory

Block I: Introduction to International Trade

Unit-1: International trade–basic concepts and impact of international trade on Indian economy –basic concepts of international trade, WTO and its implications on Indian economy in general and agriculture sector in particular.

Unit-2: Importance of foreign trade for developed and developing economies: Absolute and comparative advantage in foreign trade of India, cases on agri-business commodity trade practices in the world and its impact on India.

Unit-3: Theories of international trade: Study and impact of Absolute cost advantage theory, Comparative cost advantage trade theory, Reciprocal demand theory, Country similarity theory and New trade theory etc., on developing and developed countries.

Block II: Regulations and Policy Measures for International trade

Unit-1: Trade liberalization, quantitative and qualitative restrictions on international trade: TRIPS, TRIMS quotas, anti-dumping duties, quantitative and qualitative restrictions, tariff and non-tariff measures, trade liberalization, subsidies, green and red boxes, issues for negotiations in future in WTO; CDMs and carbon trade.

Unit-2: India's balance of payments and economic integration: India's balance of payments and inter regional Vs international trade; tariffs and trade control; exchange rate; the foreign trade multiplier.

Unit-3: Foreign demand and supply side analysis in international trade and its impact on India: Demand and supply side analysis of commodities traded in international trade, opportunity cost, trade and factor prices, implications for developing countries, market entry methods, export procedures and documentations, Economic Integration and its impact on agricultural trade with reference to India., India's export and import policies regarding agricultural products.

Block III: International business

Unit 1: International business and its scope: Stages of internationalization and international business approaches, competitive advantage and problems of international business.

Unit 2: International business environment: Introduction to international business environment, study of socio-cultural environment, technological environment, economic environment and political environment in international trade.

Unit 3: Modes of entering business environment: Study of firms' entry to international business including through FDI, MNCs, Joint Venture, Licensing, Mergers, Acquisitions, etc., vertical and horizontal integration in FDI, conflicts and break-up alliances.

Unit 4: Globalization of trade: Globalization of production, markets, investment and technology, advantages and disadvantages of globalization**.**

References

- HILL CWL AND JAIN A K. 2010. International Business: Competing in the Global Marketplace. Tata McGraw Hill Education Private Limited.
- SALVATORE D. 2014. International Economics: Trade and Finance. B.B. Press. Noida.
- VENKATESH C K, MATHAPATHI K AND GIRISH S. 2015. International Business. Kalyani Publishers.
- MANNUR H G. 2018. International Economics. Vikas Publishing House Pvt Ltd.

AMC 510 AGRICULTURAL AND FOOD MARKETING (2+1)

Objective

This course aims to develop the understanding on the concept of marketing system with specific inputs of marketing efficiency and marketing channels. The course also aims to develop learning about the applied concepts of agri and food marketing by equipping the students in the areas of food processing, food consumption, food branding and innovations, food wholesaling and retailing, food service market and policy support from government institutions.

Theory

Block I: Approaches to study marketing system

Unit 1: Role of marketing in economic development: Definition and concept of marketing, classification of markets

Unit 2: Various approaches in studying marketing system: Functional-institutional, commodity and structural approaches

Unit 3: Analysis of marketing systems for different commodity groups: Food grains, commercial crops, horticultural crops, livestock and animal products, agricultural inputs

Block II: Marketing Channel and Marketing Efficiency

Unit 1: Marketing channel and price spread: Meaning and concept of marketing channel, price spread and marketing margin

Unit 2: Evaluation of marketing efficiency: Concept of marketing efficiency-Technical and economic efficiency-evaluation of marketing efficiency-evaluation of market structure-conduct-performance-Concept of market integration

Block III: Food manufacturing, marketing and consumption

Unit 1: Structure of food processing industry: Components of food processing industry, location of food processing industry, problems faced by food processors

Unit 2: Concept of food branding: Innovations and branding in food industry

Unit 3: Concept of food wholesaling and retailing: Food wholesaling, food retailing, competition and pricing in food retailing

Unit 4: Concept of food consumption: Food consumption and marketing, food preferences and expenditure patterns, demographics of food consumption, food service market

Block IV: Role of Government in agricultural and food marketing

Unit 1: Market legislation and regulation: Market legislation and regulation in agricultural and food marketing

Unit 2: Agricultural and food marketing institutions: Commodity boards, corporations, marketing cooperatives

Practical

Identification of marketing channels and analysis of price spread. Evaluation of marketing efficiency-temporal and spatial efficiency. Market structure-conduct-performance analysis. Market integration studies and performance evaluation of marketing boards, cooperatives and other marketing parastatals.

References

- ACHARYA SS AND AGARWAL NL. 2019. Agricultural Marketing in India. 4th Ed. Oxford and IBH.
- KOHLS RL AND UHJ JN. 2005. Marketing of Agricultural Products. 9th Ed. Prentice Hall.
- MOHAN J. Agri-Marketing Strategies in India, NIPA
- SHARMA PREMJIT. 2010. Agri-Marketing Management, Daya Publishing House
- KOTLER P, KELLER K, KOSHY A AND JHA M. 2019. Marketing Management–Analysis, Planning, Implementation and Control. Pearson Education

AMC 511 GRADING AND QUALITY CONTROL IN AGRICULTURAL AND FOOD INDUSTRY (1+1)

Objective

The course aims at acquainting the students with basics of grading & standardization, its importance in agricultural marketing. Explain the students about the various grade specifications. Explain the students about the quality standards and certification. Study on important concepts like food safety and adulteration. Also, explain the Total Quality Management concepts.

Theory

Block I: Grading and Standardization

Unit 1: Significance of grading and standardization- types of grading, AGMARK standards – role of DMI in grading of agricultural products

Unit 2: Grading of food grains – general and special characteristics and grade designations and definitions quality of Rice, Wheat and Jowar.

Unit 3: Grading of pulses – general characteristics and grade designations and definitions quality of Chana, Red Gram, Bengal gram, Black gram, split pulses, husked and un husked.

Unit 4: Grading of oil seeds, Grade designations and quality of edible oil.

Block II: Quality Standards and Certification

Unit 1: Role of ISI in certification of manufactured products, BIS – its objectives and significance. BIS management system certification scheme, Quality management systems certification scheme as per IS / ISO – 9001 2008 standards. BIS and formulation of Indian standards, product certification, quality system certification, EMS certification, Hall marking of gold.

Unit 2: Eco mark scheme of India – objectives of Eco mark, Eco mark logo, criteria for the development of products, HACCP – principles of HACCP, highlights and benefits of HACCP, HACCP certification,

decision tree to identify CCPs. Retail food standards – fruits and vegetables, international food standards, British food standards, Role of CODEX Alimentarius commission - CODEX Alimentarius documentation, codex standards, codex codes of practice, codex guidelines, standard setting process, applying codex standard.

Unit 3: Global GAP – EUREP GAP, IND GAP, Integrated farm assurance standards, organic food certification and standards. Safe quality food (SQF) - SQF 1000 code, SQF 2000 code, SQF and retail standards, benefits of SQF.

Block III: Food Safety and Adulteration

Unit 1: Food hygiene and its significance, food safety and suitability, pesticides decontamination of fruits, vegetables, cereals and water. Precautions to avoid contamination of heavy metals, precaution to avoid aflatoxins contamination. Food adulteration. Detection of common adulterant in foods and simple detection methods of food.

Unit 2: Food poisoning – means and methods of food poisoning and its prevention, Quality standards in marketing of Agri / Horti products. Good agricultural practices. Good hygienic practices. Good manufacturing practices.

Unit 3: Good marketing practices. Sanitary and phyto sanitary measures – quarantine of plant, animals and man, procedures and certification. Quality – meaning, quality is fitness to use, to standard, to cost, quality terminologies, dimension of quality, total quality and factors affecting total quality. Total quality management (TQM) – basic elements of TQM, principles of TQM and Six sigma principles.

Practical

Introduction to grading laboratory, study of sampling and grading instruments, principles of sampling, estimation of moisture in food grains by hot air oven method, infrared moisture balance method. Estimation of different refractions in important cereals. Physical analysis of pulses and oil seeds. Detection of some common adulterants in foods by simple and quick methods. Visit to DMI, Regional Agmark laboratory, Bureau of Indian Standards for food safety industry and analytical quality control.

References

- S.S. ACHARYA AND N.L. AGARWAL, 2019, Agricultural Marketing in India. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
- CENTRAL AND STATE WAREHOUSING CORPORATION BULLETINS, ISO bulletin, CFTRI bulletin, NAFED Bulletin.

AMC 512 OPTIMIZATION TECHNIQUES (1+1)

Objective

This course is meant for exposing the students to the mathematical details of the techniques optimization techniques. They will be taught numerical methods of optimization, linear programming techniques, nonlinear programming and multiple objective programming. Students will also be exposed to practical applications of these techniques.

Theory

Block I: Introduction to Linear programming and its Methods

Unit 1: Classification of optimization problems, Classical optimization techniques: single variable optimization, multivariable optimization techniques with no constraints, multivariable optimization techniques with equality constraints, multivariable optimization techniques with inequality constraints.

Unit 2: Linear programming: Introduction, uses, formulation of farm and non-farm problems as LP models, graphical representation, solution to LP problems. Simplex method: profit maximization and cost minimization problem, duality, problem of degeneracy, infeasible and unbounded solutions. Sensitivity analysis.

Block II: Extension of Linear programming Models

Unit 1: Variable resource and price programming, transportation problem, recursive programming, dynamic programming, integer programming, goal programming.

Unit 2: Concept of nonlinear programming, game theory- concept, two-person zero-sum game, saddle point, solution to mixed strategies,

graphical method, inventory management. PERT and CPM, simulation and queuing theory.

Practical

Graphical and algebraic formulation of LP models. Solving of maximization and minimization problems by simplex method. Formulation of LP problems for typical farm situations. Transportation problems, game theory problems. Use of excel solvers for LP models.

References

- ANTUNES C. H., ALVES, M. J., CLIMACO J. 2016. *Multi objective Linear and Integer Programming* (EURO Advanced Tutorials on Operational Research)
- NOCEDAL, J. AND WRIGHT, S.J. 1999. *Numerical Optimization*. Springer.
- RAO, S. S. 2007. *Engineering Optimization: Theory and Practice*. New Age International Publishers.
- RUSTAGI, J.S . 1994. *Optimization Techniques in Statistics*. Academic Press.
- TAHA, H. A. 2007. *Operations Research: Introduction with CD*. Pearson Education.
- XU, H, TEO, K. L. ZHANG Y. 2016. *Optimization and Control Techniques and Applications* (Springer Proceedings in Mathematics & Statistics)
- ZELENY, M. 1974. *Linear Multi objective Programming*. Springer.

AMC 513 COMMODITY FUTURES TRADING (2+0)

Objective

This course is aimed at providing the basic understanding and the mechanics and value of futures markets for speculators and hedgers who in turn will serve as price risk management activities of agribusiness firms. The popularity of futures trading in agricultural commodities is increasing in India and therefore the role of SEBI, functioning of commodity exchanges are discussed.

Theory

Block I: Introduction to commodity market

Unit 1: Evolution of commodity futures markets- History of commodity futures markets in India, USA Asian and African countries. Present status of commodity futures trading.

Unit 2: Concepts of commodity future trading- Spot and futures markets comparison, Demand, supply - meaning and determinants. Price determination and discovery. Benefits of futures trading, product specifications. Meaning of derivatives, futures, forwards, swaps, basis, spot price, margin, long position and short position, futures price and option price (In the money, out of the money and at the money option).

Block II Instruments available for trading

Unit 1: Hedging Meaning, types of hedging, hedging strategies (long hedge, short hedge), advantages of hedging. Basis risk, cross hedge & hedge ratio, Pay off meaning and diagrammatic presentation of short and long payoffs.

Unit 2: Speculation and arbitrage Meaning, basic principles of speculation, benefits and types of speculation. Arbitrage meaning, types.

Block III: Pricing of commodity futures

Unit 1: Investment and consumption assets- cost of carry model & reverse cost of carry model.

Unit 2: The futures basis- meaning of basis, basis risk. Strengthening and weakening of basis.

Block IV Commodity exchange

Unit 1: Risk Management-Types of membership in commodity exchanges & capital requirement. Risk management in exchanges- capital adequacy, Margin system(Initial, exposure, delivery & special margin), Mark to market settlement, fixing position limits, fixing exposure limits.

Unit 2: Trading, clearing and settlement- meaning, order types, clearing mechanism. Daily mark to market settlement and final settlement mechanism.

Block V Analysis of commodity market

Unit 1: Technical analysis -Technical analysis of price patterns-Line charts, bar charts, candlestick charts, Point & Figure charts. Trend analysis-uptrend, downtrend & sideways trend, identifying resistance and support levels. Triangles, Head & shoulders, double top & bottom. Price reversal, consolidation and Gaps. Moving average - simple and exponential moving averages. Bollinger bands, Elliot wave, Fibonacci series.

Block VI Regulatory framework

Unit 1: Rules governing derivatives exchange -Rules governing commodity derivatives exchange

References

- SRIDHAR. A. N, 2008, **Futures and options– Equities and Commodities3rd Edition,** Shroff Publisher and distributors Pvt, Ltd. New Delhi.
- JOHN C. HULL, 2008, **Options, Futures and other Derivatives. 7th Edition** PHI learning centre.
- WWW. NCDEX.com
- WWW. Investopedia.com

AMC 514 RURAL MARKETING (2+0)

Objective

To explore the possibilities and potential of the rural market. It aims at critically analysing the market opportunities, consumer trends and patterns and development of better marketing strategies for the rural areas.

Theory

Block I: Rural Marketing Environment

Unit 1: Rural Market Concept & Scope: Concept, Definition and Scope of rural marketing, nature and characteristics of rural markets, potential of rural markets in India, rural V/S urban market.

Unit 2: Environmental factors: Socio-cultural, economic, demographic, technological and other environmental factors affecting rural marketing.

Unit 3: Rural finance: Concept, demand, banking model; Finance Schemes of NABARD, Other Schemes of State Govt, Central Govt.

Unit 4: Rural consumer's behaviour: Behaviour of rural consumers and farmers; buyer characteristics and buying behaviour; customer relationship management, rural market research.

Block II: Rural Marketing Strategy

Unit 1: Rural Product strategy: Marketing of consumer durable and non-durable goods and services in the rural markets with special reference to product planning; marketing mix, product mix.

Unit 2: Pricing for rural markets: Pricing policy and pricing strategy, distribution strategy, Rural retailing and modern store formats in rural areas.

Unit 3: Promotion and communication strategy: Media Planning, Distribution channels, personal selling strategies in rural markets, innovations in rural marketing.

References

- KRISHNA MACHARYULU AND RAMA KRISHNAN. 2010. *Rural Marketing: Text and Cases*: Pearson Education. 2nd edition
- SINGH S. 2004. *Rural Marketing: Focus on Agricultural Inputs,* Vikas Publishing
- KASHYAP P. 2011. *Rural Marketing*. Pearson Education
- KUMAR D AND GUPTA P. 2017. *Rural Marketing: Challenges and Opportunities*. Sage Publications.

M.Sc. (Agri.) in Agricultural Meteorology

Course Code	Course Title	Credit Hours
AGM 501	Fundamentals of Meteorology	3 (2+1)
AGM 502	Fundamentals of Agricultural Meteorology	3 (2+1)
AGM 503	Crop-Weather Relationships	2 (2+0)
AGM 504	Agro-Meteorological Measurements and Instrumentation	3 (1+2)
AGM 505	Crop Micrometeorology	3 (2+1)
AGM 506	Evapotranspiration and Soil Water Balance	3 (2+1)
AGM 507	Crop Weather Models	3 (1+2)
AGM 508	Applied Agricultural Climatology	3 (1+2)
AGM 509	Weather Forecasting	3 (2+1)
AGM 510	RS and GIS Applications in Agricultural Meteorology	3 (2+1)
AGM 511	Strategic Use of Climatic Information	3 (2+1)
AGM 512	Weather and Climate Risk Management	2 (2+0)
AGM 513	Aerobiometeorology	3 (2+1)
	Total	**37 (23+14)**
AGM 580	Qualifying Examination	2 (0+2)
AGM 581	Seminar-I	1 (0+1)
AGM 582	Seminar-II	1 (0+1)
AGM 591	Research-I	13 (0+13)
AGM 592	Research-II	14 (0+14)

AGM 501 FUNDAMENTALS OF METEOROLOGY (2+1)

Objective

To impart theoretical and practical knowledge of physical processes occurring in atmosphere and techniques used in meteorology.

Theory

Block 1: Weather Elements

UNIT 1: Solar radiation and laws of radiation; greenhouse effect, albedo, and heat balance of the earth and atmosphere; variation in pressure and temperature with height, potential temperature, pressure gradient, cyclonic and anticyclonic motions; geostrophic and gradient winds; equations of motion; general circulation, turbulence, vorticity, atmospheric waves.

UNIT 2: Gas laws, laws of thermodynamics and their application to atmosphere; water vapour in the atmosphere, various humidity parameters and their interrelationships; vapour pressure, psychrometric equation, saturation deficit, Lapse rates-ascent of dry and moist air, stability and instability conditions in the atmosphere.

Block 2: Observatory and Precipitation

UNIT 1: Agromet observatory and analysis of weather data; Condensation; clouds and their classification; evaporation and rainfall; the hydrological cycle; precipitation processes, artificial rainmaking, thunderstorms and dust storm; haze, mist, fog, and dew; air masses and fronts; tropical and extra-tropical cyclones.

UNIT 2: Effect of Earth's rotation on zonal distribution of radiation, rainfall, temperature, and wind; the trade winds, equatorial trough and its movement;

Block 3: Monsoon

UNIT 1: Monsoon and its origin; Indian monsoon and its seasonal aspects: Onset, advancement and retreat of monsoon in different parts of India, Walker and Hadley cell, El Nino, La Nina, Southern Oscillation Index and their impact on monsoon.

Practical

- Agromet observatory- different classes of observatories (A, B, C)
- Site selection and installation procedures for meteorological instruments

- Measurement of weather parameters.
- Reading and recording, calculation of daily, weekly, monthly means.
- Totals of weather data.
- Weather chart preparation and identification of low-pressure systems and ridges.
- Statistical technique for computation of climatic normals, moving average, etc.

References

- AHRENS. 2008. Meteorology today, 9th Edition. Wadsworth Publishing Co Inc.
- BARRY RG AND RICHARD JC. 2003. Atmosphere, Weather and Climate. Tailor &Fransics Group.
- BISHNOI OP. 2007. Principles of Agricultural Meteorology. Oxford Book Co.
- GHADEKAR SR. 2001. Meteorology. Agromet Publishers (Nagpur). • Ghadekar SR. 2002. Practical Meteorology. Agromet Publishers (Nagpur).
- MCLLVEEN R. 1992. Fundamentals of Weather and Climate. Chapman & Hall.
- PETTERSON S. 1958. Introduction to Meteorology. McGraw Hill.
- TREWARTHA GLENN T. 1954. An Introduction to Climate. McGraw Hill.
- VARSHNEYA MC AND PILLAI PB. 2003. Text Book of Agricultural Meteorology. ICAR.

AGM 502 FUNDAMENTALS OF AGRICULTURAL METEOROLOGY (2+1)

Objective

To impart the theoretical and practical knowledge of physical processes occurringin relation to plant and atmosphere with advanced techniques.

Theory

Block 1: Scope and importance

UNIT 1: Meaning and scope of agricultural meteorology; components of agricultural meteorology; role and responsibilities of agricultural meteorologists.

UNIT 2: Importance of meteorological parameters in agriculture; efficiency of solar energy conversion into dry matter production; meteorological factors in photosynthesis, respiration and net assimilation; basic principles of water balance in ecosystems; soil water balance models and water production functions.

Block 2: Weather forecast

UNIT 1: Crop weather calendars; weather forecasts for agriculture at short, medium and long-range levels; agromet advisories, preparation, dissemination and economic impact analysis; use of satellite imageries in weather forecasting; synoptic charts and synoptic approach to weather forecasting.

Block 3: Weather extremes and climate change

UNIT 1: Concept, definition, types of drought and their causes; prediction of drought; crop water stress index, crop stress detection; air pollution and its influence on vegetation, meteorological aspects of forest fires and their control

UNIT 2: Climatic change, greenhouse effect, CO_2 increase, global warming and their impact on agriculture; climate classification, agro-climatic zones and agro-ecological regions of India.

Practical

- Preparation of crop weather calendars
- Development of simple regression models for weather, pest and disease relation in different crops.
- Preparation of weather based agro-advisories
- Use of automated weather station (AWS)

References

- BISHNOI OP. 2007. Principles of Agricultural Meteorology. Oxford Book Co.
- KAKDE JR. 1985. Agricultural Climatology. Metropolitan Book Co.
- MAHI AND KINGRA. 2014. Fundamentals of agrometeorology. Kalyani publishers.
- MAVI HS AND TUPPER. 2004. Principles and applications of climate studies in agriculture. CRC Press
- VARSHNEYA MC AND PILLAI PB. 2003. Text Book of Agricultural Meteorology. ICAR.

AGM 503 CROP-WEATHER RELATIONSHIPS (2+0)

Objective

To study and understand the role of weather on crop growth and development.

Block 1: Climatic requirement of crops

UNIT 1: Understanding the influence of weather elements on crop growth, impact of climatic variability and extremes on crop production, climatic normals for crop production.

UNIT 2: Climatic requirements of major crops, temperature effect on crop growth, radiation impact and radiation utilization efficiency, humidity effect on crop performance, effect of soil temperature on seed germination and root growth, wind variation and crop growth.

Block 2: Crop weather relationship

UNIT 1: Meteorological indices to predict crop production, Interpretation of weather forecasts for various agricultural operations towards improved productivity, crop-weather relationship in dryland areas. Crop weather relationship of major horticultural crops of the region and agroforestry system.

UNIT 2: Rhizosphere and microorganisms in relation to weather, fertilizer and water use efficiency in relation to weather

References

- Bishnoi OP. 2007. Principles of Agricultural Meteorology. Oxford Book Co.
- Jerry L. Hatfield, Mannava VK, Sivakumar and John H. Prueger. 2017. Agroclimatology: Linking Agriculture to climate. Agronomy Monographs 60.
- Mavi HS. 1994. Introduction to Agrometeorology. Oxford & IBH.
- PrasadaRao GSLHV. 2008. Agricultural Meteorology. PHI Learning Publishers.

AGM 504 AGRO-METEOROLOGICAL MEASUREMENTS AND INSTRUMENTATION (1+2)

Objective

To impart the theoretical and practical knowledge of instruments/ equipments used for measurement of agro-meteorological variables.

Theory

Block 1: Radiation and temperature

UNIT 1: Fundamentals of measurement techniques; theory and working principles of barometer, thermometer, psychrometer, hair hygrometer, the rmohygrograph; exposure and operation of meteorological instruments/ equipments in agromet observatories.

UNIT 2: Radiation and temperature measuring instruments: working principles of albedometer, photometer, spectro-radiometer, sunshine recorder, dew recorder, quantum radiation sensors, pressure bomb apparatus, thermographs, and infra-red thermometer.

Block 2: Precipitation and Evapotranspiration

UNIT 1: Precipitation and dew instruments: working principles of rain gauge, self-recording rain gauge, Duvdevani dew gauges. Wind instruments: working principles of anemometer, wind vane, anemograph.

UNIT 2: Evapotranspiration and photosynthesis instruments: working principles of lysimeters, open pan evaporimeters, porometer, photosynthesis system, leaf area meter.

UNIT 3: Boundary layer fluxes, Flux tower, soil heat flux plates, instruments to measure soil moisture and soil temperature.

Block 3: Automatic weather station

UNIT 1: Automatic weather station – data logger and sensors, nano-sensors for measurement of weather variables; computation and interpretation of data.

Practical

- Working with the above instruments in the meteorological observatory, fields and laboratory, Recording observations of relevant parameters
- Computation and interpretation of the data
- Analysis of AWS data

References

- ANONYMOUS. 1987. Instructions to Observers at Surface Observatories. Part I, IMD, New Delhi.
- BYERS HR. 1959. General Meteorology. McGraw Hill.
- GHADEKAR SR. 2002. Practical Meteorology: Data Acquisition Techniques, Instruments and Methods. Agromet Publ.
- MIDDLETON WE AND SPILHAWS AF. 1962. Meteorological Department. University of Toronto Press.
- TANNER CB. 1973. Basic Instrumentation and Measurements for Plant Environment and Micrometeology. University of Wisconsin, Madison.
- WMO. 2008. Guide to Meteorological Instruments and Methods of Observation. WMO-No.8

AGM 505 CROP MICROMETEOROLOGY (2+1)

Objectives

To impart the theoretical and practical knowledge of physical processes occurring in lower atmosphere and within crop canopy concerning crop growth.

Theory

Block 1: Micro-climate

UNIT 1: Properties of atmosphere near the Earth's surface; exchange of mass momentum and energy between surface and overlaying atmosphere, exchange coefficient, similarity hypothesis, shearing stress, forced and free convection.

UNIT 2: Molecular and eddy transport of heat, water vapour and momentum, frictional effects, eddy diffusion, mixing; zero plane displacement, temperature instability, eddy covariance technique, microclimate near the bare ground, unstable and inversion layers, variation in microclimate under irrigated and rainfed conditions, soil moisture and temperature variation with depth; Richardson number, Raymonds analogy, Exchange coefficients.

Block 2: Micrometeorology

UNIT 1: Micrometeorology of plant canopies; distribution of temperature, humidity, vapour pressure, wind and carbon dioxide; modification of microclimate due to cultural practices, intercropping; radiation distribution and utilization by plant communities, leaf temperature and its biological effects; influence of topography on microclimate; shelter belts and wind breaks, microclimate in low plant area of meadows and grain fields, microclimate within forests, glass house and plastic house climates; instruments and measuring techniques in micrometeorology.

UNIT 2: Effects of ambient weather conditions on growth, development and yield of crops; measurement of global and diffuse radiation; measurement of albedo over natural surfaces and cropped surfaces; net radiation measurement at different levels; PAR distribution in plant canopies and interception; wind, temperature and humidity profiles in (a) short crops and (b) tall crops; energy balance over crops and LAI and biomass estimation; remote sensing and its application in relation to micrometeorology.

Practical

- Micrometerological measurements in crop canopies
- Quantification of crop microclimate
- Determination of ET and its computation by different methods.

References

- PAL AS. 1988. Introduction to Micrometeorology. Academic Press.
- BISHNOI OP. 2007. Principles of Agricultural Meteorology. Oxford Book Co.
- CHANG, JEN-HU. 1968. Climate and Agriculture: An Ecological Survey. Aldine Publishing Company.
- GATES DM. 1968. Energy Exchange in the Biosphere. UNESCO.
- GOUDRIAAN J. 1983. Crop Micrometeorology: A Simulation Study. Scientific Publ.
- GRACE J. 1983. Plant Atmospheric Relationships: Outline Studies in Ecology. Chapman & Hall.
- GUPTA PL AND RAO VUM. 2000. Practical Manual on Micrometeorology. Dept. of Agril. Meteorology, CCS HAU Hisar, India.
- JONES HG. 1992. Plants and Microclimate. Cambridge Univ. Press. Munn RE. 1970. Biometeorological Methods. Academic Press.
- MONTEITH AND UNSWORTH. 2013. Principles of Environmental Physics. Elsevier.
- ROSENBERG NJ. 1974. Microclimate – The biological Environmet. John Wile

AGM 506 EVAPOTRANSPIRATION AND SOIL WATER BALANCE (2+1)

Objective

To impart the theoretical and practical knowledge of ET estimation and determination of the components of soil water balance.

Theory

Block 1: Evapotranspiration

UNIT 1: Energy concept of soil water, hydraulic conductivity and soil water flux; theory on hydraulic conductivity in saturated and unsaturated soils; physical factors concerning water movement in soil; concepts on evaporation, evapotranspiration, potential and actual evapotranspiration.

UNIT 2: Theories of evapotranspiration and their comparison; aerodynamic, eddy correlation, energy balance, water balance and other methods, their application under different agroclimatic conditions; concepts of potential, reference and actual evapotranspiration - modified techniques.

Block 2: Water balance

UNIT 1: Influence of microclimatic and cultural factors on soil water balance; techniques of lysimetry in measuring actual evapotranspiration. Water use efficiency and scheduling of irrigation based on evapotranspiration; water use efficiency and anti transpirants, computation of Kc values and their use; irrigation scheduling based on climatological approaches.

UNIT 2: Yield functions; water use efficiency and scheduling of irrigation based on evapotranspiration; dry matter yield ET functions; radiation instruments; advanced techniques for measurement of radiation and energy balance; estimation of evapotranspiration through remote sensing.

Practical

- Measurement of various components of soil water balance.
- Evaluation of hydraulic conductivity vs. soil moisture relationship by water balance approach.
- Computation and comparison of evapotranspiration by different methods – energy balance method, aerodynamic method, Penman method, remote sensing and other methods.
- Soil moisture retention characteristics by pressure plate method.

References

- BISHNOI OP. 2007. Principles of Agricultural Meteorology. Oxford Book Co.
- BURMAN R AND POCHOP LO. 1994. Evaporation, Evapotranspiration and Climatic Data. Elsevier.
- GRACE J.1983. Plant Atmospheric Relationships: Outline Studies in Ecology. Chapman & Hall.
- MAVI HS AND TUPPER GJ. 2004. Agrometeorology: Principles and Applications of Climate Studies in Agriculture. The Haworth Press.
- MURTHY VRK. 2002. Basic Principles of Agricultural Meteorology. BS Publ.
- NIWAS R, SINGH D AND RAO VUM. 2000. Pratical Manual on Evapotranspiration. Dept. of Agril. Meteorology, CCS HAU Hisar.
- ROSENBERG NJ, BLAD BL AND VERMA SB. 1983. Microclimate –The Biological Environment. John Wiley & Sons.
- SUBRAMANIAM VP. 1982. Water balance and its application. Andhra University Press, Waltair, India

AGM 507 CROP WEATHER MODELS (1+2)

Objective

To impart the theoretical and practical knowledge of various models for estimation of crop weather responses.

Theory

Block 1: Introduction

UNIT 1: Principles of crop production; effect of weather elements on crop responses; impact of natural and induced variability of climate on crop production.

UNIT 2: Introduction and application to crop modeling, types of models, Empirical and statistical crop weather models their application with examples; concept of crop growth model in relation to weather,

soil, plant and other environmental related parameters and remote sensing inputs; growth and yield prediction models;

Block 2: crop simulation models,

UNIT 1: Dynamic crop simulation models, e. g. DSSAT, InfoCrop, APSIM, CropSyst, etc.; optimization, calibration and validation of models.Weather data and physiology-based approaches to modeling of crop growth and yield; forecasting of pests and diseases; stochastic models; advantages and limitation of modeling.

Practical

- Working with statistical and simulation models, DSSAT models, InfoCrop, Oryza, etc.

References

- WALLACH D et al. Working with dynamic crop models.
- DEWIT CT, BROUWER R AND DE VRIES FWTP. 1970. The Simulation of Photosynthetic Systems. pp. 7-70. In. Prediction and Measurement of Photosynhetic Activity.Proc. Int. Biological Programme Plant Physiology Tech. Meeting Trebon PUDOC.Wageningen.
- DUNCAN WG. 1973. SIMAI- A Model Simulating Growth and Yield in Corn. In: The Application of Systems Methods to Crop Production (D.N. Baker, Ed.). Mississippi State Univ. Mississipi.
- FRERE M AND POPAV G. 1979. Agrometeorological Crop Monitoring and Forecasting. FAO.
- HANKS RJ. 1974. Model for Predicting Plant Yield as Influenced by Water Use. Agron. J. 66: 660-665.
- HAY RKM AND PORTER JR. 2006. The physiology of crop yield (2nd Edition).
- KEULEN H VAN AND SELIGMAN NG. 1986. Simulation of Water Use, Nitrogen Nutrition and Growth of a Spring Wheat Crop. Simulation Monographs. PUDOC, Wageningen.

- SINGH P. Modelling of crop production systems: Principles and applications.
- WEIXING CAO et al. Crop modeling and decision support.

AGM 508 APPLIED AGRICULTURAL CLIMATOLOGY (1+2)

Objective

To impart the theoretical and practical knowledge of computation of different bioparameters and their applications in the agriculture.

Theory

Block 1: Climate analysis

UNIT 1: Climatic statistics: measures of central tendency and variability, skewness, kurtosis, homogeneity, correlation, regression and moving averages; probability analysis using normal, binomial, Markov-chain and incomplete gamma distribution; parametric and non-parametric tests; assessment of frequency of disastrous events.

Block 2: Precipitation and Thermalindices

UNIT 1: Precipitation indices; Climatic water budget: potential and actual evapotranspiration and their computation; measurement of precipitation, calculation of water surplus and deficit; computation of daily and monthly water budget and their applications; assessment of dry and wet spells, available soil moisture, moisture adequacy index and their applications.

UNIT 2: Thermal indices and phenology: cardinal temperatures; heat unit and growing degree day concepts for crop phenology, crop growth and development; insect-pest development; crop weather calendars; agroclimatic requirement of crops.

Block 3: Bioclimate

UNIT 1: Bioclimatic concepts: evaluation of human comfort, comfort indices (temperature, humidity index and wind chill) and clothing insulation; climate, housing and site orientation; climatic normals for animal production.

Practical

- Use of statistical approaches in data analysis
- Preparation of climatic water budget
- Estimation of agro-meteorological variables using historical records
- Degree day concept and phenology forecasting and preparation of crop calendar
- Evaluation of radiation, wind and shading effects in site selection and orientation
- Study of weather-pest and disease interactions, calculation of continentality factors; calculation of comfort indices and preparation of climograph.

References

- ANONYMOUS 1980.ICRISAT Climatic Classification – A Consultation Meeting. ICRISAT.
- BISHNOI OP. 2007. Principles of Agricultural Meteorology. Oxford Book Co.
- LAL DS. 1989. Climatology. Chaitanya Publ. House.
- MATHER JR. 1977. Work Book in Applied Climatology. Univ. of Delware, New Jersey.
- MAVI HS AND TUPPER GRAEME J. 2004. Agrometeorology: Principles and Applications of Climate Studies in Agriculture. The Haworth Press.
- STIGTER K (Ed.). 2010. Applied Agrometeorology. Springer
- SUBRAMANIAM VP. 1977. Incidence and Spread of Continental Drought. WMO/IMD Report No. 2, WMO, Geneva, Switzerland.
- THOMPSON R. 1997. Applied Climatology: Principles and Practice.Routledge.
- WALTER J SAUCIER. 2003. Principles of Meteorological Analysis. Dover Phoenix Eds.

AGM 509 WEATHER FORECASTING (2+1)

Objective

To impart theoretical and practical knowledge of forecasting techniques used for weather prediction.

Theory

Block 1: Introduction and approaches

UNIT 1: Weather forecasting system: definition, scope and importance; types of forecasting: short, medium and long-range; study of synoptic charts with special reference to location of highs and lows, jet streams, synoptic features and weather anomalies and zones of thermal advection and interpretation of satellite pictures of clouds in visible and infra-red range; weather forecasting network.

UNIT 2: Approaches for weather forecasts: methods of weather forecasts - synoptic, numerical prediction, statistical, analogue, persistence and climatological approach, nanotechnological approach, Indigenous Technical Knowledge (ITK) base- signals from flora, fauna, insects, birds, animals behaviour; various methods of verification of location specific weather forecast.

Block 2: Extreme weather events and management

UNIT 1: Special forecasts: special forecasts for natural calamities such as drought, floods, high winds, cold (frost) and heat waves, hail storms, cyclones and protection measures against such hazards.

UNIT 2: Modification of weather hazards: weather modification for agriculture; scientific advances in artificial rain making, hail suppression, dissipation of fog and stratus clouds, modification of severe storms and electric behaviour of clouds.

UNIT 3: Weather based advisories: interpretation of weather forecasts for soil moisture, farm operations, pest and disease development and epidemics, crops and livestock production; preparation of weather-based advisories and dissemination.

Practical

- Exercise on weather forecasting for various applications
- Preparation of weather-based agro-advisories based on weather forecast using various approaches and synoptic charts.
- Visit to Indian Institute of Tropical Meteorology (IITM) and India Meteorological Department (IMD) Pune.
- Visit to North Karnataka Agromet Forecasting and Research Center(NKAFC), Dharwad.

References

- WATTS A. 2005.Instant Weather Forecasting. Water Craft Books.
- RAM SASTRY AA. 1984. Weather and Weather Forecasting. Publication Division, GOI, New Delhi.
- SINGH SV, RATHORE LS AND TRIVEDI HKN. 1999. A Guide for Agrometeorological Advisory Services. Department of Science and Technology, NCMRWF, New Delhi.
- WEGMAN AND DEPRIEST. 1980. Statistical Analysis of Weather Modification Experiments. Amazon Book Co.

AGM 510 RS AND GIS APPLICATIONS IN AGRICULTURAL METEOROLOGY (2+1)

Objective

To impart the theoretical and practical knowledge of remote sensing principles and their use to estimate of agro-meteorological variables.

Theory

Block 1: Introduction

UNIT 1: Basic components of remote sensing- signals, sensors and sensing systems; active and passive remote sensing.

UNIT 2: Characteristics of electromagnetic radiation and its interaction with matter; spectral features of earth's surface features; remote sensors in visible, infrared and microwave regions.

Block 2: Imaging

UNIT 1: Imaging and non-imaging systems; framing and scanning systems; resolution of sensors; sensor platforms, their launching and maintenance. Drone technology.

UNIT 2: Data acquisition system, data pre-processing, storage and dissemination; digital image processing and information extraction.

UNIT 3: Microwave remote sensing; visual and digital image interpretation; introduction to GIS and GPS.

Block 3: Application

UNIT 1: Digital techniques for crop discrimination and identification; crop stress detection – soil moisture assessment, inventory of ground water and satellite measurement of surface soil moisture and temperature; drought monitoring, monitoring of crop disease and pest infestation. Use of satellite data in weather forecasting.

UNIT 2: Soil resource inventory; land use/land cover mapping and planning; integrated watershed development; crop yield modeling and crop production forecasting.

Practical

- Acquisition of maps
- Field data collection
- Map and imagery scales
- S/W and H/W requirements and specifications for remote sensing
- Data products, their specifications, media types, data inputs, transformation, display types, image enhancement
- Image classification methods
- Evaluation of classification errors
- Crop discrimination and acreage estimations
- Differentiation of different degraded soils
- Time domain reflectometry

- Use of spectrometer and computation of vegetation indices
- Demonstration of case studies
- Hands on training

References

- BISHNOI OP. 2007. Principles of Agricultural Meteorology. Oxford Book Co.
- CAMPBELL JB. 1996. Introduction to Remote Sensing, 2nd ed., The Guilford Press, New York.
- COLWELL RN. (Ed.). Manual of Remote Sensing. Vols. 1, II. Am. Soc. Photogrammetry, Virginia.
- CURAN PJ. Principles of Remote Sensing. ELBS/Longman.
- GEORG JOSEPH 2005.Fundamentals of Remote Sensing. University Press (India).
- JAIN AK. 1989. Fundamentals of Digital Image Processing, Prentice Hall of India.
- LILISAND TM, KIEFER RW AND CHIPMAN JW. 2003. Remote Sensing and Image Interpretation, 5th ed., John Wiley & Sons, Inc., New York.
- NARAYAN LRA. 1999. Remote Sensing and its Applications. Oscar Publ.
- PANDA BC. 2008. Principles and Applications of Remote Sensing, Viva Publications.
- PATEL AN ANDSURENDER SINGH. 2004. Remote Sensing: Principles and Applications. Scientific Publ.

AGM 511 STRATEGIC USE OF CLIMATIC INFORMATION (2+1)

Objective

To impart the theoretical and practical knowledge of climatic hazards and their mitigations.

Theory

Block 1: Climatic hazards and management

UNIT 1: Increasing awareness on potential climate hazards and mitigations: history of climate related disasters in the concerned continent/region/country/sub-region and their documented or remembered impacts; Climatic hazards and extreme weather events (Cyclone, Hailstorm, drought, flood, etc.), Impact of climatic hazard on agricultural production; efforts made in mitigating impacts of (future) disasters (prevention); trends discernible in occurrence and character of disasters, if any.

UNIT 2: Selection of appropriate land use and cropping patterns: types and drivers of agricultural land use and cropping patterns based on climatic situation; history of present land use and cropping patterns in the sub-region concerned as related to environmental issues; successes and difficulties experienced by farmers with present land use and cropping patterns; outlook for present land use and cropping patterns and possible alternatives from an environmental point of view.

UNIT 3: Adoption of preparedness strategies: priority settings for preparedness strategies in agricultural production; preparedness for meteorological disasters in development planning; permanent adaptation strategies that reduce the vulnerabilities to hazards; preparedness as a coping strategy.

Block 2: Weather and resource use

UNIT 1: Making more efficient use of agricultural inputs: agro-meteorological aspects of agricultural production inputs and their history; determination of input efficiencies based on weather conditions; other factors determining inputs and input efficiency; actual use of inputs in main land use and cropping patterns of the region.

UNIT 2: Adoption of microclimate modification techniques: review of microclimate management and manipulation methods; history of microclimate modification techniques practiced in the continent/country/

sub-region concerned; possible improvements in adoption of microclimate modification techniques, given increasing climate variability and climate change; local trends in adoption of such techniques.

UNIT 3: Protection measures against extreme climate: history of protection measures against extreme climate in the continent/region/country/sub region concerned; successes and difficulties experienced by farmers with present protection measures; outlook for present protection measures and possible alternatives; trends in protection methods against extreme climate.

Practical

- Outlook for present land use and cropping patterns and possible alternatives from environmental point of view
- Recent trends in land use and cropping patterns
- Agro-meteorological services to increase farmers design abilities of land use and cropping patterns
- Systematic and standardized data collection on protection measures against extreme climate.

References

- ANONYMOUS. Clean Development Mechanism: Building International Public-Private Partnership under Kyoto Protocol. UNEP, UNDP Publ.
- ANONYMOUS. IPCC Assesment Reports on Climate Change Policy: Facts, Issues and Anlysis. Cambridge Univ. Press.
- BISHNOI OP. 2007. Principles of Agricultural Meteorology. Oxford Book Co.
- PRETTY J AND BALL A. 2001. Agricultural Influence on Carbon Emission and Sequestration: A Review of Evidence and the Emerging Trading Options. Univ. of Essex.
- PRETTY JN. 1995. Regenerating Agriculture: Policies and Practices for Sustainable and Self Reliance. Earthscan.

AGM 512 WEATHER AND CLIMATE RISK MANAGEMENT (2+0)

Objective

To impart the theoretical and practical knowledge of weather modification techniques with risk management strategies.

Block 1: Agricultural risks

UNIT 1: Risk characterization - definitions and classification of risks; characterization of weather and climate related risks in agriculture; water related risks; radiation/heat related risks; air and its movement related risks; biomass related risks; social and economic risk factors related to weather and climate.

UNIT 2: Risks in agricultural production, history of weather and climate as accepted risk factors in agriculture in the continent/region/country/sub-region concerned and the related documented risk concepts; preparedness for weather and climate risks.

UNIT 3: Risks of droughts; monitoring, prediction and prevention of drought; drought proofing and management; modern tools including remote sensing and GIS in monitoring and combating droughts.

Block 2: Weather modification

UNIT 1: Theories of weather modification; scientific advances in clouds and electrical behaviour of clouds; hails suppression, dissipation of fog, modification of frost intensity and severe storms; shelter belts and wind breaks, mulches and anti-transpirants; protection of plants against climatic hazards; air and water pollution; meteorological conditions in artificial and controlled climates - green, plastic, glass and animal houses etc.

UNIT 2: Approaches and tools to deal with risks - history of methods for weather and climate related risk assessments in the continent/region/country/subregion concerned and their documented evidence of application to agricultural/farming systems; strategies of dealing with risks- mitigating practices before occurrence; preparedness for the inevitable; contingency planning and responses; disaster risk mainstreaming.

UNIT 3: Perspectives for farm applications - farm applications not yet dealt with, such as making risk information products more client friendly and transfer of risk information products to primary and secondary users of such information; heterogeneity of rural people in education, income, occupation and information demands and consequences for risk information products and their transfer; livelihood-focused support, participation and community perspectives; challenges for developing coping strategies including transferring risks through insurance schemes.

UNIT 4: Challenges to coping strategies-combining challenges to disaster risk mainstreaming, mitigation practices, contingency planning and responses, basic preparedness; preparedness approaches reducing emergency relief necessities; the role that insurances can play in risk spreading and transfer; application of methods that permit the incorporation of seasonal and long-term forecasts into the risk assessment models.

References

- ANONYMOUS 2003. Critical Issues in Weather Modification Research Board of Atmoshperic Science and Climate. National Research Council, USA.
- BISHNOI OP. 2007. Principles of Agricultural Meteorology. Oxford Book Co.
- CHRITCHFIELD HJ. 1994. General Climatology. Prentice Hall.
- LENKA D. 1998. Climate, Weather and Crops in India. Kalyani.
- MAVI HS AND GRAEME J TUPPER. 2004. Agrometeorology: Principles and Applications of Climate Studies in Agriculture. The Haworth Press.
- MAVI HS. 1994. Introduction to Agrometeorology. Oxford & IBH.
- MENON PA. 1989. Our Weather. National Book Trust.
- PEARCE RP. 2002. Meteorology at the Millennium. Academic Press.

- ROSENBERG NJ, BLAD BL AND VERMA SB. 1983. Microclimate – The Biological Environment. John Wiley & Sons.
- SAMRA JS, NARAIN P, RATTAN RK AND SINGH SK. 2006. Drought Management in India. Bull. Indian Society of Soil Science 24, ISSS, New Delhi.

AGM 513 AEROBIOMETEOROLOGY (2+1)

Objective

To impart theoretical knowledge on insect, pest and plant biometeorology

Theory

Block 1: Introduction

UNIT 1: Definition and structure of Aero biometeorology, role of Agrometeorology and Biogeography in forecasting pests and disease outbreak, insect movement in the atmosphere, intensification, Effect of weather & climate parameters on reproduction, growth, development, movements, food, habitat and dispersal of pests and diseases. Influence of weather & climate on Migratory pests (Desert locust, BPH etc.).

UNIT 2: Benevolent and malevolent weather conditions for salient pests & diseases of the concerned agro-climatic zones. Effects of sudden weather changes and extreme weather conditions on population built-up of the pest, heat stress and heat related mortality, climate change impact on pest and diseases.

Block 2: Biometeorology

UNIT 1: Biometeorology in integrated pest and disease management program, modification of plant canopy and its impact of plant diseases, management of segments of disease triangle: environment manipulation and host manipulation, weather based forewarning system for pest and diseases.

UNIT 2: Soil borne pathogens, their biology, management and challenges, soil borne diseases and their control, abiotic factor in soil borne disease management, Managing of pests & diseases in controlled environment, Environmental management for pest and disease

Practical

- Identification of different pests
- Pest population, observations and their index calculation
- Identification of various diseases
- Disease initiation and their intensity, per cent disease index
- Relation between weather parameters and pests and disease

References

- YAZDANI, SS AND AGARWAL ML. 2002.Elements of insect ecology. Narosa Publishing House.
- ODUM EP. Fundamentals of insect ecology.
- DHALIWAL GS AND ARORA R. Integrated pest management.
- JERRY L. HATFIELD AND IVAN J. THOMASON. 1982. Biometeorology in integrated pest management, Academic press.

M.Sc. (Agri.) in Agricultural Statistics

Course Code	Course Title	Credit Hours
AST 522	Data Analysis using Statistical Packages	3(2+1)
AST 552	Probability Theory	2(1+1)
AST 553	Statistical Methods	3(2+1)
AST 554	Actuarial Statistics	2(1+1)
AST 555	Bioinformatics	2(1+1)
AST 556	Econometrics	2(1+1)
AST 562	Statistical Inference	3(2+1)
AST 563	Design of Experiments	3(2+1)
AST 564	Sampling Techniques	3(2+1)
AST 565	Statistical Genetics	3(2+1)
AST 566	Statistical Quality Control	2(2+0)
AST 567	Optimization Techniques	2(1+1)
AST 571	Multivariate Analysis	3(2+1)
AST 572	Regression Analysis	3(2+1)
AST 573	Statistical Computing	2(1+1)
AST 575	Demography	2(2+0)
AST 576	Statistical Methods for Life Sciences	2(1+1)
AST 577	Statistical Ecology	2(2+0)
AST 578	Non Parametric Methods	2(1+1)
	Total	**46(30+16)**
Supporting courses for other than Agricultural statistics students		
AST 501	Mathematics for Applied Sciences	2 (2+0)
AST 502	Statistical Methods for Applied Sciences	4 (3+1)
AST 511	Experimental Designs	3 (2+1)
AST 512	Basic Sampling Techniques	3 (2+1)
AST 521	Applied Regression Analysis	3 (2+1)
AST 522	Data Analysis using Statistical Packages	3 (2+1)
MCA 501	Computer Fundamentals & Programming	3 (2+1)

Course Code	Course Title	Credit Hours
MCA 502	Computer Organization and Architecture	2 (2+0)
MCA 511	Introduction To Communication Technologies, Computer Networking And Internet Applications	2 (1+1)
MCA 512	Information Technology in Agriculture	2 (2+0)
Supporting courses for Agricultural statistics students		
AST 551	Mathematics - I	3 (2+1)
AST 561	Mathematics - II	2 (1+1)
AST 574	Time Series Analysis	2 (1+1)
	Total	**7 (4+3)**
AST 580	Qualifying Examination	2 (0+2)
AST 581	Seminar - I	1 (0+1)
AST 582	Seminar - II	1 (0+1)
AST 591	Research - I	13 (0+13)
AST 592	Research - II	14 (0+14)

AST 522 DATA ANALYSIS USING STATISTICAL PACKAGES 3(2+1)

Objective

This course is meant for exposing the students in the usage of various statistical packages for analysis of data. It would provide the students hands on experience in the analysis of their research data. This course is useful to all disciplines.

Theory

Block I: Basic statistical Analysis

Unit 1: Introduction to various statistical packages: Excel, Minitab, SPSS, R and Python. Data Preparation; Descriptive statistics; Graphical representation of data, Exploratory data analysis.

Unit 2: Test for normality; Testing of hypothesis using chi-square, t and F statistics and Z-test.

Unit 3: Data preparation for ANOVA, Factorial Experiments, contrast analysis, multiple comparisons.

Block – II: Multivariate Statistical Analysis

Unit 1: Estimation of variance components; Correlation and regression analysis, Probit, Logit and Tobit Models.

Unit 2: Discriminant function; Factor analysis; Principal component analysis; Analysis of time series data, Fitting of non-linear models; Neural networks.

Practical

- Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data;
- Testing the hypothesis for one sample t-test, two sample t-test, paired t-test, test for large samples - Chi-squares test, F test, one-way analysis of variance;
- Designs for Factorial Experiments, estimation of variance components;
- Linear and Multiple regression, Regression plots, Fitting of Non linear Regression models.
- Discriminant analysis - fitting of discriminant functions, identification of important variables;
- Factor analysis. Principal component analysis - obtaining principal component.

References

- ANDERSON C.W. AND LOYNES R.M. 1987. *The Teaching of Practical: Statistics*. John Wiley.
- ATKINSON A.C. 1985. *Plots Transformations and Regression*. Oxford University Press.
- CHAMBERS J.M., CLEVELAND W.S., KLEINER B AND TUKEY P.A. 1983. *Graphical Methods for Data Analysis*. Wadsworth, Belmount, California.

- CHATFIELD C. 1983. *Statistics for Technology*. 3rd Ed. Chapman & Hall. Chatfield C. 1995. *Problem Solving: A Statistician's Guide*. Chapman & Hall.
- CLEVELAND W.S. 1985. *The Elements of Graphing Data*. Wadsworth, Belmont, California.
- EHRENBERG ASC. 1982. *A Primer in Data Reduction*. John Wiley.
- ERICKSON B.H. AND NOSANCHUK T.A. 1992. *Understanding Data*. 2nd Ed. Open University Press, Milton Keynes.

AST 552 PROBABILITY THEORY 2(1+1)

Objective

This is a fundamental course in Statistics. This course lays the foundation of probability theory, random variable, probability distribution, mathematical expectation, etc. which forms the basis of basic statistics. The students are also exposed to law of large numbers and central limit theorem. The students also get introduced to stochastic processes.

Theory

Block -I: Introduction to Probability and its Properties

Unit 1: Basic concepts of probability. Elements of measure theory: class of sets, field, sigma field, minimal sigma field, Borel field in R, measure- probability measure. Axiomatic approach to probability. Properties of probability based on axiomatic definition. Addition and multiplication theorems. Conditional probability and independence of events. Bayes theorem.

Unit 2: Random variables: definition of random variable, discrete and continuous, functions of random variables. Probability mass function and Probability density function, Distribution function and its properties. Notion of bivariate random variables, bivariate distribution function and its properties. Joint, marginal and conditional distributions. Independence of random variables. Transformation of random variables (two dimensional cases only). Mathematical expectation: Mathematical

expectation of functions of a random variable. Raw and central moments and their relation, covariance, skewness and kurtosis. Addition and multiplication theorems of expectation. Definition of moment generating function, cumulating generating function, probability generating function and statements of their properties.

Block-II: Inequalities and Large Sample Theory

Unit 1: Conditional expectation and conditional variance. Characteristic function and its properties. Inversion and uniqueness theorems. Chebyshev, Markov, Cauchy- Schwartz, Sequence of random variables and modes of convergence (convergence in distribution in probability, almost surely, and quadratic mean) and their interrelations.

Unit 2: Laws of large numbers: WLLN, Bernoulli and Kintchin's WLLN. Kolmogorov inequality, Kolmogorov's SLLNs.Central Limit theorems: Demoviere- Laplace CLT, Lindberg – Levy CLT and simple applications.

Practical

Solving problems on above topics.

References

- ASH RB. 2000. *Probability and Measure Theory*. 2nd Ed. Academic Press. Billingsley P. 1986. *Probability and Measure*. 2nd Ed. John Wiley.
- CAPINSKI M AND ZASTAWNIAH. 2001. *Probability Through Problems*. Springer. Dudewicz EJ & Mishra SN. 1988. *Modern Mathematical Statistics*. John Wiley.
- FELLER W. 1972. *An Introduction to Probability Theory and its Applications*. Vols. I., II. John Wiley.
- LOEVE M. 1978. *Probability Theory*. 4th Ed. Springer.

AST 553 STATISTICAL METHODS 3(2+1)

Objective

This course lays the foundation of probability distributions and sampling distributions and their application which forms the basis of

Statistical Inference. Together with probability theory, this course is fundamental to the discipline of Statistics. The students are also exposed to correlation and regression, and order statistics and their distributions. Categorical data analysis is also covered in this course.

Theory

Block -I: Discrete and Continuous distributions

Unit 1: Descriptive statistics: probability distributions: Discrete probability distributions - Bernoulli, Binomial, Poisson, Negative-binomial, Geometric and Hyper Geometric, uniform, multinomial ~ Properties of these distributions and real life examples. Continuous probability distributions ~ rectangular, exponential, Cauchy, normal, gamma, beta of two kinds, Weibull, lognormal, logistic, Pareto. Properties of these distributions. Probability distributions of functions of random variables.

Unit 2: Sampling distributions of sample mean and sample variance from Normal population, central and non–central chi-Square, t and F distributions, their properties and inter relationships.

Block -II: Concept of correlation and Regression Analysis

Unit 1: Concepts of random vectors, moments and their distributions. Bivariate Normal distribution - marginal and conditional distributions. Distribution of quadratic forms. Cochran theorem. Correlation, rank correlation, correlation ratio and intra-class correlation. Regression analysis, partial and multiple correlation and regression.

Unit 2: Sampling distribution of correlation coefficient, regression coefficient. Categorical data analysis, Association between attributes. Variance Stabilizing Transformations.

Block -III: Introduction to Order Statistics

Unit 1: Order statistics, distribution of r-th order statistics, joint distribution of several order statistics and their functions, marginal distributions of order statistics.

- Fitting of discrete distributions and test for goodness of fit;
- Fitting of continuous distributions and test for goodness of fit; Fitting of truncated distribution.

- Computation of simple, multiple and partial correlation coefficient, correlation ratio and intra-class correlation;
- Regression coefficients and regression equations;
- Fitting of Pearsonian curves;
- Analysis of association between attributes, categorical data and log-linear models.

References

- AGRESTI, A. 2012. *Categorical Data Analysis* 3rd Ed. John Wiley.
- ARNOLD B C, BALAKRISHNAN N AND NAGARAJA H N. 1992. *A First Course in Order Statistics*. JohnWiley.
- DAVID H A AND NAGARAJA H N. 2003. *Order Statistics*. 3rd Ed. John Wiley.
- DUDEWICZ E J AND MISHRA S N. 1988. *Modern Mathematical Statistics*. John Wiley.
- HUBER P J. 1981. *Robust Statistics*. John Wiley.
- JOHNSON N L, KOTZ S AND BALAKRISHNAN N. 2000. *Continuous Univariate Distributions*. JohnWiley.

AST 554 ACTUARIAL STATISTICS 2(1+1)

Objective

This course is meant to expose to the students to the statistical techniques such as probability models, life tables, insurance and annuities. The students would also be exposed top Practical: applications of these techniques in computation of premiums that include expenses, general expenses, types of expenses and per policy expenses.

Theory

Block-I : Introduction to Actuarial Statistics and different Life tables

Unit 1: Insurance and utility theory, models for individual claims and their sums, survival function, curtate future lifetime, force of mortality.

Unit 2: Life table and it's relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables.

Unit 3: Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws. Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations.

Block - II: Concept of Insurance and Interest Schemes

Unit 1: Distribution of aggregate claims, compound Poisson distribution and its applications.

Unit 2: Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding.

Unit 3: Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance, deferred insurance and varying benefit insurance, recursions, commutation functions.

Block -III : Premium Policies and Life Annuities

Unit 1: Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursions, complete annuities-immediate and apportionable annuities-due.

Unit 2: Net premiums: Continuous and discrete premiums, true monthly payment premiums, apportionable premiums, commutation functions, accumulation type benefits. Payment premiums, apportionable premiums, commutation functions, accumulation type benefits. Net premium reserves: Continuous and discrete net premium reserve, reserves on a semi-continuous basis, reserves based on true monthly premiums, reserves on an apportionable or discounted continuous basis, reserves

at fractional durations, allocations of loss to policy years, recursive formulas and differential equations for reserves, commutation functions.

Unit 3: Some Practical: considerations: Premiums that include expenses-general expenses types of expenses, per policy expenses. Claim amount distributions, approximating the individual model, stop-loss insurance.

Practical

Solving problems on above topics.

References

- ATKINSON ME AND DICKSON DCM. 2000. *An Introduction to Actuarial Studies*. Elgar Publ.
- BEDFORD T AND COOKE R. 2001. *Probabilistic Risk Analysis*. Cambridge.
- BOOTH PM, CHADBURN RG, COOPER DR, HABERMAN, S AND JAMES DE.1999. Modern *Actuarial Theory and Practice*. Chapman & Hall.
- BOROWIAK DALE S. 2003. *Financial and Actuarial Statistics: An Introduction.* Marcel Dekker.
- BOWERS NL, GERBER HU, HICKMAN JC, JONES DA AND NESBITT CJ.1997. *Actuarial Mathematics*. 2nd Ed. Society of Actuaries, Ithaca, Illinois.
- DALE SB, ARNOLD FS. 2013. *Financial and Actuarial Statistics: An Introduction*, 2nd Ed. (Statistics: A Series of Textbooks and Monogrphs)

AST 555 BIOINFORMATICS 2(1+1)

Objective

Bioinformatics is a new emerging area. It is an integration of Statistics, Computer applications and Biology. The trained manpower in the area of Bioinformatics is required for meeting the new challenges in teaching and research in the discipline of Agricultural Sciences. This course is meant to train the students on concepts of basic biology,

statistical techniques and computational techniques for understanding bioinformatics principals.

Theory

Block – I : Concepts of Bioinformatics

Unit 1: Basic Biology: Cell, genes, gene structures, gene expression and regulation, Molecular tools, nucleotides, nucleic acids, markers, proteins and enzymes, bioenergetics, single nucleotide polymorphism, expressed sequence tag. Structural and functional genomics: Organization and structure of genomes, genome mapping, assembling of physical maps, strategies and techniques for genome sequencing and analysis.

Block – II : Programming Languages and Bioinformatics

Unit 1: Computing techniques: OS and Programming Languages – Linux, perl, bioperl,python, biopython,cgi, MySQL, phpMyAdmin; Coding for browsing biological databases on web, parsing & annotation of genomic sequences; Database designing; Computer networks – Internet, World wide web, Web browsers– EMBnet, NCBI; Databases on public domain pertaining to Nucleic acid sequences, protein sequences, SNPs, etc.; Searching sequence databases, Structural databases.

Block - III: Statistical Tools and Techniques in Bioinformatics

Unit 1: Statistical Techniques: MANOVA, Cluster analysis, Discriminant analysis, Principal component analysis, Principal coordinate analysis, Multidimensional scaling; Multiple regression analysis; Likelihood approach in estimation and testing; Resampling techniques – Bootstrapping and Jack-knifing; Hidden Markov Models; Bayesian estimation and Gibbs sampling;

Unit 2: Tools for Bioinformatics: DNA Sequence Analysis – Features of DNA sequence analysis, Approaches to EST analysis; Pairwise alignment techniques: Comparing two sequences, PAM and BLOSUM, Global alignment (The Needleman and Wunsch algorithm), Local Alignment (The Smith-Waterman algorithm), Dynamic

programming, Pairwise database searching; Sequence analysis– BLAST and other related tools, Multiple alignment and database search using motif models, Clustal W, Phylogeny; Databases on SNPs; EM algorithm and other methods to discover common motifs in bio sequences; Gene prediction based on Neural Networks, Genetic algorithms, Computational analysis of protein sequence, structure and function; Design and Analysis of microarray/ RNA seq experiments.

Practical

Solving problems on above topics.

References

- BALDI P. AND BRUNAK S. 2001. *Bioinformatics: The Machine Learning Approach.* 2nd Ed. (Adaptive Computation and Machine Learning). M I T Press.
- BAXEVANIS A. D. AND FRANCIS B. F. (Eds.). 2004. *Bioinformatics: A Practical: Guide to the Analysis of Genes and Proteins*. John Wiley.
- BERGERON B. P. 2002. *Bioinformatics Computing*. Prentice Hall.
- DUDA R. O, HART P. E AND STORK D.G. 1999. *Pattern Classification*. John Wiley.
- EWENS W. J AND GRANT G. R. 2001. *Statistical Methods in Bioinformatics: An Introduction* (*Statistics for Biology and Health*). Springer.

AST 556 ECONOMETRICS 2(1+1)

Objective

This course is meant for training the students in econometric methods and their applications in agriculture. This course would enable the students in understanding the economic phenomena through statistical tools and economics principles.

Theory

Block – I : Introduction to Linear Models

Unit 1: Representation of Economic phenomenon, relationship among economic variables, linear and non-linear economic models, single equation general linear regression model, basic assumptions, Ordinary least squares method of estimation for simple and multiple regression models; summary statistics correlation matrix, co-efficient of multiple determination, standard errors of estimated parameters, tests of significance and confidence interval estimation. BLUE properties of Least Squares estimates. Chow test, test of improvement of fit through additional regressors. Maximum likelihood estimation.

Block – II : Model checking

Unit 1: Heteroscedasticity, Auto-correlation, Durbin Watson test, Multi-collinearity. Stochastic regressors, Errors in variables, Use of instrumental variables in regression analysis. Dummy Variables. Distributed Lag models: Koyck's Geometric Lag scheme, Adaptive Expectation and Partial Adjustment Mode, Rational Expectation Models and test for rationality.

Block -III : Multi linear and Generalized Linear Models

Unit 1: Simultaneous equation model: Basic rationale, Consequences of simultaneous relations, Identification problem, Conditions of Identification, Indirect Least Squares, Two-stage least squares, K-class estimators, Limited Information and Full Information Maximum Likelihood Methods, three stage least squares, Generalized least squares, Recursive models, SURE Models. Mixed Estimation Methods, use of instrumental variables, pooling of cross-section and time series data, Principal Component Methods.

Block - IV : Index number and Demand Analysis

Unit 1: Construction of index numbers and their tests; fixed and chain based index numbers; Construction of cost of living index number.

Unit 2: Demand analysis – Demand and Supply Curves; Determination of demand curves from market data. Engel's Law and

the Engel's Curves, Income distribution and method of its estimation, Pareto's Curve, Income in equality measures.

Practical

Solving problems on above topics.

References

- CROXTON F. E. AND COWDEN D. J. 1979. *Applied General Statistics*. Prentice Hall of India.
- JAMES H. S. AND MARK W.W. 2017. Introduction to Econometrics, 3rd Ed. John Wiley
- JOHNSTON J. 1984. *Econometric Methods*. Mc Graw Hill.
- JUDGE G.C., HILL R.C., GRIFFITHS W.E., LUTKEPOHL H AND LEE T.C. 1988. *Introduction to the Theory and Practice of Econometrics*. 2nd Ed. John Wiley.

AST 562 STATISTICAL INFERENCE 3(2+1)

Objective

This course lays the foundation of Statistical Inference. The students would be taught the problems related to point and confidence interval estimation and testing of hypothesis. They would also be given the concepts of nonparametric and sequential test procedures and elements of decision theory.

Theory

Block – I : Theory of Estimation

Unit 1: Concepts of point estimation: un biasedness, consistency, efficiency and sufficiency. Statement of Neyman's Factorization theorem with applications. MVUE, Rao- Blackwell theorem, completeness, Lehmann- Scheffe theorem. Fisher information, Cramer-Rao lower bound and its applications.

Unit 2: Moments, minimum chi-square, least square and maximum likelihood methods of estimation and their properties. Interval estimation-Confidence level, shortest length CI. CI for the parameters of Normal, Exponential, Binomial and Poisson distributions.

Block – II : Testing of Hypothesis

Unit 1: Fundamentals of hypothesis testing-statistical hypothesis, statistical test, critical region, types of errors, test function, randomized and non- randomized tests, level of significance, power function, most powerful tests: Neyman-Pearson fundamental lemma, MLR families and UMP tests for one parameter exponential families. Concepts of consistency, unbiasedness and invariance of tests. Likelihood Ratio tests, asymptotic properties of LR tests with applications (including homogeneity of means and variances).Relation between confidence interval estimation and testing of hypothesis.

Unit 2: Sequential Probability ratio test, Properties of SPRT. Termination property of SPRT, SPRT for Binomial, Poisson, Normal and Exponential distributions. Concepts of loss, risk and decision functions, admissible and optimal decision functions, estimation and testing viewed as decision problems, conjugate families, Bayes and Minimax decision functions with applications to estimation with quadratic loss.

Block – III : Non- Parametric Tests

Unit 1: Non-parametric tests: Sign test, Wilcoxon signed rank test, Runs test for randomness, Kolmogorov – Smirnov test for goodness of fit, Median test and Wilcoxon-Mann-Whitney U-test. Chi-square test for goodness of fit and test for independence of attributes. Spearman's rank correlation and Kendall's Tau tests for independence.

Practical

- Methods of estimation - Maximum Likelihood, Minimum c2 and Moments;
- Confidence Interval Estimation;
- MP and UMP tests; Large Sample tests;
- Non-parametric tests, Sequential Probability Ratio Test;
- Decision functions.

References

- BOX G.E.P. AND TIAO G.C. 1992. *Bayesian Inference in Statistical Analysis*.John Wiley.
- CASELA G AND BERGER R.L. 2001. *Statistical Inference*. Duxbury Thompson Learning.
- CHRISTENSEN R. 1990. *Log Linear Models*. Springer.
- CONOVER W.J. 1980. *Practical: Nonparametric Statistics*. John Wiley.
- DUDEWICZ E. J AND MISHRA S. N. 1988. *Modern Mathematical Statistics*. John Wiley.
- GIBBONS J.D. 1985. *Non Parametric Statistical Inference*. 2nd Ed. Marcel Dekker.
- KIEFER J.C. 1987. *Introduction to Statistical Inference*. Springer.
- LEHMANN E. L. 1986. *Testing Statistical Hypotheses*. John Wiley.

AST 563 DESIGN OF EXPERIMENTS 3(2+1)

Objective

Design of Experiments provides the statistical tools to get maximum information from least amount of resources. This course is meant to expose the students to the basic principles of design of experiments. The students would also be provided with mathematical background of various basic designs involving one-way and two-way elimination of heterogeneity and their characterization properties. This course would also prepare the students in deriving the expressions for analysis of experimental data.

Theory

Block– I : Linear Model and its properties

Unit 1: Elements of linear estimation, Gauss Markoff Theorem, relationship between BLUEs and linear zero-functions. Aitken's transformation, test of hypothesis, Analysis of Variance, Partitioning of degrees of freedom.

Unit 2: Orthogonality, contrasts, mutually orthogonal contrasts, analysis of covariance; Basic principles of design of experiments, uniformity trials, size and shape of plots and BLOCKs, Randomization procedure.

Block – II : Basic Designs

Unit 1: Basic designs - completely randomized design, randomized complete BLOCK design and Latin square design; Construction of orthogonal Latin squares, mutually orthogonal Latin squares (MOLS), Youden square designs, Graeco Latin squares.

Unit 2: Factorial experiments, confounding in symmetrical factorial experiments (2nand 3nseries), partial and total confounding, asymmetrical factorials.

Block– III : Incomplete BLOCK Designs

Unit 1: Balanced Incomplete BLOCK (BIB) designs – general properties and analysis without and with recovery of intra BLOCK information, construction of BIB designs. Partially balanced incomplete BLOCK designs with two associate classes - properties, analysis and construction, Lattice designs, alpha designs, cyclic designs, augmented designs.

Unit 2: Cross-over designs. Missing plot technique; Split plot and Strip plot design; Groups of experiments. Sampling in field experiments.

Practical

- Determination of size and shape of plots and BLOCKs from uniformity trials data;
- Analysis of data generated from completely randomized design, randomized complete BLOCK design; Latin square design,
- Missing plot techniques,
- Youden square design; 2^n, 3^n factorial experiments with and without confounding, partial confounding;
- Analysis of data generated from a BIB design, lattice design, PBIB designs repeated measurement design,

- Split and strip plot designs, Analysis of covariance; Analysis of Groups of experiments,
- Analysis of clinical trial experiments.

References

- CHAKRABARTI M.C. 1962. *Mathematics of Design and Analysis of Experiments*. Asia Publ.House.
- COCHRAN W.G. AND COX D.R. 1957. *Experimental Designs*. 2nd Ed. John Wiley.
- DEAN A.M. AND VOSS D. 1999. *Design and Analysis of Experiments*. Springer.
- DEY A AND MUKERJEE R. 1999. *Fractional Factorial Plans*. John Wiley.
- DEY A 1986. *Theory of BLOCK Designs*. Wiley Eastern. Hall M Jr. 1986. *Combinatorial Theory*. John Wiley.
- JOHN J.A. AND QUENOUILLE M.H. 1977. *Experiments: Design and Analysis*. Charles & Griffin.

AST 564 SAMPLING TECHNIQUES 3(2+1)

Objective

This course is meant to expose the students to the techniques of drawing representative samples from various populations and then preparing them on the mathematical formulations of estimating the population parameters based on the sample data. The students would also be exposed to the real life applications of sampling techniques and estimation of parameters.

Theory

Block– I : Basic Sampling Techniques

Unit 1: Sample survey vs complete enumeration, probability sampling, sample space, sampling design, sampling strategy; Determination of sample size; Confidence- interval; Simple random sampling, Estimation of population proportion, Stratified random

sampling, Proportional allocation and optimal allocation, Systematic sampling, Cluster sampling, Multistage sampling with equal probability, Double sampling, Successive sampling- two occasions and inverse sampling.

Block -II : Advanced Sampling Techniques

Unit 1: PPS sampling with and without replacement, Cumulative method and Lahiri's method of selection, Horvitz-Thompson estimator, Ordered and unordered estimators, Sampling strategies due to Midzuno-Sen and Rao-Hartley-Cochran. Inclusion probability proportional to size sampling.

Unit 2: Ratio, Product and regression methods of estimation, Separate and combined ratio estimator, unbiased ratio type estimators.

Unit 3: Non-sampling errors – sources and classification, Non-response in surveys, Randomized response techniques, Response errors/ Measurement error – interpenetrating sub-sampling.

Practical

Determination of sample size and selection of sample; Simple random sampling, Stratified random sampling, systematic sampling. Sampling with varying probabilities, Ratio and regression methods of estimation, Cluster sampling, multi-stage sampling, double sampling, Inverse sampling, Imputation methods; Randomized response techniques.

References

- CASSEL C.M., SARNDAL C.E. AND WRETMAN J.H. 1977. *Foundations of Inference in Survey Sampling*. John Wiley.
- CHAUDHARI A AND STENGER H. 2005. *Survey Sampling Theory and Methods*. 2nd Ed. Chapman & Hall.
- CHAUDHARI A AND VOSS J.W.E. 1988. *Unified Theory and Strategies of Survey Sampling*. North Holland.
- COCHRAN W.G. 1977. *Sampling Techniques*. John Wiley.
- HEDAYAT A.S. AND SINHA B.K. 1991. *Design and Inference in Finite Population Sampling*. John Wiley.

AST 565 STATISTICAL GENETICS 3(2+1)

Objective

This course is meant to prepare the students in applications of statistics in quantitative genetics and breeding. The students would be exposed to the physical basis of inheritance, detection and estimation of linkage, estimation of genetic parameters and development of selection indices.

Theory

Block - I: linkage and its estimation

Unit 1: Physical basis of inheritance. Analysis of segregation, detection and estimation of linkage for qualitative characters. Amount of information about linkage, combined estimation, disturbed segregation.

Block - II: Population genetics

Unit 1: Gene and genotypic frequencies, Random mating and Hardy -Weinberg law, Application and extension of the equilibrium law, Fisher's fundamental theorem of natural selection. Disequilibrium due to linkage for two pairs of genes, sex-linked genes, Theory of path coefficients.

Unit 2: Concepts of inbreeding, Regular system of inbreeding. Forces affecting gene frequency - selection, mutation and migration, equilibrium between forces in large populations, Random genetic drift, Effect of finite population size.

Block – III : Quantitative genetics

Unit 1: Polygenic system for quantitative characters, concepts of breeding value and dominance deviation. Genetic variance and its partitioning, Effect of inbreeding on quantitative characters, Multiple allelism in continuous variation, Sex-linked genes, Maternal effects - estimation of their contribution.

Unit 2: Correlations between relatives, Heritability, Repeatability and Genetic correlation. Response due to selection, Selection index and its applications in plants and animals' improvement programmes, Correlated response to selection.

Block – IV : Models for Genetics and Environmental Effect

Unit 1: Restricted selection index. Variance component approach and linear regression approach for the analysis of GE interactions. Measurement of stability and adaptability for genotypes. Concepts of general and specific combining ability. Diallel and partial diallel crosses - construction and analysis.

Practical

- Test for the single factor segregation ratios, homogeneity of the families with regard to single factor segregation;
- Detection and estimation of linkage parameter by different procedures;
- Estimation of genotypic and gene frequency from a given data. Hardy-Weinberg law;
- Estimation of changes in gene frequency due to systematic forces, inbreeding coefficient, genetic components of variation, heritability and repeatability coefficient, genetic correlation coefficient;
- Examination of effect of linkage, epistasis and inbreeding on mean and variance of metric traits; Mating designs;
- Construction of selection index including phenotypic index, restricted selection index. Correlated response to selection**.**

References

- AGARWAL B.L AND AGARWAL S.P. 2007. *Statistical Analysis of Quantitative Genetics*. New Age International Publisher.
- BAILEY N.T.J. 1961. *The Mathematical Theory of Genetic Linkage*. Clarendon Press.
- BALDING DJ, BISHOP M AND CANNINGS C. 2001. *Hand Book of Statistical Genetics*. John Wiley.
- CROW JF AND KIMURA M. 1970. *An Introduction of Population Genetics Theory*. Harper and Row.
- DAHLBERG G. 1948. *Mathematical Methods for Population Genetics*. Inter Science Publ.

AST 566 STATISTICAL QUALITY CONTROL 2(2+0)

Objective

This course is meant for exposing the students to the concepts of Statistical Quality Control and their applications in agribusiness and agro-processing industries. This course would enable the students to have an idea about the statistical techniques used in quality control. Students who do not have sufficient background of Statistical Methods.

Theory

Block – I: Quality Control Charts

Unit 1: Introduction to Statistical Quality Control; Control Charts for Variables – Mean, Standard deviation and Range charts; Statistical basis; Rational subgroups.

Unit 2: Control charts for attributes- 'np', 'p' and 'c' charts.

Block – II : Acceptance Sampling and Sampling Techniques

Unit 1: Fundamental concepts of acceptance, sampling plans, single, double and sequential sampling plans for attributes inspection.

Unit 2: Sampling inspection tables for selection of single and double sampling plans.

References

- COWDEN D.J. 1957. *Statistical Methods in Quality Control*. Prentice Hall of India.
- DODGE H.F. AND ROMIG H.G. 1959. *Sampling Inspection Tables*. John Wiley.
- DUNCAN A.J. 1986. *Quality Control and Industrial Statistics*. 5th Ed. Irwin Book Co.
- GRANT E.L. AND LEAVENWORTH R.S. 1996. *Statistical Quality Control*. 7th Ed. McGraw Hill.
- MONTGOMERY D.C. 2008. *Introduction to Statistical Quality Control*. 6th Ed. John Wiley.
- WETHERHIL G.B. 1977. *Sampling Inspection and Quality Control*. Halsted Press.

AST 567 OPTIMIZATION TECHNIQUES 2(1+1)

Objective

This course is meant for exposing the students to the mathematical details of the techniques optimization techniques. They will be taught numerical methods of optimization, linear programming techniques, nonlinear programming and multiple Objective::: programming. Students will also be exposed to Practical: applications of these techniques.

Theory

Block – I : Introduction to Linear programming and its Methods

Unit 1: Classification of optimization problems, Classical optimization techniques: single variable optimization, multivariable optimization techniques with no constraints, multivariable optimization techniques with equality constraints, multivariable optimization techniques with inequality constraints.

Unit 2: Linear programming: simplex method, duality, sensitivity analysis, Karmarkar's method, transportation problem.

Block– II : Non-Linear programming Models

Unit 1: Nonlinear programming Unconstrained optimization techniques: direct search methods such as random search, grid search, Hooke and Jeeves' method, Powel's method. Descent methods such as gradient method, steepest descent method, conjugate gradient method, Newton's method, Marquardt method.

Unit 2: Quadratic programming, integer linear programming, integer nonlinear programming, geometric programming, dynamic programming, stochastic programming, multi Objective::: optimization, optimal control theory, genetic algorithms, simulated annealing, neural network based optimization,

Practical

- Problems based on classical optimization techniques, optimization techniques with constraints, minimization problems using numerical methods.

- Linear programming (LP) problems through graphical method, simplex method, simplex two-phase method, primal and dual method.
- Sensitivity analysis for LP problem, LP problem using Karmarkar's method.
- Problems based on Quadratic programming, integer programming, dynamic programming, stochastic programming.
- Problems based on Pontryagin's maximum principle.
- Problems based on multi Objective optimization.

References

- ANTUNES C.H., ALVES, M.J., CLIMACO J. 2016. *Multi Objective::: Linear and Integer Programming* (EURO Advanced Tutorials on Operational Research)
- NOCEDAL, J. AND WRIGHT, S.J. 1999. *Numerical Optimization*. Springer.
- RAO, S.S. 2007. *Engineering Optimization: Theory and Practice*. New Age International Publishers.
- RUSTAGI, J.S. 1994. *Optimization Techniques in Statistics*. Academic Press.

AST 571 MULTIVARIATE ANALYSIS 3(2+1)

Objective

This course lays the foundation of Multivariate data analysis. Most of the data sets in agricultural sciences are multivariate in nature. The exposure provided to multivariate data structure, multinomial and multivariate normal distribution, estimation and testing of parameters, various data reduction methods would help the students in having a better understanding of agricultural research data, its presentation and analysis.

Theory

Block – I : Introduction to Multivariate Analysis

Unit 1: Concept of random vector, its expectation and Variance-Covariance matrix. Marginal and joint distributions. Conditional

distributions and Independence of random vectors. Multinomial distribution. Multivariate Normal distribution, marginal and conditional distributions. Sample mean vector and its distribution. Maximum likelihood estimates of mean vector and dispersion matrix. Tests of hypothesis about mean vector.

Block – II : Multivariate Tests

Unit 1: Wishart distribution and its simple properties. Hotelling's T^2 and Mahalanobis D^2 statistics. Null distribution of Hotelling's T^2. Rao's U statistics and its distribution. Wilks' ? criterion and its properties. Concepts of discriminant analysis, computation of linear discriminant function, classification between k (?2) multivariate normal populations based on LDF and Mahalanobis D^2.

Block -III : Data Reduction and Classification Techniques

Unit 1: Principal Component Analysis, factor analysis. Canonical variables and canonical correlations. Cluster analysis: similarities and dissimilarities of qualitative and quantitative characteristics, Hierarchical clustering. Single, Complete and Average linkage methods. K-means cluster analysis.

Unit 2: Path analysis and computation of path coefficients, introduction to multidimensional scaling, some theoretical results, similarities, metric and non-metric scaling methods.

Practical

- Maximum likelihood estimates of mean-vector and dispersion matrix;
- Testing of hypothesis on mean vectors of multivariate normal populations;
- Cluster analysis, Discriminant function, Canonical correlation, Principal component analysis, Factor analysis;
- Multivariate analysis of variance and covariance, multidimensional scaling.

References

- ABDELMONEM A, VIRGINIA AC AND SUSANNE M. 2004. *Computer Aided Multivariate Analysis*. Chapman & Hall/CRC.
- ANDERSON TW. 1984. *An Introduction to Multivariate Statistical Analysis*. 2nd Ed. John Wiley.
- ARNOLD SF. 1981. *The Theory of Linear Models and Multivariate Analysis*. John Wiley.
- GIRI NC. 1977. *Multivariate Statistical Inference*. Academic Press.
- JOHNSON RA AND WICHERN DW. 1988. *Applied Multivariate Statistical Analysis*. Prentice Hall.
- KSHIRSAGAR AM. 1972. *Multivariate Analysis*. Marcel Dekker.

AST 572 REGRESSION ANALYSIS 3(2+1)

Objective

This course is meant to prepare the students in linear and non-linear regression methods useful for statistical data analysis. They would also be provided a mathematical foundation behind these techniques and their applications in agricultural data.

Theory

Block – I : Least square Estimation and its Properties

Unit 1: Simple and Multiple linear regressions: Least squares fit, Properties and examples. Polynomial regression: Use of orthogonal polynomials.

Block– II: Model diagnostics

Unit 1: Assumptions of regression; diagnostics and transformations; residual analysis ~ Studentized residuals, applications of residuals in detecting outliers, identification of influential observations. Lack of fit, pure error. Test of normality, test of linearity, testing homoscedasticity and normality of errors, Durbin-Watson test. Test of goodness of fit for the model evaluation and validation. Concept of multi-co linearity.

Block – III : Variable and Model Selection

Unit 1: Weighted least squares method: Properties, and examples. Box-Cox family of transformations. Use of dummy variables, over fitting and under fitting of model, Selection of variables: Forward selection, backward elimination. Stepwise and Stage wise regressions.

Block– IV : Non-Linear Models

Unit 1: Introduction to non-linear models, nonlinear estimation: Least squares for nonlinear models.

Practical

- Multiple regression fitting with three and four independent variables;
- Estimation of residuals, their applications in outlier detection, distribution of residuals;
- Test of homoscedasticity, and normality, Box-Cox transformation;
- Restricted estimation of parameters in the model, hypothesis testing, Step wise regression analysis;
- Least median of squares norm, Orthogonal polynomial fitting.

References

- BARNETT V AND LEWIS T. 1984. *Outliers in Statistical Data*. John Wiley.
- BELSLEY DA, KUH E AND WELSCH RE. 2004. *Regression Diagnostics-Identifying Influential Data and Sources of Collinearity*. John Wiley.
- CHATTERJEE S AND HADI AS. 2013. *Regression Analysis* by *Example*. A John Wiley & sons Publication.
- DRAPER NR AND SMITH H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.

AST 573 STATISTICAL COMPUTING 2(1+1)

Objective

This course is meant for exposing the students in the concepts of computational techniques. Various statistical packages would be used for teaching the concepts of computational techniques.

Theory

Block – I : Basic Statistical Computing Techniques

Unit 1: Introduction to statistical packages and computing: data types and structures, Use of Software packages like, Excel, Minitab, SPSS, "R" and Python: The R Project for Statistical Computing". Data analysis principles and practice, Summarization and tabulation of data, Exploratory data analysis; Graphical representation of data. Statistical Distributions: Fitting and testing the goodness of fit of discrete and continuous probability distributions;

Block– II : Advanced Statistical Computing Techniques

Unit 1: ANOVA, regression and categorical data methods; model formulation, fitting, diagnostics and validation; Matrix computations in linear models. Analysis of discrete data. Multiple comparisons, Contrast analysis.

Unit 2: Numerical linear algebra, numerical optimization, graphical techniques, numerical approximations, Time Series Analysis.

Unit 3: Analysis of mixed models; Estimation of variance components, Analysis of Covariance, Fitting of non-linear model, Discriminant function; Principal component analysis. Techniques in the analysis of survival data and longitudinal studies, Approaches to handling missing data, and meta-analysis

Practical

- Data management, Graphical representation of data, Descriptive statistics;
- General linear models ~ fitting and analysis of residuals, outlier detection;

- Fitting and testing the goodness of fit of probability distributions; Testing the hypothesis for one sample t-test, two sample t-test, paired t-test, test for large samples - Chi-squares test, F test, One way analysis of variance, contrast and its testing, pair wise comparisons;
- Mixed effect models, estimation of variance components; Categorical data analysis, dissimilarity measures, similarity measures;
- Analysis of discrete data, analysis of binary data;
- Numerical algorithms;
- Spatial modeling, cohort studies;
- Clinical trials, analysis of survival data;
- Handling missing data. Analysis of time series data - fitting of ARIMA models.

References

- AGRESTI A. 2013. *Categorical Data Analysis*. 3rd Ed. John Wiley.
- EVERITT BS AND DUNN G. 1991. *Advanced Multivariate Data Analysis*. 2nd Ed. Arnold.
- GEISSER S. 1993. *Predictive Inference: An Introduction*. Chapman & Hall.
- GELMAN A & HILL J. 2006. *Data Analysis Using Regression and Multilevel/Hierarchical Models*. Cambridge Univ. Press.
- GENTLE JE, HÄRDLE W AND MORI Y. 2012. *Handbook of Computational Statistics – Concepts and Methods*. 2nd Ed. Springer.
- HAN J AND KAMBER M. 2000. *Data Mining: Concepts and Techniques*. Morgan.
- HASTIE T, TIBSHIRANI R AND FRIEDMAN R. 2001. *The Elements of Statistical Learning: Data Mining, Inference and Prediction*. Springer.

• KENNEDY WJ & GENTLE JE. 1980. *Statistical Computing*. Marcel Dekker

AST 575 DEMOGRAPHY 2(2+0)

Objective

This course is meant for training the students in measures of demographic indices, estimation procedures of demographic parameters. Students would also be exposed to population projection techniques and principle involved in bioassays.

Theory

Block -I : Introduction to Life tables and Migration Models

Unit 1: Introduction to vital statistics, crude and standard mortality and morbidity rates, Estimation of mortality, Measures of fertility and mortality, period and cohort measures.

Unit 2: Life tables and their applications, methods of construction of abridged life tables, Increment-Decrement Life Tables.

Unit 3: Stationary and stable populations, Migration and immigration. Application of stable population theory to estimate vital rates, migration and its estimation. Demographic relations in Nonstable populations. Measurement of population growth, Lotka's model (deterministic) and intrinsic rate of growth, Measures of mortality and morbidity Period.

Block - II : Biological Assays

Unit 1: Principle of biological assays, parallel line and slope ratio assays, choice of doses and efficiency in assays quantal responses, probit and logit transformations, epidemiological models.

References

• COX DR. 1957. *Demography*. Cambridge Univ. Press.

• CHARLES GRIFFIN. FLEISS JL. 1981. *Statistical Methods for Rates and Proportions*. John Wiley.

- FINNEY DJ. 1981. *Statistical Methods in Biological Assays*.
- GROW A, BAVEL JV. 2016. *Agent-Based Modelling in Population Studies: Concepts, Methods, and Applications* (The Springer Series on Demographic Methods and Population Analysis)
- LAWLESS JF. 1982. *Statistical Models and Methods for Lifetime Data*. John Wiley.
- MACMAHON B AND PUGH TF. 1970. *Epidemiology- Principles and Methods*. Little Brown, Boston.

AST 576 STATISTICAL METHODS FOR LIFE SCIENCES 2(1+1)

Objective

This course focuses on statistical methods for discrete data collected in public health, clinical and biological studies including survival analysis. This would enable the students to understand the principles of different statistical techniques useful in public health and clinical studies conducted.

Theory

Block– I: Introduction to Life Sciences Models

Unit 1: Proportions and counts, contingency tables, logistic regression models, Poisson regression and log-linear models, models for polytomous data and generalized linear models.

Block– II: Survival Analysis

Unit 1: Computing techniques, numerical methods, simulation and general implementation of biostatistical analysis techniques with emphasis on data applications. Analysis of survival time data using parametric and non- parametric models, hypothesis testing, and methods for analyzing censored (partially observed) data with covariates. Topics include marginal estimation of a survival function, estimation of a generalized multivariate linear regression model (allowing missing covariates and/or outcomes).

Unit 2: Proportional Hazard model: Methods of estimation, estimation of survival functions, time-dependent covariates, estimation of a multiplicative intensity model (such as Cox proportional hazards model) and estimation of causal parameters assuming marginal structural models.

Block – III:Techniques and Different Algorithms

Unit 1: General theory for developing locally efficient estimators of the parameters of interest in censored data models. Rank tests with censored data. Computing techniques, numerical methods, simulation and general implementation of bio- statistical analysis techniques with emphasis on data applications.

Unit 2: Newton, scoring, and EM algorithms for maximization; smoothing methods; Bootstrapping; trees and neural networks; clustering; isotonic regression; Markov chain Monte Carlo methods.

Practical: Solving problems on above topics.

References

- BISWAS S. 2007. *Applied Stochastic Processes. A Biostatistical and Population Oriented Approach*. Wiley Eastern Ltd.
- COLLETT D. 2003. *Modeling Survival Data in Medical Research*. Chapman & Hall.
- COX D.R. AND OAKES D. 1984. *Analysis of Survival Data*. Chapman & Hall.
- HOSMER DW JR. AND LEMESHOW S. 1999. *Applied Survival Analysis: Regression Modeling or Time to Event*. John Wiley.
- KLEIN J.P. AND MOESCHBERGER M.L. 2003. *Survival Analysis: Techniques for Censored and Truncated Data*. Springer.

AST 577 STATISTICAL ECOLOGY 2(2+0)

Objective

This course is meant for exposing the students to the importance and use of statistical methods in collections of ecological data, species-

abundance relations, community classification and community interpretation.

Theory

Block– I: Introduction to Ecology

Unit 1: Ecological data, Ecological sampling; spatial pattern analysis: Distribution methods, Quadrant-variance methods, Distance methods.

Block – II: Species-abundance and Community classification

Unit 1: Species-abundance relations: Distribution models, Diversity indices; Species affinity: Niche-overlap indices, inter specific association, inter specific co variation.

Unit 2: Community classification: Resemblance functions, Association analysis, Cluster analysis; Community Ordination: Polar Ordination, Principal Component Analysis, Correspondence analysis, Nonlinear ordination.

Unit 3: Community interpretation: Classification Interpretation and Ordination Interpretation.

References

- GOTELLI N.J. AND ELLISON A.M. 2004. *A Primer of Ecological Statistics*
- PIELOU E.C. 1970. *An introduction to Mathematical Ecology*. John Wiley.
- REYNOLDS J.F. AND LUDWIG J.A. 1988. *Statistical Ecology: A Primer on Methods and Computing*. JohnWiley.
- YOUNG L.J., YOUNG J.H. AND YOUNG J. 1998. *Statistical Ecology: A Population Perspective*. Kluwer.

AST 578 NON- PARAMETRIC METHODS 2(1+1)

Objective

This course is meant for exposing the students the need for Non parametric Statistical Inference whenever the parametric model violates or un-specify the probability law .

Theory

Block I : Introduction to Nonparametric tests

Unit I: Parametric v/s Nonparametric tests, Assumptions underlying non-parametric tests. Scales of measurements, merits and demerits. Power efficiency of tests.

Block -II : Advanced Nonparametric test

Unit I: One sample tests: Binomial, chi-square, Kolmogorov-Smirnov and run test. Two related sample tests: McNemar tests, Sign test and wilcoxon's Matched pair sign-rank test. Two independent sample tests: Fishers exact probability test, Chi-square test, Median test, Kolmogorov-Smirnov two sample tests, Mann-Whitney U test.

Unit II: K-related samples tests: Cochran's test, Friedmans Two ways ANOVA by ranks, K-independent sample tests: Kruskal walli's one way ANOVA by ranks, Chi-square test, and median test.

Unit III: Measures of association- Coefficient of Contingency, Phi coefficient and Cramer's coefficients.Spearman's rank correlation, Kendall's coefficient of correlation, Kendall's coefficient of Concordance, Mann –Kendall trend test.

Practical

Solving Problems on above topics.

References

- CONOVER, W.J. (1980): Practical: Nonparametric Statistics, 2nd Edition, Wiley, New York.
- GIBBONS, J.D (1985):Non-parametric Methods for Quantitative Analysis, 2nd ed., American Sciences Press.
- GIBBONS, J.D (1992):Non-parametric Statistics: An introduction, SAGE Publications Inc.
- GIBBONS, J.D., AND S. CHAKRABORTI. (2003): Nonparametric Statistics Inference, 4th Edition, Marcel Dekker.

- HOLLANDER, M., AND D. A. WOLFE (1990): Nonparametric Statistical Methods, 2nd edition. New York: John Wiley & Sons.
- KENDALL, M.G. (1970): Rank Correlation Methods, 4th Ed., Griffin.

AST 501 MATHEMATICS FOR APPLIED SCIENCES 2(2+0)

Objective

This course is meant for students who do not have sufficient background of Mathematics. The students would be exposed to elementary mathematics that would prepare them to study their main courses that involve knowledge of Mathematics. The students would get an exposure to Linear Algebra, differentiation, integration and differential equations etc.

Theory

Block -I : Set Theory and Vector Calculus

Unit 1: Set theory-set operations, finite and infinite sets, operations of set, functions of sets.

Unit 2: Vectors and vector spaces, Matrices notations and operations, laws of matrix algebra; transpose and inverse of matrix, Eigen values and Eigen vectors. Determinants - evaluation and properties of determinants, Solutions of Linear Equations.

Block -II : Differential Calculus

Unit 1: Variables and functions, limits and continuity of functions. Differentiation: theorems of differentiation, differentiation of logarithmic, trigonometric, exponential and inverse functions, Differentiation of function of a function, derivatives of higher order, partial derivatives. Application of derivatives, determination of points of inflexion, maxima and minima.

Block -III: Integral Calculus

Unit 1: Integration, methods of integration, reduction formulae, definite and indefinite integral, Applications of integration in Agriculture, Differential Equations.

Practical:

Solving problems on above topics.

References

- HOHN F. E. 2013. *Elementary Matrix Algebra*, 3rd Ed., Kindle Edition
- HARVILLE D. A. 1997. *Matrix Algebra from a Statistician's Perspective*. Springer.
- HOHN F. E. 1973. *Elementary Matrix Algebra*. Macmillan.
- SEARLE S. R. 1982. *Matrix Algebra Useful for Statistics*. John Wiley. Stewart J. 2007. *Calculus*. Thompson.
- THOMAS G.B. JR. AND FINNEY R.L. 1996. *Calculus.* 9th Ed. Pearson Edu.

AST 502 STATISTICAL METHODS FOR APPLIED SCIENCES 4(3+1)

Objective

This course is meant for students who do not have sufficient background of Statistical Methods. The students would be exposed to concepts of statistical methods and statistical inference that would help them in understanding the importance of statistics. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation. The students would get an exposure to presentation of data, probability distributions, parameter estimation, tests of significance, regression and multivariate analytical techniques.

Theory

Block-I : Introduction to Statistics

Unit 1: Review of probability-Addition and Multiplication Theorems, Baye's Theorem, Random variable and mathematical expectation.

Unit 2: Discrete and continuous probability distributions, Binomial, Poisson, Normal distribution and their applications in Agriculture. Correlation-Simple multiple, partial and rank correlation. Regression-

Simple and multiple linear regression. Coefficient of determination, Fitting of Quadratic model.

Block -II : Sampling Distribution and ANOVA

Unit 1: Introduction to Sampling Techniques- SRS, Stratified and Systematic sampling. Concept of sampling distribution, Introduction to theory of estimation-Point and interval estimation. Tests of significance based on Normal, Student-t, chi-square and F distributions. Test of significance for correlation and regression coefficients.

Unit 2: Introduction to ANOVA: One way, Two Way with single and multiple observations per cell.

Block -III : Non-Parametric Test

Unit 1: Introduction to Non-parametric tests –Scales of Measurement, Sign, and Wilcoxon Mann-Whitney U-test, Run test and Median test.

Practical

- Problems on Probability and probability distributions
- Fitting of Binomial, Poisson and Normal distributions
- Correlation and regression analysis, fitting of liinear and Quadratic regression models
- Problems on sampling distribution and setting of confidence intervals
- Testing of hypothesis based on Large sample tests- Normal test and exact sampling distributions – Student- t, Chi- square, and F tests.
- ANOVA: One way, Two way, Two Way ANOVA with single and multiple observations per cell.
- Problems on Non-parametric tests.

References

- GOON A.M, GUPTA M.K AND DASGUPTA B. 1977. *An Outline of Statistical Theory*. Vol. I. The World Press.

- GOON A.M, GUPTA M.K. AND DASGUPTA B. 1983. *Fundamentals of Statistics*. Vol. I. The World Press.
- HOEL P.G. 1971. *Introduction to Mathematical Statistics*. John Wiley.
- HOGG R.V AND CRAIG T.T. 1978. *Introduction to Mathematical Statistics*. Macmillan.
- MORRISON D.F. 1976. *Multivariate Statistical Methods*. McGraw Hill.
- HOGG RV, MCKEAN JW, CRAIG AT. 2012. *Introduction to Mathematical Statistics* 7th Edition.
- SIEGEL S, JOHAN N & CASELLAN JR. 1956. *Non-parametric Tests for Behavior Sciences*. John Wiley.
- ANDERSON TW. 2009. *An Introduction to Multivariate Statistical Analysis*, 3rd Ed . John Wiley

AST 511 EXPERIMENTAL DESIGNS 3(2+1)

Objective

This course is meant for students of agricultural and animal sciences other than Agricultural Statistics. Designing an experiment is an integrated component of research in almost all sciences. The students would be exposed to concepts of Design of Experiments so as to enable them to understand the concepts involved in planning, designing their experiments and analysis of experimental data.

Theory

Block -I : Basic Designs

Unit 1: Need for designing of experiments, characteristics of a good design. Basic principles of designs- Randomization, Replication and Local control.

Unit 2: Uniformity trials, size and shape of plots and BLOCKs, Analysis of variance, completely randomized design, Randomized BLOCK design and Latin square design. Missing plot technique and

relative efficiency in randomized BLOCK and Latin square designs. Analysis of covariance, Transformations of data.

Block -II : Factorial Experiments and Incomplete BLOCK Designs

Unit 1: Factorial experiments, (symmetrical as well as asymmetrical). Orthogonality and partitioning of degrees of freedom. Concept of confounding- complete and partial confounding.

Unit 2: Split plot and Strip plot designs. Balanced Incomplete BLOCK Design, resolvable designs and their applications, Lattice design: concepts, randomization procedure, analysis and interpretation of results.

Practical

- Uniformity trial data analysis, formation of plots and BLOCKs, Fairfield Smith Law,
- Analysis of data obtained from CRD, RBD and LSD
- Missing plot techniques and relative efficiency of RBD and LSD.
- Problems on ANCOVA and data transformation
- Analysis of factorial experiments- Symmetrical and Asymmetrical
- Analysis of Confounding experiments - complete and partial confounding.
- Split plot and strip plot designs.
- Problems on BIBD and Lattice designs.

References

- COCHRAN WG AND COX GM. 1957. *Experimental Designs*. 2nd Ed. John Wiley.
- DEAN AM AND VOSS D. 1999. *Design and Analysis of Experiments*. Springer.
- MONTGOMERY DC. 2012. *Design and Analysis of Experiments*, 8th Ed. John Wiley.
- FEDERER WT. 1985. *Experimental Designs*. MacMillan.

- FISHER RA. 1953. *Design and Analysis of Experiments*. Oliver & Boyd.
- NIGAM AK AND GUPTA VK. 1979. *Handbook on Analysis of Agricultural Experiments*. IASRI Publ.
- PEARCE SC. 1983. *The Agricultural Field Experiment: A Statistical Examination of Theory and Practice*. John Wiley.

AST 512 BASIC SAMPLING TECHNIQUES 3(2+1)

Objective

This course is meant for students of agricultural and animal sciences other than Statistics. The students would be exposed to elementary sampling techniques. It would help them in understanding the concepts involved in planning and designing their surveys, presentation of survey data analysis of survey data and presentation of results. This course would be especially important to the students of social sciences.

Theory

Block -I : Fundamentals of Sampling Techniques

Unit 1: Concept of sampling, sample survey vs complete enumeration, planning of sample survey, sampling from a finite population.

Unit 2: Simple random sampling with and without replacement, sampling for proportion, determination of sample size, inverse sampling, Stratified sampling.

Block – II :Advanced Sampling Techniques

Unit 1: Cluster sampling, Multi-stage sampling, systematic sampling; Introduction to PPS sampling,

Unit 2: Use of auxiliary information at estimation, Ratio product and regression estimators. Double Sampling, sampling and non-sampling errors

Practical

- Random sampling ~ use of random number tables, concepts of unbiasedness, variance, etc.

- Simple random sampling, determination of sample size, inverse sampling, stratified sampling, cluster sampling and systematic sampling
- Estimation using ratio and regression estimators;
- Estimation using multistage design, double sampling

References

- COCHRAN WG. 1977. *Sampling Techniques*. John Wiley.
- MURTHY MN. 1977. *Sampling Theory and Methods*. 2nd Ed. Statistical Publ. Soc., Calcutta.
- SINGH D, SINGH P AND KUMAR P. 1982. *Handbook on Sampling Methods*. IASRI Publ.
- SUKHATME P. V, SUKHATME B. V, SUKHATME S AND ASOK C. 1984. *Sampling Theory of Surveys with Applications*. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.
- COCHRAN WG. 2007. *Sampling Techniques*, 3rd Edition. John Wiley & Sons Publication

AST 521 APPLIED REGRESSION ANALYSIS 3(2+1)

Objective

This course is meant for students of all disciplines including agricultural and animal sciences. The students would be exposed to the concepts of correlation and regression. Emphasis will be laid on diagnostic measures such as autocorrelation, multi collinearity and heteroscedasticity. This course would prepare students to handle their data for analysis and interpretation.

Theory

Block– I: Introduction to correlation and Regression

Unit 1: Introduction to correlation analysis and its measures, Correlation from grouped data, correlation, Rank correlation, Testing of population correlation coefficients; Multiple and partial correlation coefficients and their testing.

Block – II: Variable Selection and Checking

Unit 1: Problem of correlated errors; Auto correlation; Heteroscedastic models, Durbin Watson Statistics; Removal of auto correlation by transformation; Analysis of collinear data; Detection and correction of multi collinearity, Regression analysis; Simple, Multiple and partial Regression Method of least squares for curve fitting; Testing of regression coefficients.

Unit 2: Diagnostic of multiple regression equation; Concept of weighted least squares; regression equation on grouped data; Various methods of selecting the best regression equation.

Block – III: Nonlinear Regression Models

Unit 1: Concept of nonlinear regression and fitting of quadratic, exponential and power curves.

Practical

- Correlation coefficient, various types of correlation coefficients, partial and multiple, testing of hypotheses;
- Multiple linear regression analysis, partial regression coefficients, testing of hypotheses, residuals and their applications in outlier detection
- Handling of correlated errors, multi collinearity;
- Fitting of quadratic, exponential and power curves.
- Problems on Autocorrelation.

References

- KLEINBAUM D. G, KUPPER L. L, NIZAM A. 2007. *Applied Regression Analysis and Other Multivariable Methods* (Duxbury Applied) 4th Ed.
- DRAPER N. R AND SMITH H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.
- EZEKIEL M. 1963. *Methods of Correlation and Regression Analysis*. John Wiley.
- KOUTSOYIANNIS A. 1978. *Theory of Econometrics*. Mac Millan.

• KUTNER M. H, NACHTSHEIM C. J AND NETER J. 2004. *Applied Linear Regression Models*. 4th Ed. With Student CD. McGraw Hill.

MCA 501 COMPUTER FUNDAMENTALS AND PROGRAMMING 3(2+1)

Objective

This is a course on Computer Fundamentals and Programming that aims at exposing the students to understand how computer works, analytical skills to solve problems using computers. And to write computer programs using C.

Theory

Block-I : Computer Fundamentals

Unit 1: Functional units of computer, I/O devices, primary and secondary memories. Number systems: decimal, octal, binary and hexadecimal; Representation of integers, fixed and floating point numbers, Operator precedence, character representation; ASCII, Unicode.

Block-II : Introduction to C Programming Language

Unit 1: Programming Fundamentals with C - Algorithm, techniques of problem solving, flowcharting, stepwise refinement; Constants and variables; Data types: integer, character, real, data types; Arithmetic expressions, assignment statements, logical expressions. Control flow.

Unit 2: Arrays and structures. Pointers, dynamic memory allocations.

Unit 3: Program Structures – functions, subroutines.

Unit 4: I/O operations, Program correctness; Debugging and testing of programs.

Practical

- Conversion of different number types;
- Creation of flow chart, conversion of algorithm/flowchart to program;

- Mathematical operators, operator precedence;
- Sequence, control and iteration;
- Arrays and string processing;
- Matrix operations, Sorting, Pointers and File processing – Reading and writing text files.

References

- BALAGURUSWAMY E. 2019. *Programming with ANSI C*. Tata McGraw Hill.
- GOTTFRIED B. 2017. *Programming with C, Schaum Outline Series*. Tata McGraw Hill.
- KANETKAR Y. 1999. *Let Us C*. BPB Publ.
- MALVINO A. P. AND BROWN J. A.. 2017. *Digital Computer Electronics*. Tata Mc Graw Hill.
- MANO M. M. 1999. *Digital Logic and Computer Design*. Prentice Hall of India.

MCA 502 COMPUTER ORGANIZATION AND ARCHITECTURE 2(2+0)

Objective

This is a course on Computer Organization and Architecture that aims at exposing the students to understand basic knowledge of how computer works.

Theory

Block -I : Introduction to Digital Electronics

Unit 1: Number systems; Boolean algebra - minimization of Boolean function using Karnaugh Map.

Unit2: Logic Gates, Combinational circuits – multiplexer, de-multiplexer, encoder, decoder; Sequential circuits: Flip-flops, Half and Full adder, Shift register, Counters.

Block-II : Basic Computer Organization and Design

Unit 1: Organization of CPU, Control Unit- Instruction and Execution cycle in CPU, Register Organization, The Instruction Cycle, Instruction Pipelining.

Unit 2: Memory organization - Internal memory: Semiconductor Main Memory (RAM, ROM, EPROM), Cache Memory, Advanced DRAM Organization; External Memory - Magnetic Disks, RAID, Optical Memory, Magnetic Tape.

Unit 3: Basic structure of computer hardware and system software – Addressing methods and machine programme sequencing; Input-output organizations - accessing I/O devices - direct memory access (DMA) – interrupts.

Block III : Microprocessors

Unit 1: Introduction to microprocessors – CISC and RISC Architecture, Study of functional units of microprocessors.

References

- GEAR C.W. 1974. *Computer Organization and Programming*. McGraw Hill.
- HAYES J.P. 1988. *Computer Architecture and Organisation*. McGraw Hill.
- MALVINO A.P AND BROWN J.A. 1999. *Digital Computer Electronics*. Tata McGraw Hill.
- MANO M.M. 1999. *Digital Logic and Computer Design*. Prentice Hall of India.
- MANO M.M. 2007. *Computer System Architecture*. Prentice Hall of India.
- Stallings W. 2016. *Computer Organization and Architecture: Designing for Performance*.Pearson Edu.

MCA 511 INTRODUCTION TO COMMUNICATION TECHNOLOGIES, 2(1+1)

COMPUTER NETWORKING AND INTERNET APPLICATIONS

Objective

This is a course on Introduction to Networking and Internet Applications that aims at exposing the students to understand Computer networking and web applications development.

Theory

Block –I : Introduction to Computer web networking and web Technology

Unit 1: Networking fundamentals, types of networking, network topology; Introduction to File Transfer Protocol (FTP), Telnet, Simple Mail Transfer Protocol (SMTP), Internet Protocol v4 & v6. Network infrastructure and 59 Security-switches, routers, firewall, intranet, internet, Virtual Private Network.

Unit 2: World Wide Web (WWW), working with Internet; Web pages, web sites, web servers; Web Applications.

Block- II : Introduction to HTML

Unit 1: Hyper Text Markup Language (HTML), DHTML, web based application development. Static websites, dynamic websites. Client Side processing – scripting languages, Jquery. Server Side processing ASP.NET/JSP.

Practical

Network and mail configuration; Using Network Services; Browsing of Internet; Creation of web pages; Creation of websites using HTML and scripting languages.

References

- COX V, WERMERS L AND REDING E.E. 2006. *HTML Illustrated Complete*. 3rd Ed. Course Technology.
- NIEDERST J. 2001. *Web Design in a Nutshell*. O'Reilly Media.
- TANENBAUM A.S. 2003. Computer Networks. *Prentice* Hall of India.

MCA 512 INFORMATION TECHNOLOGY IN AGRICULTURE 2(2+0)

Objective

This is a course on Introduction to Networking and Internet Applications that aims at exposing the students to understand analogy of computer, basic knowledge of MS Office. Also to understand Internet and WWW, use of IT application and different IT tools in Agriculture.

Theory

Block- I : Computer Fundamentals

Unit 1: Introduction to Computers, Anatomy of computer, Operating Systems, definition and types, Applications of MS Office for document creation & Editing, Data presentation, interpretation and graph creation, statistical analysis, mathematical expressions.

Block – II : Introduction to DBMS and C Programming Language

Unit 1: Database, concepts and types, uses of DBMS in Agriculture, World Wide Web (WWW): Concepts and components, Introduction to computer programming languages, concepts and standard input/output operations. e-Agriculture, concepts and applications,

Block –III : ICT in Agriculture

Unit 1: Use of ICT in Agriculture, Computer Models for understanding plant processes. IT application for computation of water and nutrient requirement of crops, Computer controlled devices (automated systems) for Agri - input management, Smartphone Apps in Agriculture for farm advises, market price, postharvest management etc.,

Unit 2: Geospatial technology for generating valuable agri - information. Decision support systems, concepts, components and applications in Agriculture, Agriculture Expert System, Soil Information Systems etc. for supporting Farm decisions, Preparation of contingent crop-planning using IT tools.

References

- VANITHA G. 2011. *Agro-informatics*
- http://www.*agrimoon*.com
- http://www.agriinfo.in
- http://www.eagri.org
- http://www.agriglance.com
- http://agritech.tnau.ac.in

AST 551 MATHEMATICS-I 3(2+1)

Objective

This course lays the foundation of all other courses of Agricultural Statistics discipline by preparing them to understand the importance of mathematical methods in research. The students would be exposed to the basic mathematical tools of real analysis, calculus, differential equations and numerical analysis. This would prepare them to study their main courses that involve knowledge of Mathematics.

Theory

Block -I : Differential Calculus

Unit 1: Calculus: Limit and continuity, differentiation of functions, successive differentiation, partial differentiation, mean value theorems, Taylor and Maclaurin's series. Application of derivatives, L'hospital's rule.

Unit 2: Real Analysis: Convergence and divergence of infinite series, comparison test- D'Alembert's, Ratio - test, Cauchy's root test, Raabe's test, Kummer's test, Gauss test. Absolute and conditional convergence. Riemann integration, Lebesgue integration, power series, Fourier series, Laplace transformation, multiple integrals. Integration of rational, irrational and trigonometric functions. Application of integration.

Block-II : Differential equations and Numerical Analysis

Unit 1: Differential equation: Differential equations of first order, linear differential equations of higher order with constant coefficient.

Unit 2: Numerical Analysis: Simple interpolation, Divided differences, Numerical differentiation and integration.

Practical

Solving problems on above topics.

References

- BARTLE RG. 1976. *Elements of Real Analysis*. John Wiley. Chatterjee SK. 1970. *Mathematical Analysis*. Oxford & IBH.
- GIBSON GA. 1954. *Advanced Calculus*. Macmillan.
- HENRICE P. 1964. *Elements of Numerical Analysis*. John Wiley.
- HILDEBRAND FB. 1956. *Introduction to Numerical Analysis*. Tata McGraw Hill.
- PRIESTLEY HA. 1985. *Complex Analysis*. Clarenton Press.
- RUDIN W. 1985. *Principles of Mathematical Analysis*. McGraw Hill. Sauer T. 2006. *Numerical Analysis With CD-Rom*. Addison Wesley. Scarborough JB. 1976. *Numerical Mathematical Analysis*. Oxford & IBH. Stewart J. 2007. *Calculus.*Thompson

AST 561 MATHEMATICS-II 2(1+1)

Objective

This is another course that supports all other courses in Agricultural Statistics. The students would be exposed to the advances in Linear Algebra and Matrix theory. This would prepare them to study their main courses that involve knowledge of Linear Algebra and Matrix Algebra.

Theory

Block -I : Linear Algebra and Graph Theory

Unit 1: Linear Algebra: Group, ring, field and vector spaces, Sub-spaces, basis, Gram Schmidt's orthogonalization, Galois field - Fermat's theorem and primitive elements. Linear transformations. Graph theory: Concepts and applications.

Block – II: Matrix Algebra and its Applications

Unit 1: Matrix Algebra: Basic terminology, linear independence and dependence of vectors. Row and column spaces, Echelon form. Determinants, Trace of matrices rank and inverse of matrices. Special matrices – idempotent, symmetric, orthogonal. Eigen values and eigen vectors, Spectral decomposition of matrices.

Unit 2: Unitary, Similar, Hadamard, Circulant, Helmert's matrices. Kronecker and Hadamard product of matrices, Kronecker sum of matrices. Sub-matrices and partitioned matrices, Permutation matrices, full rank factorization, Grammian root of a symmetric matrix. Solutions of linear equations, Equations having many solutions.

Unit 3: Generalized inverses, Moore-Penrose inverse, Applications of g-inverse. Inverse and Generalized inverse of partitioned matrices, Differentiation and integration of vectors and matrices, Quadratic forms.

Practical

Solving problems on above topics

References

- ASCHBACHER M. 2000. *Finite Group Theory*. Cambridge University Press.
- DEO N. 1984. *Graph Theory with Application to Engineering and Computer Science*. Prentice Hall of India.
- GENTLE JE. 2007. *Matrix Algebra: Theory, Computations and Applications in Statistics*. Springer.
- GRAYBILL FE.1961. *Introduction to Matrices with Applications in Statistics*. Wadsworth Publ.
- HADLEY G. 1969. *Linear Algebra*. Addison Wesley.

AST 574 TIME SERIES ANALYSIS 2(1+1)

Objective

This course is meant to teach the students the concepts involved in time series data. They would also be exposed to components of time series, stationary models and forecasting/ projecting the future scenarios

based on time series data. It would also help them in understanding the concepts involved in time series data presentation, analysis and interpretation.

Theory

Block– I : Introduction to Time Series and its Models

Unit 1: Components of a time-series. Autocorrelation and Partial autocorrelation functions, Correlogram and periodogram analysis.

Unit 2: Linear stationary models: Autoregressive, moving average and mixed processes. Linear non-stationary models: Autoregressive integrated moving average processes.

Block - II: Forecasting and Model Selection Criteria

Unit 1: Forecasting: Minimum mean square forecasts and their properties, calculating and updating forecasts.

Unit 2: Model identification: Objective:::s, Techniques, and Initial estimates. Model estimation: Likelihood function, Sum of squares function, Least squares estimates. Seasonal models. Intervention analysis models and Outlier detection.

Practical

- Time series analysis, autocorrelations, correlogram and periodogram;
- Linear stationary model; Linear non-stationary model; Model identification and model estimation;
- Intervention analysis and outlier detection.

References

- BOX GEP, JENKINS GM AND REINSEL GC. 2007. *Time Series Analysis: Forecasting and Control*. 3rd Ed. Pearson Edu.
- BROCKWELL P.J AND DAVIS R.A. 2002. *Introduction to Time Series and Forecasting*. 2nd Ed. Springer.
- CHATTERJEE S, HADI A AND PRICE B.1999. *Regression* Analysis by Examples. John Wiley.

- DRAPER N. R AND SMITH H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.
- JENKINS, G. M, REINSEL, G. C, GRETA M. L,GEORGE E.P.B. 2015. *Time Series Analysis: Forecasting and Control*, Wiley Series in Probability and Statistics.
- JOHNSTON J. 1984. *Econometric Methods*. McGraw Hill.

M.Sc. (Agri.) in Agronomy

Course Code	Course Title	Credit Hours
AGR 501	Modern Concepts in Crop Production	3 (3+0)
AGR 502	Principles and Practices of Soil Fertility and Nutrient Management	3 (2+1)
AGR 503	Principles and Practices of Weed Management	3 (2+1)
AGR 504	Principles and Practices of Water Management	3 (2+1)
AGR 505	Conservation Agriculture	2 (1+1)
AGR 506	Agronomy of Major Cereals and Pulses	2 (1+1)
AGR 507	Agronomy of Oilseed, Fibre and Sugar Crops	3 (2+1)
AGR 508	Agronomy of Medicinal, Aromatic & Underutilized Crops	3 (2+1)
AGR 509	Agronomy of Fodder and Forage Crops	3 (2+1)
AGR 510	Agrostology and Agro- Forestry	3 (2+1)
AGR 511	Cropping System and Sustainable Agriculture	2 (2+0)
AGR 512	Dryland Farming and Watershed Management	3 (2+1)
AGR 513	Principles and Practices of Organic Farming	3 (2+1)
AGR 514	Research Techniques in Agronomy	2 (1+1)
	Total	**38 (26+12)**
AGR 580	Qualifying Examination	2 (0+2)
AGR 581	Seminar - I	1 (0+1)
AGR 582	Seminar - II	1 (0+1)
AGR 591	Research - I	13 (0+13)
AGR 592	Research - II	14 (0+14)

AGR 501 MODERN CONCEPTS IN CROP PRODUCTION (3+0)

Objective

To teach the basic concepts of soil management and crop production.

Theory

Block I: Agro-biological principles

Unit 1: Crop growth analysis in relation to environment; geo-ecological zones of India.

Unit 2: Quantitative agro-biological principles and inverse yield nitrogen law; Mitscherlich yield equation, its interpretation and applicability; Baule unit.

Unit 3: Effect of lodging in cereals; physiology of grain yield in cereals; optimization of plant population and planting geometry in relation to different resources, concept of ideal plant type and crop modeling for desired crop yield.

Block II: Scientific principles of crop production

Unit 1: Scientific principles of crop production; crop response production functions; concept of soil plant relations; yield and environmental stress, use of growth hormones and regulators for better adaptation in stressed condition.

Unit 2: Integrated farming systems, organic farming, and resource conservation technology including modern concept of tillage; dry farming; determining the nutrient needs for yield potentiality of crop plants, concept of balance nutrition and integrated nutrient management; precision agriculture. Modern crop production concepts: soil less cultivation, Aeroponic, Hydroponic, Robotic and terrace farming. Use of GIS, GPS and remote sensing in modern agriculture, precision farming and protected agriculture.

References

- BALASUBRAMANIYAN, P. AND PALANIAPPAN, S. P., 2001, *Principles and Practices of Agronomy*. Agrobios.
- FAGERIA N. K. 1992. *Maximizing Crop Yields*. Marcel Dekker.
- HAVLIN J. L., BEATON J. D., TISDALE S. L. AND NELSON W. L. 2006. *Soil Fertility and Fertilizers.* 7th Ed. Prentice Hall.
- PARODA R. S. 2003. *Sustaining our Food Security*. Konark Publ.

- REDDY, . S. R., 2000. *Principles of Crop Production*. Kalyani Publ.
- SANKARAN S. AND MUDALIAR T. V. S. 1997, *Principles of Agronomy*. The Bangalore Printing & Publ.
- SINGH S. S. 2006, *Principles and Practices of Agronomy*. Kalyani.
- ALVIN P. T. AND KOZLOWSKI T. T. (ed.). 1976, *Ecophysiology of Tropical Crops*. Academia Pul., NewYork.
- GARDNER P. P, PEARCE G. R. AND MITCHE LLRL. 1985, *Physiology of Crop Plants*. Scientific Pub. Jodhpur.
- LALR., 1989, *Conservationtillage for sustainable agriculture: Tropic sversus Temperate Environments. Advances in Agronomy*42:85-197.
- WILSIE C. P. 1961, *Crop Adaptation and Distribution*. Euresia Pub., New Delhi.

AGR 502 PRINCIPLES AND PRACTICES OF SOIL FERTILITY AND NUTRIENT MANAGEMENT (2+1)

Objective

To impart knowledge of fertilizers and manures as sources of plant nutrients and appraise about the integrated approach of plant nutrition and sustainability of soil fertility.

Theory

Block 1: Basic concepts of Soil fertility and Essential plant nutrients

Unit 1: Soil fertility and productivity - factors affecting; features of good soil management; problems of supply and availability of nutrients; relation between nutrient supply and crop growth; organic farming - basic concepts and definitions.

Unit 2: Criteria of essentiality of nutrients; Essential plant nutrients – their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients.

Block 2: Manures and Fertilizers

Unit 1: Preparation and use of farmyard manure, compost, green

manures, vermi compost, bio fertilizers and other organic concentrates their composition, availability and crop responses; recycling of organic wastes and residue management.

Unit 2: Commercial fertilizers; composition, relative fertilizer value and cost; crop response to different nutrients, residual effects and fertilizer use efficiency; agronomic, chemical and physiological, fertilizer mixtures and grades; methods of increasing fertilizer use efficiency; nutrient interactions.

Unit 3: Time and methods of manures and fertilizers application; foliar application and its concept; relative performance of organic and inorganic nutrients; economics of fertilizer use; integrated nutrient management; use of vermi-compost and residue wastes in crops.

Practical

- Determination of soil pH and soil EC
- Determination of soil organic C
- Determination of available N, P, K and S of soil
- Determination of total N, P, K and S of soil
- Determination of total N, P, K, S in plant
- Determination of selected micronutrients in soil & plant
- Computation of optimum and economic yield

References

- BRADY, N.C AND WEIL, R.R. 2002. *The Nature and Properties of Soils.* 13th Ed. Pearson Edu.
- FAGERIA, N.K, BALIGAR, V.C AND JONES, C.A. 1991. *Growth and Mineral Nutrition of Field Crops.* Marcel Dekker.
- HAVLIN, J.L, BEATON, J.D, TISDALE S.L AND NELSON W.L. 2006. *Soil Fertility and Fertilizers.* 7thEd. Prentice Hall.
- PRASAD, R AND POWER, J.F. 1997. *Soil Fertility Management for Sustainable Agriculture*. CRC Press.

• YAWALKAR, K. S, AGRAWAL, J. P AND BOKDE S. 2000. *Manures and Fertilizers*. Agri-HortiPubl.

AGR 503 PRINCIPLES AND PRACTICES OF WEED MANAGEMENT (2+1)

Objective

To familiarize the students about the weeds, herbicides and methods of weed control.

Theory

Block I: Weed ecology and classification

Unit 1: Weed biology, and ecology and classification, crop-weed competition including allelopathy; principles and methods of weed control and management; weed indices, weed shift in different eco-systems.

Unit 2: Herbicides introduction and history of their development; classification based on chemical, physiological application and selectivity; mode and mechanism of action of herbicides.

Unit 3: Herbicide structure - activity relationship; factors affecting the efficiency of herbicides; herbicide formulations, herbicide mixtures, sequential application of herbicides, rotation; weed control through use of nano-herbicides and bio-herbicides, myco-herbicides bio-agents and allelo chemicals; movement of herbicides in soil and plant, Degradation of herbicides in soil and plants; herbicide resistance crops, residue, persistence and management; development of herbicide resistance in weeds and their management, herbicide combinations and rotation.

Block II: Weed management in crops

Unit 1: Weed management in major crops and cropping systems; alien, invasive and parasitic weeds and their management; weed shifts in cropping systems; aquatic and perennial weed control; weed control in non-crop area.

Unit 2: Integrated weed management; recent developments in weed management- robotics, use of drones and aeroplanes, cost: benefit analysis of weed management.

Practical

- Identification of important weeds of different crops, Preparation of a weed herbarium, Weed survey in crops and cropping systems, Crop-weed competition studies, Weed indices, calculation and interpretation with data, Preparation of spray solutions of herbicides for high and low-volume sprayers, Use of various types of spray pumps and nozzles and calculation of swath width, Economics of weed control, Herbicide resistance analysis in plant and soil.
- Bioassay of herbicide resistance and residues,
- Calculation of herbicide requirement

References

- BÖGER, PETER, WAKABAYASHI, KO, HIRAI, KENJI (Eds.). 2002. *Herbicide Classes in Development*. *Mode of Action*, *Targets*, *Genetic Engineering*, *Chemistry*. Springer.
- CHAUHAN, B AND MAHAJAN, G. 2014. *Recent Advances in Weed Management*. Springer.
- DAS, T. K. 2008. *Weed Science :Basics and Applications*, Jain Brothers (New Delhi).
- FENNIMORE, STEVEN, A. AND BELL, CARL. 2014. *Principles of Weed Control*, 4thEd, California Weed Sci . Soc.
- GUPTA, O. P. 2007. *Weed Management*: *Principles and Practices*, 2ndEd.
- JUGULAN, MITHILA (ed). 2017. *Biology, Physiology and Molecular Biology of Weeds*. CRC Press.
- MONACO, T. J, WELLER, S. C. AND ASHTON, F. M. 2014. *Weed Science Principles and Practices*, Wiley
- POWLES, S. B AND SHANER, D. L. 2001. Herbicide Resistance and World Grains, CRC Press.

- WALIA, U. S. 2006. *Weed Management*, Kalyani.
- ZIMDAHL, R.L.(ed).2018. *Integrated Weed Management for Sustainable Agriculture, B.D.Sci.Pub.*

AGR 504 PRINCIPLES AND PRACTICES OF WATER MANAGEMENT (2+1)

Objective

To teach the principles of water management and practices to enhance the water productivity

Theory

Block I: Water resources and its utilization

Unit 1: Water and its role in plants; Irrigation: Definition and objectives, water resources and irrigation development in India and concerned state, major irrigation projects, extent of area and crops irrigated in India and in different states.

Unit 2: Field water cycle, water movement in soil and plants; transpiration; soil-water plant relationships; water absorption by plants; plant response to water stress, crop plant adaptation to moisture stress condition. Water availability and its relationship with nutrient availability and losses.

Unit 3: Soil, plant and meteorological factors determining water needs of crops, scheduling, depth and methods of irrigation; micro irrigation systems; deficit irrigation; fertigation; management of water in controlled environments and polyhouses. Irrigation efficiency and water use efficiency.

Block II: Water management in crops and cropping systems

Unit 1: Water management of crop and cropping system, Quality of irrigation water and management of saline water for irrigation, water use efficiency, Crop water requirement- estimation of ET and effective rainfall; Water management of the major crops and cropping systems. Automated irrigation system.

Unit 2: Excess of soil water and plant growth; water management in problem soils, drainage requirement of crops and methods of field drainage, their layout and spacing; rain water management and its utilization for crop production.

Unit 3: Quality of irrigation water and management of saline water for irrigation, water management in problem soils.

Unit 4: Soil moisture conservation, water harvesting, rain water management and its utilization for crop production.

Unit 5: Hydroponics

Practical

- Determination of Field capacity by field method
- Determination of Permanent Wilting Point by sunflower pot culture technique
- Determination of Field capacity and Permanent Wilting Point by Pressure Plate Apparatus
- Determination of Hygroscopic Coefficient
- Determination of maximum water holding capacity of soil
- Measurement of matric potential using gauge and mercury type tensiometer
- Determination of soil-moisture characteristics curves
- Determination of saturated hydraulic conductivity by constant and falling head method
- Determination of hydraulic conductivity of saturated soil below the water table by auger hole method
- Measurement of soil water diffusivity
- Estimation of unsaturated hydraulic conductivity
- Estimation of upward flux of water using tensiometer and from depth ground water table

References

- MAJUMDAR, D.K. 2014. *Irrigation Water Management: Principles and Practice*. PHL Learning private publishers
- MUKUND JOSHI AND PRABHAKARA SHETTY, T. K. 2013. *A Text Book of Irrigation and Water Management Hardcover*, Kalyani publishers
- LENKA, D.1999. *Irrigation and Drainage*. Kalyani.
- MICHAEL, A. M. 1978. *Irrigation: Theory and Practice*. Vikas Publ.
- PALIWAL, K. V. 1972. *Irrigation with Saline Water*. IARI Monograph, New Delhi.
- PANDA, S. C. 2003. *Principles and Practices of Water Management*. Agrobios.
- PRIHAR, S. S. AND SANDHU, B. S. 1987. *Irrigation of Food Crops – Principles and Practices*. ICAR.
- REDDY, S. R. 2000. *Principles of Crop Production*. Kalyani.
- SINGH PRATAP AND MALIWA LPL. 2005. *Technologies for Food Security and Sustainable Agriculture*. Agrotech Publ.

AGR 505 CONSERVATION AGRICULTURE (1+1)

Objective

To impart knowledge of conservation agriculture for economic development.

Theory

Block I: Basic concepts of conservation agriculture

Unit 1: Conventional and conservation agriculture systems, sustainability concerns, conservation agriculture: Historical background and present concept, global experiences, present status in India.

Unit 2: Nutrient management in CA, water management, weed management, energy use, insect-pest and disease management, farm machinery, crop residue management, cover crop management.

Block II: Impact of conservation agriculture

Unit 1: Climate change mitigation and CA, C-sequestration, soil health management, soil microbes and CA.

Unit 2: CA in agro forestry systems, rainfed / dryland regions.

Unit 3: Economic considerations in CA, adoption and constraints, CA: The future of agriculture

Practicals

- Study of long-term experiments on CA,
- Evaluation of soil health parameters,
- Estimation of C-sequestration,
- Machinery calibration for sowing different crops, weed seed bank estimation under CA, energy requirements, economic analysis of CA.

References

- ARAKERI, H. R. AND ROY, D. 1984. *Principles of Soil Conservation and Water Management*. Oxford & I.B.H.
- BISHT, J. K, MEENA, V. S, MISHRA, P. K AND PATTANAYAK, A. 2016. Conservation Agriculture-Anapproach to combat climate change in Indian Himalaya. Publisher: Springer Nature. Doi:10/1007/978-981-10-2558-7.
- DHRUVANARAYANA,V. V. 1993. *Soil and Water Conservation Research in India*. ICAR.
- FAO. 2004. *Soil and Water Conservation in Semi-AridAreas*. *SoilsBull.,* Paper57.
- GRACIA-TORRES L, BENITES J, MARTINEZ-VILELA A AND HOLGADO-CABERA A. 2003. Conservation Agriculture Environment Farmerse xperiences, innovations Socio-economic policy.

• MUHAMMAD, F. AND K, AMDAMBOT HMS. 2014. Conservation Agriculture. Publisher: Springer

AGR 506 AGRONOMY OF MAJOR CEREALS AND PULSES (1+1)

Objective

To impart knowledge of crop husbandry of cereals and pulse crops.

Theory

Block I: Production technology of cereals

Unit 1: Origin and history, area and production, classification, varieties, climate, soil, water and cultural requirements, nutrition, quality components, handling and processing of the produce for maximum production of *Rabi* cereals.

Unit 2: Origin and history, area and production, classification, varieties, climate, soil, water and cultural requirements, nutrition, quality components, handling and processing of the produce for maximum production of *Kharif* cereals.

Block II: Production technology of pulses

Unit 1: Origin and history, area and production, classification, varieties, climate, soil, water and cultural requirements, nutrition, quality components, handling and processing of the produce for maximum production of *Rabi* pulses.

Unit 2: Origin and history, area and production, classification, varieties, climate, soil, water and cultural requirements, nutrition, quality components, handling and processing of the produce for maximum production of *Kharif* pulses.

Practical

- Phenological studies at different growth stages of crop
- Estimation of crop yield on the basis of yield attributes
- Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities

- Working out growth indices (CGR, RGR, NAR, LAI, LAD, LAR, LWR, SLA, SLW etc)
- Assessment of land use and yield advantage (Rotational intensity, Cropping intensity, Diversity Index, Sustainable Yield Index, Crop Equivalent Yield, Land Equivalent ration, Aggressiveness, Relative Crowding Coefficient, Competition Ratio and ATER etc)
- Estimation of protein content in pulses
- Planning and layout of field experiments
- Judging of physiological maturity in different crops
- Intercultural operations in different crops
- Determination of cost of cultivation of different crops
- Working out of harvest index of various crops
- Study of seed production techniques in selected crops
- Visit of field experiments on cultural, fertilizer, weed control and water management aspects
- Visit to nearby villages for identification of constraints in crop production

References

- DAS, N. R. 2007. *Introduction to Crops of India*. Scientific Publ.
- HUNSIGI, G. AND KRISHNA, K. R. 1998. *Science of Field Crop Production*. Oxford & IBH.
- JESWANIL, M. AND BALDEV. B. 1997. *Advances in Pulse Production Technology*. ICAR.
- KHARE, D. AND BHALE M. S. 2000. *Seed Technology*. Scientific Publ.
- KUMAR RANJEET AND SINGH, N. P. 2003. *Maize Production in India: Golden Grainin Transition*. IARI, New Delhi.
- PALM, DEKA, J. AND RAI, R. K. 1996. *Fundamentals of Cereal Crop Production*. Tata McGraw Hill.
- PRASAD RAJENDRA. 2002. *Text Book of Field Crop Production*. ICAR.

- SINGH, C, SINGH, P. AND SINGH, R. 2003. *Modern Techniques of Raising Field Crops*. Oxford & IBH.
- Singh, S. S. 1998. *Crop Management*. Kalyani.
- YADAV, D. S. 1992. *Pulse Crops*. Kalyani.

AGR 507 AGRONOMY OF OILSEED, FIBRE AND SUGAR CROPS (2+1)

Objective

To teach the crop husbandry of oil seed, fiber and sugar crops

Theory

Block I: Production technology of oilseeds

Unit1: Origin and history, area and production, classification, varieties, climate, soil, water and cultural requirements, nutrition, quality component, handling and processing for maximum production of *rabi* oilseeds – Rapeseed and mustard, Linseed and Niger

Unit 2: Origin and history, area and production, classification, varieties, climate, soil, water and cultural requirements, nutrition, quality component, handling and processing for maximum production of *kharif* oilseeds - Groundnut, Sesame, Castor, Sunflower, Soybean and Safflower

Block II: Production technology of fiber and sugar crops

Unit 1: Origin and history, area and production, classification, varieties, climate, soil, water and cultural requirements, nutrition, quality component, handling and processing for maximum production of Fiber crops - Cotton, Jute, Ramie and Mesta.

Unit 2: Origin and history, area and production, classification, varieties, climate, soil, water and cultural requirements, nutrition, quality component, handling and processing for maximum production of Sugar crops – Sugar-beet and Sugarcane.

Practical

- Planning and layout of field experiments
- Cutting of sugarcane setts, its treatment and methods of sowing,

wrapping and propping of sugarcane

- Determination of cane maturity and calculation on purity percentage, recovery percentage and sucrose content in cane juice phenological studies at different growth stages of crop
- Intercultural operations in different crops
- Cotton seed treatment
- Working out growth indices (CGR, RGR, NAR, LAI, LAD, LAR, LWR, SLA, SLW etc.,)
- Assessment of land use and yield advantage (Rotational intensity, Cropping intensity, Diversity Index, Sustainable Yield Index Crop Equivalent Yield, Land Equivalent ration, Aggressiveness, Relative Crowding Coefficient, Competition Ratio and ATER etc)
- Judging of physiological maturity in different crops and working out harvest index
- Working out cost of cultivation of different crops
- Estimation of crop yield on the basis of yield attributes
- Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities
- Determination of oil content in oilseeds and computation of oil yield
- Estimation of quality of fiber of different fiber crops
- Study of seed production techniques in various crops
- Visit to field experiments on cultural, fertilizer, weed control and water management aspects
- Visit to nearby villages for identification of constraints in crop production

References

- DAS, N. R. 2007. *Introduction to Crops of India*. Scientific Publ.
- LAKSHMI KANTAM N. 1983. *Technology in Sugar cane Growing*. 2nd Ed. Oxford&IBH.

• PRASAD RAJENDRA. 2002. *Text Book of Field Crop Production*. ICAR.

AGR 508 AGRONOMY OF MEDICINAL, AROMATIC AND UNDER UTILIZED CROPS (2+1)

Objective

To acquaint students about different medicinal, aromatic and underutilized field crops, their package of practices **and processing**

Theory

Block I: Cultivation practices of medicinal plants

Unit 1: Importance of medicinal and aromatic plants in human health, national economy and related industries, classification of medicinal and aromatic plants according to botanical characteristics and their uses, export potential and indigenous technical knowledge.

Unit2: Climate and soil requirements; cultural practices; yield and important constituents of medicinal plants (Mulhati, Isabgol, Rauwolfia, Poppy, Aloe vera, Satavar, Stevia, Safed Musli, Kalmegh, Asaphoetida, Nuxvomica, Rosadle, etc).

Block II: Cultivation practices of aromatic plants

Unit1: Climate and soil requirements; cultural practices; yield and important constituents of aromatic plants (Citronella, Palmarosa, Mentha, Basil, Lemongrass, Rose, Patchouli, Geranium).

Unit 2: Climate and soil requirements; cultural practices; yield of under-utilized crops (Rice bean, Lathyrus, Sesbania, Cluster Sbean, French bean, Fenugreek, Grain Amaranth, Coffee, Tea and Tobacco).

Unit 3: Post harvest handling–drawing, processing, grading, packing and storage, value addition and quality standards in herbal products.

Practical

• Identification of crops based on morphological and seed characteristics

- Raising of herbarium of medicinal, aromatic and under-utilized plants
- Quality characters in medicinal and aromatic plants
- Methods of analysis of essential oil and other chemicals of importance in medicinal and aromatic plants.

References

- CHADHA, K. AND GUPTA, R. 1995. *Advances in Horticulture*. Vol.II. *Medicina land Aromatic Plants*. MalhotraPubl.
- DAS, N.R. 2007. *Introduction to Crops of India*. Scientific Publ.
- HANDA, S.S. 1984. *Cultivation and Utilization of Medicinal Plants*. RRL, CSIR, Jammu.
- HUSSAIN, A.1984. *Essential Oil Plants and their Cultivation*. CIMAP, Lucknow.
- HUSSAIN, A. 1993. *Medicinal Plants and their Cultivation.* CIMAP, Lucknow.
- ICAR, 2006. *Hand Book of Agriculture.* ICAR, New Delhi.
- KUMAR, N, KHADER, MD. ABDUL, RANGASWAMI, J. B. M. & IRULAPPAN 1997. *Introduction to Spices, Plantation Crops, Medicinal and Aromatic Plants.* Oxford & IBH.
- PRAJAPATI, N.D, PUROHIT, S.S, SHARMA, A.K. AND KUMAR, T. 2003. *A Hand Book of Medicinal Plants: A Complete Source Book*. Agrobios.
- SHARMA, R. 2004. *Agro-Techniques of Medicinal Plants*. Daya Publ. House.

AGR 509 AGRONOMY OF FODDER AND FORAGE CROPS (2+1)

Objective

To teach the crop husbandry of different forage and fodder crops along with their processing.

Theory

Block I: Adaptation and distribution of fodder and forage crops

Unit1: Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important fodder crops like sorghum, maize, bajra, guar, cowpea, oats, barley, berseem, senji, lucerne, Indian sweet clover. etc.

Unit2: Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important forage crops / grasses, Napier grass, Panicum, Lasiuras, Cenchrus,etc.

Block II: Harvesting and processing of fodder and forage crops

Unit1: Year-round fodder production and management, preservation and utilization of forage and pasture crops.

Unit2: Principles and methods of hay and silage making; chemical and biochemical changes, nutrient losses and factors affecting quality of hay and silage; use of physical and chemical enrichments and biological methods for improving nutrition; value addition of poor quality fodder. Fodder production through hydroponics. Azolla cultivation.

Unit3: Economics of forage cultivation uses and seed production techniques of important fodder crops.

Practical

- Practical training of farm operations in raising fodder crop;
- Canopy measurement, yield, leaf: stem ratio and quality estimation, *viz.* Crudeprotein, NDF, ADF, lignin, silica, cellulose and IVDMD, *etc.* of various fodder and forage crops
- Anti-quality components like HCN in sorghum and such factors in other crops
- Hay and silage making and economics of their preparation.

References

- CHATTERJEE, B.N. 1989. *Forage Crop Production – Principles and Practices*. Oxford & IBH.
- DAS, N. R. 2007. *Introduction to Crops of India*. Scientific Publ.
- NARAYANAN, T. R. AND DABADGHAO, P.M. 1972. *Forage Crops of India*. ICAR.

- SINGH, P. AND SRIVASTAVA, A. K. 1990. *Forage Production Technology*. IGFRI, Jhansi.
- SINGH, C, SINGH, P. AND SINGH, R. 2003. *Modern Techniques of Raising Field Crops*. Oxford & IBH.
- TEJWANI, K. G. 1994. *Agro forestry in India*. Oxford & IBH.

AGR 510 AGROSTOLOGY AND AGRO-FORESTRY (2+1)

Objective

To teach crop husbandry of different forage, fodder and agro forestry crops / trees along with their processing.

Theory

Block I: Agrostology

Unit1: Agrostology: definition and importance; principles of grassland ecology: grassland ecology–community, climax, dominant species, succession, biotype, ecological status of grasslands in India, grass cover of India; problems and management of grasslands.

Unit 2: Importance, classification (various criteria), scope, status and research needs of pastures; pasture establishment, their improvement and renovation-natural pastures, cultivated pastures; common pasture grasses.

Block II: Agro-forestry

Unit 1: Agro-forestry: definition and importance; agro-forestory systems, agri silviculture, silvipasture, agri silvipasture, agri horticulture, aqua silviculture, alley cropping and energy plantation.

Unit 2: Crop production technology in agro-forestory and agrostology system; silvipastoral system: meaning and importance for wasteland development; selection of species, planting methods and problems of seed germination in agro-forestry systems; irrigation and manuring in agro-forestry systems, associative influence in relation to above ground and underground interferences; lopping and coppicing in

agro-forestry systems; social acceptability and economic viability, nutritive value of trees; tender operation; desirable tree characteristics.

Practical

- Preparation of charts and maps of India showing different types of pastures and agro-forestry systems
- Identification of seeds and plants of common grasses, legumes and trees of economic importance with reference to agro-forestry
- Seed treatment for better germination of farm vegetation
- Methods of propagation/ planting of grasses and trees in silvipastoral system
- Fertilizer application in strip and silvi pastroal systems
- After-care of plantation
- Estimation of protein content in loppings of important fodder trees
- Estimation of calorie value of wood of important fuel trees
- Estimation of total biomass and fuel wood
- Economics of agro-forestry
- Visit to important agro-forestry research stations

References

- CHATTERJEE, B. N AND DAS, P. K. 1989. *Forage Crop Production. Principles and Practices.* Oxford & IBH.
- DABADGHAO, P. M AND SHANKARANARAYAN, K. A. 1973. *The Grass Cover in India*. ICAR.
- DWIVEDI, A. P. 1992. *Agro forestry - Principles and Practices.* Oxford & IBH.
- INDIAN SOCIETY OF AGRONOMY. 1989. *Agro forestry System in India. Research and Development,* New Delhi.
- NARAYAN, T. R AND DABADGHAO, P. M. 1972. *Forage Crop of India*. ICAR, NewDelhi.

AGR 511 CROPPING SYSTEMS AND SUSTAINABLE AGRICULTURE (2+0)

Objective

To acquaint the students about prevailing cropping systems in the country and practices to improve their productivity.

Theory

Block I: Cropping Systems

Unit1: Cropping systems: definition, indices and its importance; physical resources, soil and water management in cropping systems; assessment of land use.

Unit 2: Concept of sustainability in cropping systems and farming systems, scope and objectives; production potential under mono culture cropping, multiple cropping, alley cropping, sequential cropping and inter cropping, mechanism of yield advantage in inter cropping systems.

Unit 3: Above and below ground interactions and allelopathic effects; competition relations; multi-storied cropping and yield stability in inter cropping, role of non-monetary.

Block II: Approaches for sustainability

Unit 1: Crop diversification for sustainability; role of organic matter in maintenance of soil fertility; crop residue management; fertilizer use efficiency and concept of fertilizer use in intensive cropping system. Advanced nutritional tools for big data analysis and interpretation.

Unit 2: Plant ideo types for dry lands; plant growth regulators and their role in sustainability.

Unit 3: Artificial Intelligence-Concept and application.

References

- PANDA, S. C. 2017. *Cropping Systems and Sustainable Agriculture*. Agrobios (India)
- PANDA, S. C. 2018. *Cropping and Farming Systems*. Agrobios.

- PALANIAPPAN, S. P. AND SIVARAMAN, K. 1996. *Cropping Systemsinthe Tropics; Principles and Management* .New Age.
- PANDA, S. C. 2003.*Cropping and Farming Systems*. Agrobios.
- REDDY, S. R. 2000.*Principles of Crop Production*. Kalyani.
- SANKARAN, S. AND MUDALIAR, T. V. S. 1997. *Principles of Agronomy.* The Bangalore Printing & Publ.Co.
- SINGH, S. S. 2006. *Principles and Practices of Agronomy*. Kalyani.
- TISDALE, S. L, NELSON, W. L, BEATON, J. D AND HAVLIN, J. L. 1997. *Soil Fertility and Fertilizers*. Prentice Hall.

AGR 512 DRYLAND FARMING AND WATERSHED MANAGEMENT (2+1)

Objective

To teach the basic concepts and practices of dry land farming and soil moisture conservation.

Theory

Block I: Concept and characteristics of dry land farming

Unit 1: Definition, concept and characteristics of dry land farming; dry land versus rain fed farming; significance and dimensions of dry land farming in Indian agriculture.

Unit 2: Soil and climatic parameters with special emphasis on rainfall characteristics; constraints limiting crop production in dry land areas; types of drought, characterization of environment for water availability; crop planning for erratic and aberrant weather conditions.

Unit 3: Stress physiology and resistance to drought, adaptation of crop plants to drought, drought management strategies; preparation of appropriate crop plans for dry land areas; mid contingent plan for aberrant weather conditions.

Block II: Moisture conservation practices

Unit 1: Tillage, tilth, frequency and depth of cultivation, compaction in soil tillage; concept of conservation tillage; tillage in

relation to weed control and moisture conservation; techniques and practices of soil moisture conservation (use of mulches, kinds, effectiveness and economics); antitranspirants; soil and crop management techniques, seeding and efficient fertilizer use.

Unit 2: Concept of watershed resource management, problems, approach and components.

Practical

- Method of Seed Priming
- Determination of moisture content of germination of important dryland crops
- Determination of Relative Water Content and Saturation Deficit of Leaf
- Moisture stress effects and recovery behaviour of important crops
- Estimation of Potential ET by Thornthwaite method
- Estimation of Reference ET by Penman Monteith Method
- Classification of climate by Thornthwaite method (based on moisture index, humidity index and aridity index)
- Classification of climate by Koppen Method
- Estimation of water balance by Thornthwaite method
- Estimation of water balance by FAO method
- Assessment of drought
- Estimation of length of growing period
- Estimation of probability of rain and crop planning for different drought condition
- Spray of anti-transpirants and their effect on crops
- Water use efficiency
- Visit to dryland research stations and watershed projects

References

- REDDY, T. Y. 2018. *Dryland Agriculture Principles and Practices*, Kalyani publishers
- DAS, N. R. 2007. *Tillage and Crop Production*. Scientific Publ.
- DHOPTE, A. M. 2002. *Agrotechnology for Dryland Farming*. Scientific Publ.
- DHRUV NARAYAN V, V. 2002. *Soi land Water Conservation Research in India*. ICAR.
- GUPTA, U. S. (Ed.). 1995. *Production and Improvements of Crops for Dry lands*. Oxford & IBH.
- KATYAL, J. C. AND FARRINGTON, J. 1995. *Research for Rainfed Farming*. CRIDA.
- RAO, S. C. AND RYAN, J. 2007. *Challenges and Strategies of Dryland Agriculture*. Scientific Publ.
- SINGH, P. AND MALIWAL, P. L. 2005. *Technologies for Food Security and Sustainable Agriculture.* Agrotech Publ. Company.
- SINGH, R. P. 1988. *Improved Agronomic Practices for Dryland Crops*. CRIDA.
- SINGH, R. P. 2005. *Sustainable Development of Dryland Agriculture in India*. Scientific Publ.
- SINGH, S. D. 1998. *Arid Land Irrigation and Ecological Management*. Scientific Publ.
- VENKATESH WARLU, J. 2004. *Rainfed Agriculture in India. Research and Development Scenario*. ICAR.

AGR 513 PRINCIPLES AND PRACTICES OF ORGANIC FARMING (2+1)

Theory

Block I : Principles and Practices of Organic farming

Unit I : Organic farming - concept and definition, its relevance to Indian and global agriculture and future prospects; principles of organicagri culture; organics and farming standards; organic farming

and sustainable agriculture; selection and conversion of land, soil and water management - land use, conservation tillage; shelter zones, hedges, pasture management, agro-forestry.

Unit II : Organic farming and water use efficiency; soil fertility, nutrient recycling, organicresidues, organic manures, composting, soil biota and decomposition of organicresidues, earthworms and vermicompost, green manures, bio-fertilizers and biogastechnology.

Block I : Cultivation practices underOrganicfarming

Unit III : Farming systems, selection of crops and crop rotations, multiple and relay cropping systems, intercropping inrelation to maintenance of soil productivity.

Unit IV : Control of weeds, diseases and insectpest management, biological agents and pheromones, bio-pesticides.

Unit V : Socio-economicim pacts; marketing and eXport potential: inspection, certification, labeling and accreditation procedures; organic farming and national economy.

Practical

- Method of making compost by aerobic method
- Method of making compost by an aerobic method
- Method of making vermi compost
- Identification and nursery raising of important agro-forestry tress and tress for shelter belts
- Efficient use of biofertilizers, technique of treating legume seeds with Rhizobium
- Cultures, use of Azotobacter, Azospirillum and PSB cultures in field
- Visit to abiogas plant
- Visit to anorganic farm
- Quality standards, inspection, certification and labeling and accreditation procedures for farm produce from organic farms

References

- ANANTHAKRISHNAN , T.N. (Ed.). 1992. Emerging Trendsin Biological Control of Phytophagous Insects. OXford & IBH.
- GAUR, A. C. 1982. A Manual of Rural Composting, FAO/UNDP Regional Project Document, FAO.
- MUKUND JOSHI. 2016. New Vistas of Organic Farming. Scientific Publishers
- LAMPIN,N. 1990.Organic Farming. PressBooks, lpswitch,UK.
- PALANIAPPAN, S. P and ANANDURAI, K. 1999. Organic Farming-Theory and Practice. Scientific Publ.
- VENKATARAO, B. V. 1995. Small Farmer Focused Integrated Rural Development:Socio-economic Environment and Legal Perspective: Publ.3, Pari saraprajna Parishtana, Bangalore.
- REDDY, M. V . (Ed.). 1995. Soil Organisms and Litter Decompositioninthe Tropics. OXford & IBH.
- SHARMA, A. 2002. Hand Book of Organic Farming. Agrobios.
- SINGH, S. P. (Ed.). 1994. Technology for Production of Natural Enemies. PDBC, Bangalore.
- SUBBARAO, N. S. 2002. Soil Microbiology. OXford & IBH.
- TRIVEDI, R. N. 1993. A Text Book of Environmental Sciences, Anmol Publ.
- VEERESH, G. K, SHIVASHANKAR, K. AND SINGLACHAR, M. A. 1997.OrganicFarming and Sustainable Agriculture. Association for Promotion of Organic Farming, Bangalore.
- WHO. 1990. Public Health Impact of Pesticides Used in Agriculture. WHO.
- WOOLMER, P. LAND SWIFT, M. J. 1994. The Biological Management of Tropical Soil Fertility. TSBF & Wiley.

AGR 514 RESEARCH TECHNIQUES IN AGRONOMY (1+1)

Objectives

To teach the analysis of data of experimental designs and presentation of data.

Theory

Block I

Unit 1: Origin and Development of Agricultural Research, recent advances, modern trends. Types, Levels and methods of research, role of Agricultural Research worker, requirements of researcher and duties.

Unit 2: Research projects proposal, format and screening. Pitfalls in experiments. Field experimentation, Laboratory and pot culture experiments. Principles of field experimental designs, soil heterogencity and measures of competitions under field experimental conditions. Uniformity trials.

Unit 3: Size and shape of the plots and blocks; arrangement of blocks; border effect and procedures of agronomic observations. Analysis of data of experimental designs; missing plot technique; care while conducting field experiments; soil, plant and climatic observations; Experiments on cultivators field.

Unit 4: Experimental design, CRD and RCBD, Latin square and factorial experiments. Confounding and split plot designs Correlation and regression analysis, crop response curves, dynamics of crop growth and modeling, Transformation of experimental data.

Block II Presentation of data

Unit 1: Presentation of data, writing and reviewing of technical papers, participation in agronomic seminar and conferences, thesis writing

Unit 2: Biometric observations of agronomic experiments, crop growth and development measurements, indices, and forms of growth analysis in field experiments. Use of growth analysis technique to study the variations in yield. Factors deteremining the yield.

Practical

- Visit to library to familiarize with the technical information

- Field layout of baseline 3,4,5, method
- Layout and analysis of data of duplicate plot design, CRD and RBD, Latin square and lattice design, Factorial experiments use of contrasts, Confounding design, Dry matter accumulation curves – partition analysis
- Pattern of nutrient accumulation in relation, dry matter
- Methods of estimating leaf area and leaf angle
- Estimation of growth indices (AGR, CGR, RGR NAR etc.),
- Computation of leaf ratio and dry matter efficiency,
- Correlation studies, Regression analysis, Response functions
- Testing of means, LSD, Tukey's test, Dunken's Multiple range tests
- Collection of observations on field experiments
- Study of laboratory equipments.
- Preparation of thesis; research paper
- Preparing research project; preparation for conference, workshop and seminars.

References

- AVVAL, S. H. M., MANANDHAR, A. AND SHAH, A., 2018, Fundamentals of energy analysis for crop production agriculture. https://ohioline.osu.edu/factsheet/fabe-6621.
- HOLT, D. (1997), Practical Ethics in Agronomy Research. *Adv. Agron.*60: 149-190.
- KASTENS, K., PFIRMAN, S., STUTE, M., HAHN, B., ABBOTT, D. AND SCHOLZ, C., How to Write Your Thesis. https://www.ldeo.columbia.edu/~martins/sen_sem/thesis_org.html.
- KATE EBY, 2018, The Essential Guide to Writing Winning Project Proposals. https://www.smartsheet.com/project-proposal-writing
- SUNDARARAJ, N., NAGARAJU, S., VENKATARAMU, M. N. AND JAGANNATH, M. K., 1972, Design and analysis of field experiments. Published by Directorate of Research, University of Agricultural Science, Bangalore, India.

M.Sc. (Agri.) in Apiculture

Course Code	Course Title	Credit Hours
API 501	Bee Morphology and Anatomy	2 (1+1)
API 502	Biology of Honey bees	2 (1+1)
API 503	Bee Physiology	2 (1+1)
API 504	Bee Ecology and Behaviour	2 (1+1)
API 505	Bee Toxicology	2 (1+1)
API 506	Beekeeping and its management	2 (1+1)
API 507	Honey and Beeproducts	2 (1+1)
API 508	Bee Pollination and Crop Production	2 (1+1)
API 509	Bee Pests and Diseases	2 (1+1)
API 510	Non-*Apis* Pollinators	2 (1+1)
API 511	History, Development & Techniques of beekeeping	3 (2+1)
API 512	Classification and Systematics of Bees	4 (3+1)
API 513	Genetics and Breeding of honey bees	3 (2+1)
	Total	**30 (17+13)**
API 580	Qualifying Examination	2 (0+2)
API 581	Seminar-I	1 (0+1)
API 582	Seminar-II	1 (0+1)
API 591	Research-I	13 (0+13)
API 592	Research-II	14 (0+14)

API 501 BEE MORPHOLOGY AND ANATOMY (1+1)

Objective

To study the morphological and anatomical characters of different honeybee species, castes and their distinguishing features.

Theory

Block 1: Study of morphological features of honeybees.

Unit 1: Study of integument, body wall, body segments and their importance

Study of integument, its structures, primary and secondary segmentation and its modifications. Body regions - head, thorax and abdomen, appendages and other structures with modifications and their importance

Unit 2: Different honey bee castes & their distinguishing features.

Distinguishing morphological characters of different honey bee castes and species.

Block 2: Anatomy of Bees

Unit 1. Study of different organ systems of bees.

Structure and modification of digestive, excretory, respiratory, reproductive, circulatory, nervous, sensory and glandular systems of honey bees.

Unit 2.Techniques in cytology, karyology and embryology of bees

Approaches to study cytology, karyology and embryology of honeybees.

Practicals

- Studying the morphological characteristics of different species of honey bees
- Preparation of slides of different appendages such as mouth parts, antennae, legs, sting in different honey bee species.
- Dissection of internal system such as digestive, circulatory and glandular systems.

References

- IMMS, A.D., 1925. A General Textbook of Entomology: Including the Anatomy, Physiology, Development and Classification of Insects. Methuen & Company Limited.
- ROMOSER, W.S., 1981. The science of entomology (No. Ed. 2). Macmillan Publishing Co. Inc.
- CHAPMAN, R.F., KERKUT, G.A. AND GILBERT, L.I., 2013. Structure of the digestive system. Comprehensive insect physiology, biochemistry, and pharmacology, pp:165-211.
- METCALF, C.L., FLINT, W.P. AND METCALF, R.L., 1951. Destructive and useful insects. Destructive and useful insects., (Edn 3).
- ROSS, H.H., ROSS, C.A., ROSS, J.R. AND MAZOKHINA-PORSHNI?A?Kova, G.A., 1985. E?ntomologii?a?.
- SNODGRASS, R.E., 2018. Principles of insect morphology. Cornell University Press.
- SPENCER RHODES, 2022, Principles of Insect Morphology, Society and Culture Books. ISBN-9781666889321
- DEVARASSOU, K., 2021, Introductory Entomology, Notion Press.
- RATHODLAL SINGH, 2019, An Objective And Subjective Book on Insect Morphology, Akinik Publications.
- PRASAD, T.V., 2019. Handbook of Entomology,New Vishal Publications.
- PRASAD, T. V., 2020, Objective Entomology, New Vishal Publications.

API 502 BIOLOGY OF HONEY BEES (1+1)

Objective

To study the evolutionary history of honeybees, their nutrition, different races, strains , growth and development, moulting and polyethism and reproductive biology.

Theory

Block 1: Evolution of bees, different species of honeybees, their growth and development

Unit 1: Evolutionary history of honeybees, different races, strains and their Growth and development

Evolutionary history of honey bees, different species of honey bees, their races and strains, growth and development of different honey bee species and their castes.

Unit 2: Biotic and nutritional factors affecting growth and development of honeybees

Biotic factors influencing growth and development, growth curves, role of nutrition on honey bee biology

Block 2: Moulting and polyethism in bees

Unit 1. Study of Moulting in honey bees

Moulting and associated phenomenon in honeybees and its significance.

Unit 2.Study of polytheism in bees

Polytheism and its basis, feeding response of honey bees, Sex and caste determination in honeybees.

Block 3: Nest selection, architecture and colony development regulation in bees

Unit 1: Nest selection, architecture and colony development regulation in bees

Nest selection and nest architecture, regulatory mechanism of bee colony development

Block 4: Reproductive Biology in honey bees.

Unit 1: Reproduction, swarming, supersedure and mating in honeybees.

Reproduction, swarming, supersedure and mating behaviour of honey bees. Abnormalities in honey bees

Practicals

- Study of honey bee life cycle with special reference to hive bees
- Sex and caste determination
- Observations on swarming, supersedure and mating.
- Various methods of feeding honey bees.
- Comparative studies of nesting sites and its architecture in different species of honey bees, honeybee morphometry.
- Cell size assessment in different honey bee species.

References

- HALDHAR, S.M., 2010. Objective Agricultural Entomology on a Competitive View Vol. I. New Vishal Publication, New Delhi.
- DHALIWAL G. S., 2013, An outline of entomology. Kalyani Publishers, Ludhiana, pp: 408.
- REDDY, D. S., 2019, Applied Entomology, New Vishal Publications.
- RAGUMOORTHI, K. N., 2017, Insecta -An Introductory

API 503 BEE PHYSIOLOGY (1+1)

Objective

To study the functional details of different organ systems in honey bees, their nutrition, including glandular systems and bee pheromones

Theory

Block 1: Importance of bee physiology, functional details of different organ systems in honeybees and bee nutrition

Unit 1: Bee Physiology, its importance and functional details

Importance of physiology, functional details of various systems-digestive, excretory, respiratory, reproductive, circulatory nervous and sensory systems.

Unit 2. Study of larvae and adult nutrition.

Nutrition of larvae and adult honey bee.

Block 2: Moulting mechanism, glandular system & bee pheromones

Unit 1: Physiology of moulting.

Study of physiology of moulting in honeybees

Unit 2: Endocrine and exocrine systems of honey bees and bee pheromones

Endocrine and exocrine glandular systems of honey bees. Honey bee pheromones – production, composition and importance.

Practicals

- Study of honey stomach and other functional region of digestive system of hemolymph and its composition.
- Study of glandular systems and their composition.
- Diet preparation including pollen substitute and supplement and their quality assessment.
- Laying worker development – determining factors influencing it.
- Feeding response associated with specific olfactory stimulus and memory.

References

- IMMS, A.D., 1925. A General Textbook of Entomology: Including the Anatomy, Physiology, Development and Classification of Insects. Methuen & Company Limited.
- WIGGLESWORTH V. B.,1984, Insect Physiology, Springer Netherlands.
- ALAM, M. A., 2014, Textbook of Insect Physiology and Morphology, Centrum Press.
- NATION, J.L., 2008, Insect physiology and biochemistry. CRC press.
- SRIRAMULU, M. AND GOUR, T. B., 2013, Insect Physiology, Kalyani Publishers.

API 504 BEE ECOLOGY AND BEHAVIOUR (1+1)

Objective

To study the trophic levels of eco - system, nutrient cycling, bee behavioural concepts (foraging, swarming, defense, robbing, etc.,) and communication

Theory:

Block 1: Study of trophic levels of eco - system, nutrient cycling

Unit 1: Eco system, trophic levels and related concepts.

Different trophic levels of an eco-system, nutrient cycling, growth curves, life tables, population regulation, dispersal and migration. Intra and inter specific interaction,

Block 2: Distribution and abundance of bee species, evolution and degree of sociality in bees

Unit 1: Distribution and abundance of different bee species. Evolution and degree of sociality.

Block 3: Study of different bee behavioural concepts (foraging, swarming, defense, robbing, etc.,)

Unit 1: Bee behavioural concepts (foraging, swarming, defense, robbing, etc.,)

Study of foraging, swarming, defense, robbing, homoeostasis, thermoregulation and migratory behaviour in honey bees.Activities of queen and drones.Bee behaviour in queenless colony.

Unit 2: Pheromones and communication behaviour through dance language.

Role of pheromones in social organization. Handling, processing and storage of food, factors affecting bee behaviour-seasonal changes, age and environmental factors, Communication through dancing.

Practicals

- Visit to the meteorological observatory to study various instruments used in recording weather parameters.
- Studying the habitats and distribution pattern of all the species of honey bees.

- Location of food source and communication.
- Movement pattern of the foraging bees.
- Diurnal variation in foraging activity, swarming behaviour, Behaviour of worker bees in queen less and queen right colonies and defensive behaviour of workers against various predators.
- Population estimation of bee colonies.

References

- RIBBANDS, C. R., 1953,The behavior and social life of honey bees. New York: Dover Publications,
- SEELEY, T.D., 2014, Honeybee ecology: a study of adaptation in social life (Vol. 36). Princeton University Press.
- GRUETER, C. AND LEADBEATER, E., 2014, Insights from insects about adaptive social information use. Trends in ecology & evolution, 29(3) :177-184.
- TIMOTHY D. SCHWALTER,2006, Insect Ecology, Elsevier Science.
- SHADANAN UPADHYAY, 2017, Insect Ecology, Upadhyay, Shadanan.
- PETE W PRICE, 2011, Insect Ecology, Cambridge University Press.

API 505 BEE TOXICOLOGY (1+1)

Objective

To study insecticidal classifications, their modes of action and metabolism, their bioassays, bee poisoning, pesticidal residue analysis and Insecticides Act

Theory

Block 1: Introduction to toxicology, Insecticidal classification and their bioassays

Unit 1: Definition and scope of toxicology, insecticide bioassay and their classification

Toxicology – definition and scope. Insecticide bioassay and its importance. Insecticides classification.

Unit 2: Different types of insecticidal formulations, their modes of action and metabolism.

Types of formulations, mode of action and structure - activity relationship of major groups of insecticides. Insecticide metabolism, penetration and distribution of insecticides.

Block 2: Concepts in bee poisoning, pesticidal residue analysis and Insecticides Act.

Unit 1: Types of bee poisoning, symptoms of pesticidal poisoning and their prevention.

Bee poisoning - symptoms, factors contributing to bee poisoning, remedies and prevention of bee poisoning. Poisoning by plants – injury, detection and remedies. Weedicide poisoning, industrial poisoning, bee attractants and repellents.

Unit 2: Study of pesticidal residues, their analysis.

Pesticide residues in bee environment and residue analysis of pesticidal formulation.

Unit 3: Study of Insecticidal Acts

Insecticidal Acts and regulations formulated by Central Insecticides Board, New Delhi and safe use of pesticides.

Practicals

- Study of different groups of insecticides and their formulations.
- Bioassay with different insecticides on honey bees and finding LD_{50} values.
- Relative susceptibility of different species of honey bees to insecticides.
- Effect of pesticides on bee pollination.
- Bee repellents.
- Bee safety measures.

References

- RANGASWAMY, K.T., MK, P.K., TOPAGI, S., JAGADISH, K.S., BASAVARAJ, S., PRAMEELA, H.A., KEDARNATH AND ACHARI, R., 2018, A Compendium of Insecticides Registered in India. University of Agricultural Sciences Bangalore
- SRIVASTAVA, R.P. AND SAXENA, R.C., 1989, Textbook of Insect Toxicology. Himanshu Publications.
- H. C. L. GUPTA, 2020, Insecticides: Toxicology and uses.Science Technology.

API 506 BEEKEEPING AND ITS MANAGEMENT (1 + 1)

Objective

To study about different honeybee species and their comb structure, hiving of feral colonies, handling and inspection of bee colonies, beekeeping equipments, important bee flora, management of bee colonies during different seasons and prevention of swarming, robbing and absconding, besides migratory beekeeping

Theory

Block 1: Historical concepts in beekeeping, honeybee species and their comb structure, ideal location to start an apiary.

Unit 1: History of beekeeping, different honey bee species and their comb structure.

History and development of beekeeping in the world, India and Karnataka. Honeybee species and their comb structure. Starting of beekeeping -how, where and when to start beekeeping. Ideal location for apiary establishment.

Unit 2: Hiving of feral colonies, handling and inspection of bee colonies, bee keeping equipments

Locating and hiving of feral colonies. Handling and inspection of bee colonies. Beekeeping equipments. Density and arrangements of bee hives in the apiary.

Block 2: Bee flora and seasonal management of bee colonies.

Unit 1: Study of important bee flora, management of bee colonies during different seasons and prevention of swarming, robbing and absconding

The important beeflora for efficient beekeeping. Seasonal management of bee colonies, management of colonies during honey flow and dearth periods. Swarming, robbing and absconding and their prevention.

Unit 2: Queenlessness in colonies and their management, Uniting and dividing of colonies. Mass queen rearing and instrumental insemination.

Study of queenlessness in bee colonies and their management. Uniting and dividing of bee colonies. Techniques adopted for mass queen rearing and instrumental insemination of queen bee. Double queen management. Package bees.

Block 3: Concepts of migratory beekeeping, commercial honey production, study of bee hives, beekeeping equipments and wild bee management.

Unit 1: Study of migratory beekeeping, commercial honey production, study of bee hives, beekeeping equipments and wild bee management

Migratory beekeeping. Management of colonies for commercial honey production. Study of beehives and other beekeeping equipments. Wild bee management.

Practicals

- Selection of ideal sites for locating an apiary.
- Hiving natural colonies, handling of bee colonies and swarm catching.
- Study of robbing and its prevention.
- Swarming and its prevention.
- Dividing and uniting colonies.
- Preparation and feeding colonies with artificial food supplements / substitutes.

- Working out economics and maintenance of records.
- Seasonal management methods.
- Study of bee keeping equipments and their handling.
- Visits to different apiaries in Karnataka.
- Mass multiplication of queen.

References

- ABROL, D. B., 2009, Bees and Beekeeping in India. Kalyani Publishers, Ludhiana, New Delhi.
- RAMAKRISHNA IYER, T.V.,1940, Handbook of Economic Entomology for South India, Madras Government Press, pp: 298.
- DAVID, B.V. AND KUMARASWAMI, T., 1975. Elements of economic entomology.
- RAJAGOPAL, D., KENCHARADDI, R. N., KUBERAPPA, G. C. AND HANUMANTHASWAMY, B. C., 1996, Beekeeping for beginners, Apiculture Technical Series No.1,University of Agricultural Sciences, Bangalore, pp.28.
- SUNITHA, N. D., GULED, M. B., MULLA, S. R. AND JAGGINAVAR, S. B., 2003, Beekeeping (A promising income generating activity for Self Help Groups in Watershed), Technical Series No.30,University of Agricultural Sciences, Dharwad, pp.118.

API 507 HONEY AND BEE PRODUCTS (1 + 1)

Objective

To study the different categories, physico-chemical properties, harvesting, processing, storage and marketing, including the purity standards of honey and bee products and their value addition.

Theory

Block 1: Honey, its categories, properties and related concepts.

Unit 1: Study of different categories, physico-chemical properties, harvesting, processing, storage and marketing of honey

Honey- categories and types, physico - chemical properties, harvesting, processing – conventional and improved methods of honey processing, storage, marketing of honey and honey marketing channels in India.

Unit 2: Study of different purity standards of honey

Various purity standards of honey *viz.,* Prevention of Food Adulteration (PFA), Bureau of Indian Standards (BIS), AGMARK and Food Safety Standards Authority of India (FSSAI).

Detection of adulteration by conventional methods.

Unit 3: Different properties of honey and its value addition

Properties of honey and its value addition, crystallization and fermentation of honey and its prevention. Uses and value addition of honey.

Block 2: Study of other bee products

Unit 1: Other bee products (bee wax, pollen, propolis, royal jelly and bee venom)

Other bee products – Definition, physical and chemical properties, production, processing, uses and marketing of products such as bee wax, pollen, propolis, royal jelly and bee venom.

Practicals

- Extraction and processing of honey
- Analysis of honey and its composition
- Spoilage of honey and its prevention.
- Properties and sensory evaluation of honey from different sources.
- Mellisopalynological study of honey
- Study of quality standards of honey.
- Collection and purification of wax, propolis, royal jelly.
- Visit to honey processing plant and beekeepers societies in Karnataka.

References

- ABROL, D. B., 2009, Bees and Beekeeping in India. Kalyani Publishers, Ludhiana, New Delhi.
- KRELL, R., 1996, Value added products from beekeeping FAO Agricultural Services Bulletin No. 124. Chapter V.

API 508 BEE POLLINATION AND CROP PRODUCTION (1+1)

Objective

Study of modes of pollination, its efficiency, ecology, bee foraging behaviour, impact of bee pollination on crop yields and hybrid seed production.

Theory

Block 1: Study of pollination, its efficiency, ecology, etc.,

Unit 1: Different modes of pollination, pollination ecology, foraging behavior of bees

Modes of pollination, and its ecological significance. Assessment of pollination efficiency, pollination ecology, foraging behavior of honey bees. Pollination of agricultural, horticultural, plantation and greenhouse crops.

Unit 2: Managed bee pollination, case studies, bee pollination in hybrid seed production

Managing bees for pollination. Case studies of bee pollination, Role of bees in hybrid seed production of crops. Moving bees to crops, pollination services, mechanical aids to pollination, economics of bee pollination and problems encountered in pollination. Pollination specialties.

Practicals

- Crop wise pollinator diversity
- Bee floral structure and pollinator efficiency.
- Quantification of forage resource in crops,

- Determination of nectar sugar, pollen yield of different flower species.
- Assessment of the extent of cross pollination in selected crops.
- Study of bee attractants and repellents in relation to bee pollination.
- Bee fidelity.
- Assessment of yield and quality parameters in crops under bee pollination.
- Determining relative abundance of honey bee species in different crops.
- Pollination in relation to forager density.
- Training bees to exploit rich sources.
- Collection of pollinators from important horticultural and agricultural crops and their submission.

References

- SOUTHWOOD, T.R.E. AND HENDERSON, P.A., 2009. Ecological methods. John Wiley & Sons.
- AVTAR S. ATWAL, 2013, Mellifera Beekeeping and Pollination,Kalyani Publishers, Ludhiana, New Delhi
- ABROL, D.B.,2009, Bees and Beekeeping in India. Kalyani Publishers, Ludhiana, New Delhi.
- FAEGRI, K., VAN DER PIJL, 1979, The principles of pollination ecology.Elsevier Science.
- BELAVADI, V. V. AND GANESHAIAH, K. N., 2013, Insect Pollination Manual, University of Agricultural Sciences, Gandhi Krishi Vigyan Kendra, Bengaluru. 1-44.
- DELAPLANE, K.S., 2021, Crop Pollination by Bees, Volume 1: Evolution, Ecology, Conservation, and Management,CABI.
- JAMES, R., JAMES, R.R. AND PITTS-SINGER, T.L., 2008. Bee pollination in agricultural ecosystems, Oxford University Press on Demand.

API 509 BEE PESTS AND DISEASES (1 + 1)

Objective

To study the bio ecology and management of major pests of honey bees, besides their major diseases and management strategies.

Theory

Block 1: Study of major pests of honey bees their biology and management

Unit 1: Bio ecology and management of major pests of bees

Natural enemies - classification, abundance and distribution. Biology and management of insect enemies, mite and vertebrate pests of honey bees and their management

Block 2: Study of major bee diseases and their management

Unit 1: Major honey bee diseases and their management.

Honey bee diseases - bacterial, protozoan, viral, fungal - virulence, infection, epizootology, symptomatology, pathology and management. Colony collapse disorder (CCD).

Practicals

- Collection and identification of bee pests.
- Examination of colonies affected by pests and diseases.
- Collection, isolation and identification of bee samples infected by bacterial, fungal, viral and protozoan pathogens.
- Studying the symptoms of various bee diseases.
- Preservation of honey bee pathogens *in vitro*.
- Study of acarine diseases and their management.
- Methods of pest and disease management in beekeeping.

References

- ABROL, D.B.,2009, Bees and Beekeeping in India. Kalyani Publishers, Ludhiana, New Delhi.

- NAGARAJA, N. AND RAJAGOPAL, D., 2019, Honey Bees: diseases, parasites, pests, predators and their management. MJP publisher.
- KHAN, M.S. AND POONAM SRIVASTAVA, 2011, Honey bee enemies and their management, Project Coordinating Unit, All India Coordinated Research Project on Honey Bees and Pollinators (ICAR), CCS Haryana Agricultural University, Hisar, Haryana

API 510 NON-*APIS* POLLINATORS (1 + 1)

Objective

To study classification, morphology and anatomy of Non *Apis* pollinators and their diversity, including bee flora and commercial production of important non-*Apis* bees.

Theory

BLOCK 1: Classification of Non *Apis* pollinators and their diversity

Unit 1: Non *Apis* pollinators, their diversity, sociality and communication.

Classification and diversity of pollinators. Study of non-*Apis* pollinators and their sociality levels. Caste determination, nest structure, division of labour and communication in different apoideans.

Block 2: Morphology and Anatomy of non – *Apis* pollinators, pollinator-plant relationships

Unit 1: Study of comparative morphological and anatomical features of different non –*Apis* pollinators

Comparative morphological and anatomical studies of non – *Apis* bees. Biology of specific non – *Apis* bees.

Unit 2: Study of relationship between non –*Apis* pollinators and bee flora

Evolution of pollinator- plant relationship pertaining to non –*Apis* pollinators.

Block 3: Commercial production of non-*Apis* bees

Unit 1: Commercial production of non-*Apis* bees and their importance

Commercial production of non-*Apis* bees. Importance of other groups of pollinators.

Practicals

- Study of taxonomic characters of non-*Apis* bees and their identification by using taxonomic keys.
- Collection and identification of various non-*Apis* insect pollinators.
- Study of pollinator competition on flowering plants.
- Study of nesting sites, foraging behaviour and efficiency of non-*Apis* pollinators
- Collection and submission of non – *Apis* pollinators.

References

- ROOPA, A.N., GAVIGOWDA, ESWARAPPA, G., JAGADISH, K.S. AND PREM JOSE VAZHACHARICKAL, 2020, Bio-ecology of stingless bee, Trigonairidipennis Smith (Hymenoptera:Apidae) in GKVK campus - An overview, Amazon Publishers, USA (ISBN Number: 9798606573875), pp. 162.
- PREMJOSE VAZHACHARICKAL, JOBIN JOSE MANIMALAKUNNEL, JAGADISH K.S AND ESWARAPPA, G., 2021,Management, pest and diseases of stingless bee (Trigonairidipennis Smith) with a special focus to South India, Amazon Publishers, USA (ISBN Number: ISBN 979-8711010777)
- PREM JOSE VAZHACHARICKAL AND SAJAN JOSE, 2018, Stingless bees culture (Meliponiculture) in Kerala,Hand book for farmers, ISBN 9781729237908
- PREM JOSE VAZHACHARICKAL, JOBIN JOSE, JAGADISH, K.S. AND ESWARAPPA, G., 2020,Meliponiculture around the globe: an overview of challenges and opportunities with a special focus to Kerala, India, Amazon Publishers, USA (ISBN Number: ISBN 9798677937286), pp. 162.

API 511 HISTORY, DEVELOPMENT AND TECHNIQUES OF BEEKEEPING (2 +1)

Objective

To study the history and development of apiculture, important scientists and their innovations, major institutes pertaining to beekeeping and their contribution and techniques in beekeeping

Theory

Block 1: History and Development of Apiculture, important scientists and their innovations

Unit 1: History and Development of Apiculture, important scientists and their innovations

History and Development of Apiculture in India and world from ancient to modern times.

Eminent personalities involved and innovations in the development of beekeeping.

Block 2: Major institutes pertaining to beekeeping and their contribution

Unit 1: Institutions involved in beekeeping in India and abroad and their role.

Institutions involved in beekeeping in India and abroad Research and training in beekeeping.

Role of Government and other organizations in development of Apiculture.

Practicals

- Materials and techniques for collection of bee samples
- Preservation, mounting and drawing of bee specimens.
- Microtomy, micrometry and photography.
- Slide making and preparation of display mounts.
- Sampling techniques in Apiculture.
- Experimental designs applicable to apiculture research.

- Library – its use, classification of literature, information retrieval.
- Use of CD ROM
- Networking and Informatic Centres.
- Writing of research papers and thesis, proof reading, presentation of papers in scientific fora
- Use of audio-visual aids.

References

- RAMAKRISHNA IYER, T.V., 1940, Handbook of Economic Entomology for South India, Madras Government Press, pp. 298.
- DAVID, B.V. AND KUMARASWAMI, T., 1975, Elements of economic entomology.
- ABROL, D.B.,2009, Bees and Beekeeping in India. Kalyani Publishers, Ludhiana, New Delhi.
- BELAVADI, V. V. AND GANESHAIAH, K. N., 2013, Insect Pollination Manual, University of Agricultural Sciences, Gandhi Krishi Vigyan Kendra, Bengaluru. pp. :1-44.
- TARAKAD VYTHINATHA RAMAKRISHNA AIYAR, 1940, Handbook of Economic Entomology for South India, Printed by The Superintendent, Government press, Digitized:13 May,2009, Published by Cornell University, pp. : 528.
- VASANTHRAJ DAVID, B. AND RAMAMURTHY V.V., 2011, Elements of Economic Entomology 6th edition, Namrutha publications.

API 512 CLASSIFICATION AND SYSTEMATICS OF BEES (3 + 1)

Objectives

To study historical concepts and principles of bee classification, particularly w.r.t. Order Hymenpotera, its families, sub-families and tribes of Apoidea

Theory

Block 1: Historical concepts in the classification of bees and principles of bee classification

Unit 1: History and Principles of bee classification

History of bee classification, Principles of bee classification, zoological nomenclature, concepts of species, genera and other categories. Zoo-geography of honey bee. Phylogeny and evolution

Block 2: Order Hymenpotera, its families, sub-families and tribes of Apoidea

Unit 1: Order Hymenpotera, its families, sub-families and tribes of Apoidea Construction and use of taxonomic key. Knowledge of the order – Hymenoptera and families, sub-families and tribes of Apoidea. Morphometrics and its importance in establishing ecotypes.

Practicals

- Collection, preservation and identification of various families, sub-families, genera and species of Apoidea
- Preparation of keys for identification of the bees
- Morphometric studies of different species and different races of honey bees.
- Collection and submission of specimens of different bee species.

References

- RICHARDS, O.W. AND DAVIES, R.G., 2013, Imms' general textbook of Entomology: Volume 2: Classification and biology.Springer Science & Business Media.
- ROMOSER, W.S., 1981. The science of entomology (No. Ed. 2). Macmillan Publishing Co. Inc.
- CHAPMAN, R.F., KERKUT, G.A. AND GILBERT, L.I., 2013,Structure of the digestive system. Comprehensive insect physiology, biochemistry, and pharmacology, pp. :165-211.
- METCALF, C.L., FLINT, W.P. AND METCALF, R.L., 1951, Destructive and useful insects. Destructive and useful insects., (Edn 3).

• ROSS, H.H., ROSS, C.A., ROSS, J.R. AND MAZOKHINA-PORSHNI?A?KOVA, G.A., 1985, E?ntomologii?a?.

API 513 GENETICS AND BREEDING OF HONEY BEES (2+1)

Objectives

To study the cytology and mutation of honeybees; queen bee and its relationship with colony and its breeding for desirable traits, besides bee genomics

Theory

Block 1: Cytology and mutation of honeybees. Knowledge of queen, its relationship with colony.

Unit 1: Cytology and mutation of honeybees. Knowledge of queen, its relationship with colony, queen cell production and theory of inheritance.

- Study of cytology and mutation of honeybees. Knowledge of queen, its relationship with colony. Classification and judging of queens, selection of breeder queen and drone, Methods of queen cell production, queen mating, maintenance of nuclei, principles of inheritance.

Unit 2: Different methods of breeding and selection of queen bees.

- Various methods of breeding and selection of prolific queen. Breeding techniques – instrumental insemination, strorage, transport and preservation of semen.

Unit 3: Breeding for desirable traits and study of bee genomics

Breeding for disease resistance, increased honey production, pollination, prolificity and other characters. Inter specific breeding and genomics of honeybees.

Practicals

- Selection of mother stock.
- Assessment of traits of good colony with respect to yield, swarming, temperament, pollination etc.

- Maintenance of records on pedigree, age, quality of queen, mass multiplication of queen. Instrumental insemination technique.
- Grading of colonies with respect to forage collection, disease resistance, growth, swarming, absconding etc.

References

- BUCHAREST, 1977, Bee Genetics, selection and reproduction, Apimondia Publishing house,
- RUTTNER, F., 1988, Breeding techniques and selection for breeding of the honeybeean introduction to the rearing of queens, the conduct of selection procedures and the operation of mating stations.

M.Sc. (Agri.) in Biochemistry

Course Code	Course Title	Credit Hours
BCM 501	Basic Biochemistry	4 (3+1)
BCM 502	Intermediary Metabolism	3 (3+0)
BCM 503	Enzymology	3 (2+1)
BCM 504	Molecular Biology	3 (2+1)
BCM 505	Techniques in Biochemistry	4 (2+2)
BCM 506	Immuno Chemistry	3 (2+1)
BCM 507	Plant Biochemistry	3 (2+1)
BCM 508	Animal Biochemistry	3 (3+0)
BCM 509	Nutritional Biochemistry	3 (2+1)
BCM 510	Nitrogen and Sulphur Metabolism	3 (2+1)
BCM 511	Biochemistry on Xenobiotics	2 (2+0)
	Total	**34 (25+9)**
BCM 580	Qualifying Examination	2(0+2)
BCM 581	Seminar - I	1 (0+1)
BCM 582	Seminar - II	1 (0+1)
BCM 591	Research - I	13 (0+13)
BCM 592	Research - II	14 (0+14)

BCM 501 BASIC BIOCHEMISTRY (3+1)

Objective

The course is designed to provide elementary knowledge/overview of structure and function of proteins, carbohydrates, lipids, nucleic acids and other biomolecules and their metabolism.

Block 1: INTRODUCTION TO BIOCHEMISTRY

Unit 1: Scope and importance of biochemistry

Biochemistry as modern science and its various divisions, Scope and importance of biochemistry in agriculture and allied sciences.

Unit 2: Foundation of life

Fundamental principles governing life, supramolecular structures, significance of weak non covalent interactions in biology

Unit 3: Water

Structure and properties of water, ionization of water, acid base concept, pH and buffers, significance of structure-function relationship

Unit 4: Physical techniques for structure determination

General introduction to physical techniques for determination of structure of biopolymers.

Block 2: STRUCTURE AND FUNCTION OF BIOMOLECULES

Unit 1: Biomolecules

Structure, classification, properties and function of carbohydrates, amino acids, proteins, lipids and nucleic acids.

Unit 2: Immunoglobulins and PR proteins

Structure, formation and different forms of immunoglobulins, PR proteins and their classification

Unit 3: Plant secondary metabolites, such as phenolics, terpenoids, alkaloids and glucosinolates (Three lectures), Structure, classification and function of plant secondary metabolites

Block 3: METABOLISM – THE BASICS

Unit 1: Molecules aiding metabolism

Structure and biological functions of vitamins and coenzymes, enzymes: classification and mechanism of action; regulation, factors affecting enzyme action. Hormones: animal, plants, and insect hormones.

Unit 2: Thermodynamics –principles and energetic of life

Fundamentals of thermodynamic principles applicable to biological processes, Bioenergetics.

Block 4: CATABOLISM AND ITS REGULATION

Unit 1: Catabolism of energy molecules

Important and basic degradative metabolic pathways of carbohydrates, lipids and proteins and their regulation

Unit 2: ATP formation

Formation of ATP, substrate level phosphorylation, electron transport chain and oxidative phosphorylation, chemiosmotic theory and proton motive force

Block 5: FUNDAMENTALS OF MOLECULAR BIOLOGY AND GENETIC ENGINEERING

Unit 1: Molecular biology processes

Overview of replication, transcription, reverse transcription and translation and post translational modification.

Unit 2: Recombinant DNA technology

Restriction enzymes, DNA cloning, applications of cloning, transgenics.

Practicals

1. Preparation of standard and buffer solutions
2. Detection of carbohydrates, amino acids and proteins
3. Extraction and estimation of sugars
4. Extraction and estimation of amino acids
5. Extraction and estimation of proteins
6. Estimation of acid value of fat/oil
7. Estimation of peroxide value of fat/oil
8. Estimation of saponification value in fats and oils
9. Fatty acid composition in fat/oil by GC
10. Estimation of DNA and RNA by spectroscopic methods
11. Estimation of Ascorbic acid
12. Separation of biomolecules by TLC and Paper chromatography

13. Estimation of alpha amylase activity
14. Qualitative tests for secondary plant metabolites.
15. Extraction of oil and estimation of total fatty acid
16. Extraction and estimation of total phenolics

References

- NELSON, D. L. AND COX, M. M., 2017, Lehninger Principles of Biochemistry. 7th edition. W. H. Freeman & Co Ltd
- SATYANARAYANA, U. AND CHAKRAPANI, U., 2017, Biochemistry. 5th edition, Elsevier
- MORAN, L. A., HORTON, H. R., SCRIMGEOUR, K. G. AND PERRY, M. D., 2012, Principles of Biochemistry. 5th edition Pearson,
- VOET, D. AND VOET, J. G., 2011, Biochemistry. 4th edition John Wiley.
- PRATT, C. W. AND CORNELY, K., 2014, Essential Biochemistry. 3rd Edition. Wiley
- MOORTHY, K., 2007, Fundamentals of Biochemical Calculations. 2nd edition. CRC Press
- CONN, E. E., STUMPF, P. K., BRUENING, G. AND DOI, R. H., 2006, Outlines of Biochemistry. 5th edition. Wiley.

BCM 502 INTERMEDIARY METABOLISM (3+0)

Objectives

The course is designed to give an insight into the different metabolic pathways, their interrelationship, regulation, metabolic disorders in human and pathway engineering in plants.

Block 1: INTRODUCTION TO METABOLISM

Unit 1: Overview of metabolism

The living cell - a unique chemical system, biochemical reaction types, bioenergetics, bioavailability of nutrients, transport mechanism, signal transduction.

Unit 2: Metabolic pathways

Catabolism and anabolism, compartments of metabolic pathways, experimental approaches to study metabolism

BLOCK 2: METABOLISM OF ENERGY NUTRIENTS

Unit 1: Carbohydrate metabolism

Major catabolic and anabolic pathways of carbohydrate metabolism, the glyoxylate pathway,

Unit 2: Lipid metabolism (Five lectures). Fatty acid oxidation, ketone bodies, fatty acid biosynthesis, synthesis of triacylglycerols, cholesterol, eicosanoids

Unit 3: Protein metabolism

General reactions of amino acid metabolism, degradative and biosynthetic pathways of amino acids, urea cycle, amino acids as metabolic precursors.

Unit 4: Energy transduction and oxidative phosphorylation (Four lectures)

Mechanisms of energy transduction, electron transport system, oxidative phosphorylation, control of ATP production

BLOCK 3: SULPHUR AND NUCLEOTIDE METABOLISM

Unit 1: Sulphur metabolism

Sulphate reduction and incorporation of sulphur in to amino acids

Unit 2: Nucleotide metabolism

Synthesis and degradation of purine and pyrimidine nucleotides

BLOCK 4: METABOLIC REGULATION AND DEFECTS IN METABOLISM

Unit 1: **Regulation of metabolic pathways**

Regulation of carbohydrate, lipid, protein, nucleotide metabolism and oxidative phosphorylation

Unit 2: Defects in metabolism

Disorders of carbohydrates, lipids, amino acids and nucleic acid metabolism, and inborn errors of metabolism. Metabolic pathway engineering.

References

- NELSON, D. L. AND COX, M. M., 2017, Lehninger Principles of Biochemistry. 7th edition. W. H. Freeman & Co Ltd
- SATYANARAYANA, U. AND CHAKRAPANI, U., 2017, Biochemistry. 5th edition, Elsevier
- CAMPBELL, M. K. AND FARRELL, S. O., 2009, Biochemistry. 6thedition Thomson Higher Education.
- MORAN, L. A., HORTON H. R., SCRIMGEOUR K. G. AND PERRY, M. D., 2012, Principles of Biochemistry. 5th edition Pearson,
- VOET, D. AND VOET, J. G., 2011, Biochemistry. 4thedition . John Wiley.
- PRATT, C. W. AND CORNELY, K., 2014, Essential Biochemistry. 3rd Edition. Wiley
- MOORTHY, K., 2007, Fundamentals of Biochemical Calculations. 2nd edition. CRC Press

BCM 503 ENZYMOLOGY (2+1)

Objective

To impart knowledge about the catalytic role of enzymes, their structure, physico-chemical, kinetic and regulatory properties and mechanism of action.

BLOCK 1: INTRODUCTION TO ENZYMES Unit

1: Structure and function of enzyme

Historic perspective, general properties of enzymes, enzyme compartmentalization in cell organelles, nomenclature and classification of enzymes, ribozymes, isozymes, abzymes

Unit 2: Extraction and purification of enzymes

Extraction of soluble and membrane-bound enzymes, purification of enzymes, measurement of enzyme activity

BLOCK 2: ENZYME STRUCTURE AND FUNCTION

Unit 1: Chemical nature of enzyme

Enzyme specificity, monomeric and oligomeric enzymes, catalytic mechanism, mechanism of enzyme action, pseudoenzymes, enzyme promiscuity.

Unit 2: Cofactors and coenzymes

Chemical nature and involvement of cofactors and coenzymes in enzyme catalyzed reactions, metal activated enzymes and metalloenzymes, mechanism of enzyme catalyzed reactions without cofactors.

Unit 3: Nature of active site

Active site, identification of binding sites and catalytic sites

BLOCK 3. ENZYME KINETICS

Unit 1: Single substrate kinetics

Relationship between initial velocity and substrate concentration, Michaelis-Menten equation, Lineweaver-Burk and Eadie-Hofstee plots, analysis of kinetic data, numerical exercises.

Unit 2: Enzyme inhibition

Reversible and irreversible enzyme inhibition, uses of enzyme inhibition

Unit 3: Kinetics of allosteric enzymes

Nature of allosteric enzymes, sigmoidal kinetics, MWC model and allosteric regulation, KNF model and allosteric regulation.

Unit 4: Regulation of enzyme activity

Feedback regulation, regulatory enzymes, control of enzymatic activity, symmetry and sequential model, reversible covalent modification of enzymes.

BLOCK 4: APPLICATION OF ENZYMOLOGY

Unit 1: Industrial application of enzymes

Industrial application of enzyme catalysis in sectors like food processing, detergents, biofuels, paper and pulp, biosensors and clinical applications of enzymes

Unit 2: Biotechnological application of enzymes

Large scale production and purification of enzymes, immobilization of enzymes.

Practical

1. Soluble protein estimation
2. Enzyme assay by taking any model enzyme
3. Isolation and purification of any model enzyme
4. Study of the effect of enzyme and substrate concentrations on enzyme activity
5. Determination of Km and Vmax
6. Determination of pH and temperature optima
7. Effect of inhibitors on enzyme activity
8. Determination of pH and temperature stability of enzyme
9. Electrophoretic analysis of isozymes

References

- PALMER, T. AND BONNER, P. L., 2007, Enzymes: Biochemistry, Biotechnology, Clinical Chemistry. 2nd edition. Woodhead Publishing
- OKOTORE, R. O., 2015, Essentials of Enzymology. XLIBRIS
- HERALD, J., 2016, Essentials of Enzymology. Syrawood Publishing House
- SUZUKI, H., 2015, How Enzymes Work: From Structure to Function. Jenny Stanford Publishing.
- BUGG, T. D. H., 2012, Introduction to Enzyme and Coenzyme Chemistry, 3rd Edition. WILEY
- GUO, Y., 2014, Enzyme Engineering. Science Press
- BISSWANGER, H., 2011, Practical Enzymology. Wiley-Blackwell.

BCM 504 MOLECULAR BIOLOGY (2+1)

Objectives

To provide knowledge of life processes at the molecular and cellular levels, including the storage, transfer and regulation of genetic information and specialist theoretical knowledge and practical experience of gene manipulation and the analysis of nucleic acids and proteins

BLOCK 1: INTRODUCTION TO NUCLEIC ACIDS

Unit 1: History

Historical development of molecular biology, nucleic acids as genetic material

Unit 2: Properties of nucleic acid

Nucleic acid structure, chemical and physical properties of nucleic acids, spectroscopic and thermal properties of nucleic acids, DNA supercoiling

Unit 3: Genes and genome

Concept of genes and genome, genome complexity, genome organization in prokaryotes and eukaryotes, chromatin structure and function, repetitive and non-repetitive DNA, satellite DNA central dogma, genome editing.

BLOCK 2: SYNTHESIS OF NUCLEIC ACID

Unit 1: DNA replication

Modes of replication, DNA polymerases, topoisomerases, DNA ligase, model of replisome, semi conservative replication in prokaryotes and eukaryotes, inhibitors of replication, DNA damage and repair.

Unit 2: Transcription

Basic principles of transcription, transcription initiation, elongation and termination, RNA processing, RNA interference, siRNAs, miRNAs and other ncRNAs, DNA/RNA editing. regulation of transcription, reverse transcription.

BLOCK 3. PROTEIN SYNTHESIS

Unit 1: Translation machinery

Ribosomes structure and function, organization of ribosomal proteins and RNA genes, genetic code, aminoacyltRNA synthases

Unit 2: Mechanism of protein synthesis

Initiation, chain elongation and termination of translation, energetics, inhibitors of translation

Unit 3:Post-translational events

Post translational modifications of nascent polypeptide, protein targeting and turnover, regulation of gene expression in prokaryotes and eukaryotes, nucleases and restriction enzymes.

BLOCK 4: GENE MANIPULATION

Unit 1: DNA sequencing

Importance, Sanger method, and Maxam-Gilbert method, High-Throughput Sequencing (HTS) techniques (pyro sequencing, SOLiD, dye termination), applications of DNA sequencing.

Unit 2: Recombinant DNA technology

Vectors, isolation of genes, recombinants vector, selection of recombinants, characterization and expression of cloned DNA, transformation, transgenesis, mutation, molecular mechanism of mutation, site directed mutagenesis, in vitro mutagenesis.

Unit 3: Techniques in molecular biology

Polymerase chain reaction (PCR), expression cloning, gel electrophoresis, molecular markers, macromolecule blotting and probing, arrays (DNA array and protein array) – principles and application

Practical

1. Isolation and purification of DNA and RNA
2. To check the purity of isolated DNA and RNA
3. Restriction fragmentation of genomic DNA
4. Separation of oligos by agarose gel electrophoresis

5. Southern blotting experiments
6. Northern blotting experiments
7. Cloning of DNA fragment in vector
8. Selection of recombinant
9. SSR analysis of DNA
10. cDNA synthesis using RT- PCR
11. Basic tools in bioinformatics analysis

References

- SNAPE, A., PAPACHRISTODOULOU, D., ELLIOTT, W. H. AND ELLIOTT, C., 2014, Biochemistry and Molecular Biology. Oxford University Press
- KREBS, J. E., GOLDSTEIN, E. S. AND KILPATRICK, S. T., 2018, Lewin's GENES XII. Jones & Bartlett Learning
- LODISH, H., BERK, A., KAISER, C. A., KRIEGER, M. AND BRETSCHER, A., 2016, Molecular Cell Biology.W H Freeman & Co.
- HOFFMANN, A. AND CLOKIE, S., 2018, Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press.
- PRIMROSE, S. B., TWYMAN, R. M. AND OLD, R. W., 2002, Principles of Gene Manipulation: 6th Ed. Wiley
- KARP, G., 2013, Cell and Molecular Biology. Wiley
- NEIDLE, S., 2008, Principles of Nucleic Acid Structure. Elsevier Inc.
- WATSON, J., BAKER, T. A., BELL, S. P., GANN, A., LEVINE, M. AND LOSICK, R., 2014,
- Molecular biology of the gene 7th edition, Pearson.

BCM 505 TECHNIQUES IN BIOCHEMISTRY (2+2)

Objectives

To provide hands-on experience to different biochemical techniques commonly used in research along with the knowledge on principles and the instrumentation.

BLOCK 1: SEPARATION TECHNIQUES

Principles and applications of separation techniques

Unit 1: Chromatography techniques

Principles and applications of paper, thin layer, gel filtration, ion-exchange, affinity, column &HPTLC, GC, HPLC and FPLC

Unit 2: Electrophoretic technique

General principles,paper and gel electrophoresis, native and SDS-PAGE, 2D-PAGE, capillary electrophoresis

Unit 3: Hydrodynamic methods

Hydrodyanmic methods of separation of biomolecules such as viscosity and sedimentation velocity, - their principles

Unit 4: Centrifugation

Basic principles of sedimentation, type, care and safety aspects of centrifuge preparative and analytical centrifugation.

BLOCK 2: SPECTROSCOPIC TECHNIQUES

Unit 1: Spectrophotometry

Principles and applications of UV-visible, Fluorescence, IR and FTIR, Raman, NMR and FTNMR, ESR and X-Ray spectroscopy

Unit 2: Mass spectroscopy

MS/MS, LC-MS, GC-MS, MALDI-TOF, applications of mass spectrometry in biochemistry

Unit 3: Atomic absorption spectrophotometry

Principle, function and instrumentation of atomic absorption spectrophotometry.

BLOCK 3. MICROSCOPY

Unit 1: Microscopic techniques

Principles and applications, light, UV, phase contrast, fluorescence and electron microscopy, flow cytometry.

BLOCK 4: TRACER, IMAGING, IMMUNOCHEMICAL AND OTHER TECHNIQUES

Unit 1: Tracer technique

Tracer techniques in biology: concept of radioactivity, radioactivity counting methods with principles of different types of counters, concept of á, â and ã emitters, scintillation counters, ã-ray spectrometers, autoradiography, applications of radioactive tracers in biology.

Unit 2: Imaging techniques

Principles and applications of phosphor imager, MRI and CT scan.

Unit 3: Immunochemical technique

Production of antibodies, immunoprecipitation, immunoblotting, immunoassays, RIA and ELISA.

Unit 4: Other techniques

Cryopreservation, polymerase chain reaction (PCR), FACS.

Practical

1. Expression of concentration in terms of dilution, molarity, normality, percent expression
2. pH measurement and buffer preparation
3. Determination of absorption maxima of biomolecules
4. Estimation of biomolecules through spectrophotometry and other methods
5. Separation of carbohydrates and amino acids by paper chromatography
6. Separation and analysis of fatty acids/lipids by GC
7. Separation/estimation of biomolecules through HPLC and FPLC
8. Separation of proteins using ion exchange, gel filtration and affinity chromatography
9. Electrophoretic separation of proteins and nucleic acids
10. Centrifugation- differential and density gradient
11. (NH4)2SO4 precipitation and dialysis

12. Use of radioisotopes in metabolic studies
13. PCR
14. ELISA
15. Western blotting/ Dot blotting

References

- BOYER, R., 2011, Biochemistry Laboratory: Modern Theory and Techniques 2nd Edition. Pearson
- HOFMANN, A. AND CLOKIE, S., 2010, Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology. 7th edition. Cambridge University Press.
- SAWHNEY, S. K. AND SINGH, R., 2000, Introductory Practical Biochemistry. 2nd Ed. Narosa
- KATOCH, R., 2011, Analytical Techniques in Biochemistry and Molecular Biology. Springer
- BOYER, R., 2009, Modern Experimental Biochemistry. Fifth impression. Pearson
- LOTTSPEICH, F. AND ENGELS, J. W., (Eds), 2018, Bioanalytics: Analytical Methods and Concepts in Biochemistry and Molecular Biology. Wiley-VCH
- WILSON, K. AND WALKER, J., 2010, Principles and Techniques of Biochemistry and Molecular Biology, 7th Edition. Cambridge University Press.

BCM 506 IMMUNOCHEMISTRY (2+1)

Objectives

To give an insight into the biochemical basis of immunity and immune techniques.

BLOCK 1: BASICS OF IMMUNOLOGY

Unit 1: Introduction to immunology

History and scope of immunology, antigens, adjuvants, immune system, organs, tissues and cells, immunoglobulins, molecular

organization of immunoglobulin. haptens, Ag-Ab interaction, plant immunity, proteasome mediated process, plantibodies

Unit 2: Antibodies

Classes of antibodies, antibody diversity, theories of generation of antibody diversity, vaccine, monoclonal and polyclonal antibodies, hybridoma, recombinant antibodies, complement system - classical and alternate.

Unit 3: The immune responses

Cellular interactions in immune response, major histocompatibility complex, cell mediated immune response, cytokines.

Unit 4: Immunoregulation and immunological techniques

Immunoregulation, immunological tolerance, hypersensitivity, mechanisms of immunity, innate resistance and specific immunity, current immunological techniques – ELISA, RIA, immunoblotting, FACS; basics of PCR and hybridization based methods of detection, microarray based detection, multiplexing.

Practical

1. Handling, inoculation and bleeding of laboratory animals
2. Preparation of antigens and antisera, natural antibodies
3. Carbon clearance test
4. Antigen-antibody interaction,
5. Precipitation and agglutination
6. Direct and indirect haemagglutination
7. Immunoelectrophoresis
8. Complement fixation
9. Quantitation of immunoglobulins by zinc sulphate turbidity and single radial immunodiffusion
10. ELISA
11. Western blotting

12. Fluorescent Ab test
13. Hybridoma technique

References

- PUNT, J., STRANFORD, S., JONES, P., OWEN, J., 2018, Kuby Immunology. 8th edition. W. H. Freeman
- RENSHAW, S., 2016, Immunohistochemistry and Immunocytochemistry: Essential Methods, 2nd Edition. John Wiley & Sons, Ltd.
- ABBAS, A. K., LICHTMA, A. H. AND PILLAI, S., 2018, Cellular and Molecular Immunology. 9th edition. Elsevier
- DELVES, P. J., MARTIN, S. J., BURTON, D. R. AND ROITT, I. M., 2017, Roitt's Essential Immunology, 13th Edition. Wiley-Blackwell.

BCM 507 PLANT BIOCHEMISTRY (2+1)

Objectives

To provide an understanding of metabolic processes in plants and the role of different biosynthetic pathways in plant growth and development.

BLOCK 1: PHOTOSYNTHESIS

Unit 1: Photosynthetic machinery

Structure and function of plant cell and its organelles, phytochromes, chloroplast morphology structure, structure and chemistry of photosynthetic pigments, light reaction of photosynthesis

Unit 2: Photosynthesis – the process

Carbon reduction inC3, C4 and CAM plants, photorespiration, sucrose-starch interconversion.

BLOCK 2: CONVERSION OF PHOTOSYNTHATES

Unit 1: Synthesis of major biomolecules

Biosynthesis of structural carbohydrates, storage proteins and lipids.

Unit 2: Nitrogen and sulphur metabolism

Basic concepts of nitrogen and sulphur metabolism : biological nitrogen fixation, nitrate assimilation in plants, sulphur chemistry and function, reductive sulphate assimilation pathway, sulphated compounds.

BLOCK 3: GROWTH AND DEVELPOMENT

Unit 1: Germination and fruit ripening

Biochemistry of seed germination – stages, requirements, metabolism and mobilization of storage material; Biochemistry of fruit ripening – ripening process, cell wall degrading enzymes, role of ethylene and regulation of ethylene production.

Unit 2: Phytohormones

Different classes of phytohormones, their biosynthesis and mode of action.

BLOCK 4: SECONDARY METABOLITES

Unit 1: Biochemistry of plant secondary metabolites

Biochemistry and significance of plant secondary metabolites - phenolics, terpenoids, alkaloids, cyanogenic glycosides and glucosinolates, effect of biotic and abiotic factors on plant metabolism and plant defense system.

Practical

1. Fractionation of cell organelles
2. Estimation of starch
3. Assay of ADPG pyrophosphorylase/starch synthase
4. Assay of PAL/SOD
5. Assay of PPO/LOX
6. Estimation of individual amino acids
7. Qualitative tests of secondary metabolites (alkaloids, sterols etc.)
8. Content and composition of carotenoids, anthocyanin and chlorophylls
9. Determination of polyphenols/phenolics

10. Fractionation of storage proteins
11. Estimation of glucosinolates
12. Estimation of cyanogenic compounds

References

- BUCHANNAN, B. B., GRUISSEM, W. AND JONES, R. L., (eds.), 2000, Biochemistry and Molecular Biology of Plants. 2nd edition. WILEY Blackwell
- HELDT, H. W., 2010, Plant Biochemistry and Molecular Biology. 4th ed. Oxford University Press
- Goodwin, T. W. and Mercer, E. I., 2005, Introduction to Plant Biochemistry. 2nd edition. CBS
- HELDT, H. W. AND PIECHULLA, B., 2010, Plant Biochemistry. 4th Edition. Elsevier
- HARINDA, MAKKEA AND KLAUS., 2007, Plant Secondary Metabolites. Springer
- LELAND, J. CSEKE, ARA KIRAKOSYAN, PETER B., KAUFMAN, SARA WARBER, JAMES A. DUKE., HARRY, L., BRIELMANN., 2006. Natural Products from Plants. 2nd Edition. CRC Press.

BCM 508 ANIMAL BIOCHEMISTRY (3+0)

Objectives

To impart knowledge regarding biochemistry of various physiological processes, specialized tissues and hormone action in animal system

Block 1:ANIMAL BIOCHEMISTRY

Unit 1: Biochemistry of assimilation

Digestion and absorption of food, Detoxification, biochemistry of specialized tissues – connective tissue, skin, muscle, nervous tissue and blood and other body fluids.

Unit 2: Nutrients and their biochemistry

Water, electrolyte and acid-base balance, structure, function and mechanism of major trace elements, vitamins, energy nutrients and biochemistry of respiration, bioactive peptides and functional oligosaccharides.

Unit 3: Hormones and their role

Hormones of thyroid, hypothalamus, pituitary, pancreas, adrenals and sex hormones, Membrane receptors of hormones, signal transduction.

Unit 4: Immune system

Immune systems, immunoglobulins, monoclonal antibodies, formation of antibody, antibody diversity, complement system – classical and alternate, major histocompatibility complexes, cell mediated immune response, mechanisms of immunity.

References

- BRADLEY, A., 2018, Animal Physiology and Biochemistry. 1st edition. Ed tech Press
- R. A. AGARWAL, R. A., SRIVASTAVA, A. K. AND KUMAR, K., 2010, Animal Physiology and Biochemistry. Fifth revised edition. S. Chand.
- RODWELL, V. A., BENDER, D. A., BOTHAM, K. M., KENNELLY, P. J. AND WEIL, P. A., 2018, Harper's Illustrated Biochemistry, 31st edition. McGraw-Hill Education.

BCM 509 NUTRITIONAL BIOCHEMISTRY (2+1)

Objectives

To impart knowledge regarding the biochemical aspects of various nutrients and their interactions in foods during processing, storage and deterioration.

Block 1: NUTRITIONAL BIOCHEMISTRY

Objectives: To understand the fundamentals of human nutrition, biochemical functions of nutrients its bioavailability and food sensitivity.

Unit 1: Fundamentals of human nutrition

Fundamentals of human nutrition, concept of balanced diet, biochemical co rption, digestive secretions, their characteristic features and control, protection of microflora of the GI tract

Unit 2: Biochemical functions of nutrients

Biochemical functions of nutrients, macro- and micronutrients-carbohydrates, fats and proteins, vitamins, water soluble and fat soluble vitamins, mineral and phytonutrients, prebiotics and probiotics, enzymes and metabolic protein factors, cofactor role, electrolytic function, constituents of skeletal tissues, interrelationship in nutrient functions, mineral deficiency diseases; nutraceuticals, antinutritional factors, biochemistry of postharvest storage.

Unit 3: Bioavailability of nutrients

Factors affecting bioavailability of nutrients, biological value of proteins; effect of cooking, processing and preservation of different food products on nutrients, energy- and micronutrient malnutrition, deficiency diseases of macro and micronutrients.Biogenesis of food flavors and aroma, nutritional quality of plant, dairy, poultry and marine food products

Unit 4: Food sensitivity

Food sensitivity: immunologically mediated food sensitivity, nature and properties of antigens in foods, mechanism of induction of all allergic reactions, diagnostic tests for food, hypersensitivity, non-immunologically mediated food sensitivity, food sensitivity due to metabolic diseases, gastrointestinal diseases, food additives, pharmacologic agents, food toxins and poisonous and psychological factors.

Practicals

1. Estimation of amylose and amylopectin
2. Estimation of resistant starch
3. Estimation of w3, w6 and trans fatty acid
4. Estimation of phenols in plant tissue/sample

5. Estimation of carotenoids
6. Estimation of amylase, trypsin and chymotrypsin inhibitor activities
7. Estimation of Vitamin C in fruits
8. Estimation of reducing & non reducing sugar in fruits
9. Estimation of protein contents
10. Estimation of dietary fiber
11. Determination of limiting amino acids acids (lysine and methionine)
12. Estimation of phytate/ oxalate
13. Estimation of total antioxidant activity by different methods
14. Estimation of curcumin.

References

- DAMODARAN, S. AND PARKIN, K. L. (ed.), 2017, Fennema's Food Chemistry. CRC Press Gibney MJ, Lanham-New SA, Cassidy, A and Voster HH (ed.) 2009. Introduction to Human Nutrition. Wiley-Blackwell
- TRUEMAN, P., 2007, Nutritional Biochemistry. MJP Publishers
- COX, C., 2015, Nutritional Biochemistry: Current Topics in Nutrition Research. Apple Academic Press Inc.
- HAUGEN, S. AND MEIJER, S., 2010, Handbook of Nutritional Biochemistry : Genomics, Metabolomics & Food Supply. Nova Science Publishers Inc.

BCM 510 NITROGEN AND SULFUR METABOLISM (2+1)

Objectives

To impart knowledge of general nitrogen and sulfur metabolism in plants and the assimilatory pathways.

Block 1: NITROGEN METABOLISM

Unit 1: **Nitrogen metabolism**

Nitrogen cycle, assimilation of inorganic nitrogen, nitrate uptake and transporters, enzymology of nitrate reduction - Nitrate reductase

(NR) and Nitrite reductase (NiR), NR regulation, nitrate signaling. Assimilation of inorganic nitrogen and N-transport amino acids - glutamine synthetase (GS), glutamate synthase (GOGAT), glutamate dehydrogenase (GDH), aspartate amino transferase (AspT) and asparagine synthetase (AS), interaction between carbon metabolism and amino acid synthesis, biosynthesis of amino acids.

Nitrogen fixation - an overview, enzymology of nitrogen fixation - nitrogenase, nifgenes and their regulation, symbiotic nitrogen fixation - biochemical basis of rhizobial infection, nodule development. Mechanism of creation of microaerobic environment for nitrogen fixation. metabolic exchange between host plant and bacteroids.

BLOCK 2: SULFUR METABOLISM

Unit 1: Sulphur metabolism

Overview of sulfate assimilation, sulfur chemistry and function, sulfate uptake and transport, reductive sulfate assimilation pathway, synthesis and function of sulfur containing amino acids, glutathione and its derivatives, role of sulfated compounds in metabolism.

Practicals

1. Estimation of nitrite content
2. Estimation of nitrate content
3. In vivo assay of nitrate reductase activity
4. In vitro assay of nitrate reductase activity
5. In vitro assay of nitrite reductase activity
6. In vitro assay of glutamine synthetase activity
7. In vitro assay of glutamate synthase and glutamate dehydrogenase activity
8. Estimation of ureides and amides
9. Assay of nitrogenase activity by acetylene reduction method
10. Estimation of hydrogen evolution by legume nodules
11. Estimation of cysteine, methionine, pyruvate and glutathione

12. Assay of APS activity

References

- BOTHE, H. AND TREBST, A., (eds.), 1981, Biology of Inorganic Nitrogen and Sulfur. Conference proceedings. Springer-Verlag
- DE KOK *et al*., 2012, Sulfur Metabolism in Plants. Part of the Proceedings of the International Plant Sulfur Workshop book series. Springer
- BRAY, C. M., 1983, Nitrogen Metabolism in Plants. Longman.
- BIDWELL, R. G. S., 1983, Plant Physiology: A Treatise, Vol. 8: Nitrogen Metabolism. Academic Press
- FOYER, C. H. AND ZHANG, H., 2010, Nitrogen Metabolism in Plants in the Post-Genomic Era. Annual Plant Reviews, Vol.42. WILEY-BLACKWELL
- BUCHANAN, B. B., GRUISSEM, W. AND JAMES, R. L., (Eds.), 2000. Biochemistry and Molecular Biology of Plants. American Society of Plant Physiologists.

BCM 511 BIOCHEMISTRY ON XENOBIOTICS (2+0)

Objectives

To impart knowledge on xenobiotics and the mechanism of their metabolism and detoxification in living system.

BLOCK 1:BIOCHEMISTRY ON XENOBIOTICS

Unit 1: Xenobiotics

Xenobiotics: classification and their effects on biological systems, Problems related to xenobiotics degradation, potential effects of toxic agents on immune system function, biotic metabolism of xenobiotics - biodegradation/biotransformation

Unit 2: Mode of degradation

Mode of degradation - Enzymatic and Non-enzymatic, Metabolism of toxic compounds with reference to role of detoxifying enzymes, Mechanism of xenobiotics detoxification – in animal using the enzymes

of Phase I and Phase II, Role of microbes in xenobiotics degradation and co-metabolism, Biodegradation and its genetics, manipulation of xenobiotic degradative genes

Unit 3: Plant metabolism of xenobiotics (Seven lectures)

Plant metabolism of xenobiotics - transformation, conjugation and compartmentation, Metabolic responses of pesticides in plants, Impact, metabolism, and toxicity of heavy metals in plants, Regulation of xenobiotics in higher plants: signalling and detoxification.

BLOCK 2: PHYTOREMEDIATION

Unit 1: Phytoremediation

Phytoremediation, Advances in development of transgenic plants for remediation of xenobiotic pollutants, safety assessment of xenobiotics

References

- RICHARDSON, M., 1996, Environmental Xenobiotics. CRC Press
- SINGH, A., PRASAD, S. M. AND SINGH, R. P., (eds), 2016, Plant Responses to Xenobiotics.
- Springer.
- CHANG, Y-C., (ed), 2019, Microbial Biodegradation of Xenobiotic Compounds. CRC Press
- COSTAS IOANNIDES., (ed), 2002, Enzyme Systems that Metabolise Drugs and Other Xenobiotics. WILEY
- LEE, P., AIZAWA, H., GAN, L., PRAKASH, C. AND ZHONG, D., 2014, Handbook of Metabolic Pathways of Xenobiotics. WILEY
- EMERSON, M. L., 2012, Xenobiotics: New Research. Nova Science
- SHAMAAN, N. A., 2008, Biochemistry of xenobiotics : towards a healthy lifestyle and safe environment. Penerbit University Putra Malaysia.

M.Sc. (Agri.) in Bioinformatics

Course Code	Course Title	Credit Hours
BIM 501	Introduction to Bioinformatics & Computational Biology	3(2+1)
BIM 502	Statistical Genomics	3(2+1)
BIM 503	Genome Assembly and Annotation	2(1+1)
BIM 504	Biomolecular Modelling and Simulation	3(2+1)
BIM 505	Transcriptomics and Metagenomics	3(2+1)
BIM 506	Biological Data Management	3(2+1)
BIM 507	Biological Network Modelling and Analysis	3(2+1)
BIM 508	Computer Programming in bioinformatics	3(2+1)
BIM 509	Machine Learning Techniques in bioinformatics	3(2+1)
BIM 510	Advanced Bioinformatics	3(2+1)
	Total	**29(19+10)**
BIM 580	Qualifying Examination	2 (0+2)
BIM 581	Seminar - I	1 (0+1)
BIM 582	Seminar - II	1 (0+1)
BIM 591	Research - I	13 (0+13)
BIM 592	Research - II	14 (0+14)

BIM 501 INTRODUCTION TO BIOINFORMATICS AND COMPUTATIONAL BIOLOGY (2+1)

Objective

To provide theoretical and practical knowledge about handling and processing of genomic data, optimization and data mining techniques used in bioinformatics.

Theory

BLOCK I : Biological databases and online Biological tools

Unit I: Overview of available genomic resources on the web; NCBI/ EBI/ EXPASY etc; Nucleic acid sequence databases; Gen Bank/ EMBL/ DDBJ; Database search engines: Entrez, SRS. Overview/concepts in sequence analysis; Pair wise sequence alignment algorithms: Needleman and Wunsch, Smith and Waterman; BLAST, FASTA; Scoring matrices for Nucleic acids and proteins: PAM, BLOSUM, Multiple sequence alignment: PRAS, CLUSTALW. Sequence based gene prediction and its function identification.

Unit II: Pre-processing of gene expression data; Data Normalization techniques, Data quality control: Modelling of errors, Imputation etc; High-throughput screening.

BLOCK II: Optimization Techniques and Genetic Algorithms

Unit I: Optimization Techniques: concept and applications, Simulated Annealing, Genetic Algorithms: Ab initio methods for structure prediction; Information theory, entropy and relative entropy.

Unit II: Foundations for Machine learning Techniques: Unsupervised and Supervised Learning, Cross Validation Techniques, Markov Model, Bayesian Inference: concepts and applications, Hidden Markov Model and applications, Introduction to WEKA package.

Practical's

- Database Similarity Searches.
- Multiple sequence alignment,
- Genome databases,
- Structural databases,
- Derived databases,
- Gene annotation,
- Gene prediction software.
- Analysis of DNA microarray experiments

- Expression profiling by microarray/gene chip
- Proteomics, Pattern recognition
- Hidden Markov Models
- Gibbs Sampling
- Analysis of single and multiple DNA or protein sequences.

References

- BALDI, P. AND BRUNAK, S., 2001, Bioinformatics: The Machine Learning Approach. MIT Press.
- BAXEVANIS, A. D. AND FRANCIS, B. F. 2004, Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. John Wiley.
- WANG, J. T. L., ZAKI, M. J., TOIVONEN, H. T. T. AND SHASHA, D., 2004, Data Mining in Bioinformatics.Springer.
- Amaratunga, D. and Cabrera, J., 2004, EXPLORATION AND ANALYSIS of DNA Microarray and Protein Array. John Wiley.
- GUPTA, G. K., 2006, Introduction to Data Mining with Case Studies. Prentice Hall of India, New Delhi.
- HAN, J. AND KAMBER, M., 2006, Data Mining: Concepts and Techniques. Morgan Kaufman.
- HAND, D. H., MANNILA, P. SMYTH., 2001, Principles of Data Mining. Prentice Hall of India, New Delhi.

BIM 502 STATISTICAL GENOMICS (2+1)

Objective

To builds the basic understanding of statistical methods used in genetics and genomics.

Theory

BLOCK I: Overview of Population Genetics and Molecular Markers

Unit I Fundamentals of Population genetics: Hardy –Weinberg law, Effect of systematic forces on changes in gene frequency; Principles of Quantitative genetics: Values, Means and Variances, Detection and

Estimation of Linkage, Inbreeding, Selection, Genetic Parameter Estimation, Variance component estimation, BLUP, G x E interaction, Path Analysis

Unit II: Molecular Marker based classification: similarity measures, clustering methods, bootstrapping; QTL mapping: Detection and Estimation of QTL, Single Marker Analysis, Interval Mapping and MQM;

BLOCK II: Gene expression analysis

Unit I: Design and Analysis of Expression Data; Genome Selection; Genome Prediction, Genetic Markers, Association Mapping; Genome Wide Association Analysis.

Practical's

- Population genetics: Hardy-Weinberg law
- Estimation of linkage
- Inbreeding
- Selection
- Genetic parameter estimation
- Variance component estimation
- BLUP, Path analysis
- Molecular marker based classification
- Estimation of QTL
- Single marker analysis
- MQM
- Analysis of gene expression data
- Genome selection and Genome prediction.

References

- XU, SHIZHONG., 2013, Principles of Statistical Genomics. Springer
- BEN HUI LIU., 1997, Statistical Genomics: Linkage, Mapping, and QTL Analysis.

- SORENSEN, D. AND GIANOLA, D., 2002, Likelihood, Bayesian and MCMC Methods in Genetics. Springer.
- BEN, H. L. AND LEMING, M. S., 2013, Statistical Genomics and Bioinformatics.

BIM 503 GENOME ASSEMBLY AND ANNOTATION (1+1)

Objective

To study genome assembly annotations of genes and genomes of organisation.

Theory

BLOCK I: Genome Assembly

Unit I: Types and methods of genome sequence data generation; Shot gun sequencing method; Problems of genome assembly, Approaches of genome assembly: Comparative Assembly, *De novo* Assembly; Read coverages; Sequencing errors, Sequence Quality Matrix, Assembly Evaluation; Challenges in Genome Assembly

Unit II: Various tools and related methods of genome assembly: MIRA, Velvet, ABySS, ALLPATHS-LG, Bambus2, Celera Assembler, SGA, SOAPdenovo, etc.

BLOCK II: Genome Annotation

Unit I: Basic concepts of genome annotation; Structural and Functional Annotation; Identification of open reading frame (ORF) and their regularization, Identification of gene structure, coding regions and location of regulatory motifs

Practicals

- Genome assembly methods for data from various sequencing platform
- Sequencing error determination
- Sequence quality matrix
- Various tools for genome assembly: MIRA, Velvet, ABySS, ALLPATHS-LG, Bambus2, Celera Assembler, SGA, SOAP denovo, *etc.*
- Structural and functional Genome annotation.

References

- JUNG, S., PAUL, GORDON, M. K., SENSEN, C. W., 2012, Genome Annotation. Chapman and Hall/ CRC • Venter, J. C., 2000. Annotation of the Celera Human Genome Assembly. Celera.
- MARK MENOR., 2007, Multi-genome Annotation of Genome Fragments Using Hidden Markov Model Profiles
- CARSON HINTON HOLT., 2012, Tools and Techniques for Genome Annotation and Analysis
- ALISTAIR G. RUST., EMMANUEL MONGIN. AND EWAN BIRNEY LORAINE, A. E. AND HELT, G. A., 2002, Genome annotation techniques: new approaches and challenges. Drug Discovery Today. 570 - 576 pp.
- WEIZHONG LI AND ADAM GODZIK., 2002, Discovering new genes with advanced homology detection. Trends in Biotechnology, 20: 8, 315-316 p.

BIM 504 BIO-MOLECULAR MODELLING AND SIMULATION (2+1)

Objective

To understand Bio molecular Modelling and Simulation.

Theory

BLOCK I: Bio-molecular Modelling

Unit I: Methods for 3D Structure Prediction: Homology modeling of protein 3D structures – approaches to loop building, energy considerations and evaluation of the accuracy of the model. ab initio approach to 3D structure prediction; Threading approach to 3D structure prediction. A Comparison of protein structure prediction methods: CASP.

Unit II: Basic principles of modeling: modeling by energy minimization technique, concept of rotation about bonds, energy minimization by basic technique for small molecules, Ramachandran plot, torsional space minimization, energy minimization in Cartesian space, molecular mechanics-basic principle.

BLOCK II: Bio-molecular Simulation

Unit I: Basic concepts of Simulation Modelling: Units and derivatives, Force field and energy landscape, Truncation of non-bonded interactions, Introduction to solvation, Periodic boundary condition, Wald summation, implicit solvent model and continuum electrostatics, Monte Carlo simulation on parallel computers. Replica-exchange simulations, Restraint potentials, Free energy calculations, Membrane simulations

Unit II: Energy Minimization: Concept of energy minimization - hypersurface, local and global energy minima, statement of problem. Derivative minimization methods - first derivative methods: the steepest descents method, line search in one dimension, arbitrary step approach, conjugate gradients minimization. Second derivative method – the Newton-Raphson method. Applications of energy minimization.

Practical's

- Protein structure databases: PDB, MODBASE, Structure visualization – Rasmol and PyMol, Structural analysis-classification, CATH, SCOP,
- Protein geometry – bond length, bond angle, torsion angle, calculation of surface area, volume and radii: Swiss PDB Viewer.
- Small molecule generation - peptides and nucleic acids: ISIS draw / ChemSketch, Selection of query sequence, template selection: pdbBLAST,
- Comparative 3D structure prediction – SWISSMODEL, Model generation - building side chains and loops using Modeller,
- Threading, ab initio modeling, Structure validation - generation and analysis of Ramachandran plot using PROCHECK, WHATCHECK *via* SAVS server,
- Force field calculation and energy minimization, Structure refinement - loop building, removing non-bonded contacts, adding missing side chains *via* WhatIf interface,
- Scoring structural similarity - 3D structure alignment - RMS superimposition – VMD, Molecular dynamics simulation using Tinker.

- Simulation dynamics, Monte carlo simulation on parallel computers.
- Replica exchange simulation, free energy calculation. Docking

References

- SCHLICK, T., 2010, Molecular Modeling and Simulation: An Interdisciplinary Guide. Science.
- GUNSTEREN, W. F., WEINER, P. K., WILKINSON, A. J., 1997, Computer Simulation of Biomolecular Systems: Theoretical and experimental application. Springer.
- MARTIN, J. F., 2007, A Practical Introduction to the Simulation of Molecular Systems. Cambridge University Press.
- LEACH, A. R., 2001, Molecular Modeling: Principles and Applications. Prentice Hall. 784p
- BOURNE, P. E. AND H. WEISSIG., 2003, Structural Bioinformatics. Wiley-Liss. 650 p.
- MARX, D. AND HUTTER, J., 2009, Ab Initio Molecular Dynamics: Basic Theory and Advanced Methods. Cambridge University Press. 578p.

BIM 505 TRANSCRIPTOMICS AND METAGENOMICS (2+1)

Objective

To study Transcriptomics and Metagenomics of organisms

Theory

BLOCK I: Transcriptomics

Unit I: Techniques of Transcriptomics: Microarrays, RNA-seq, Chip-Seq, EST-clustering, differential expression analysis

Unit II: Microbial Diversity analysis: Taxonomic and genetic annotation of high throughput sequence data, microbial diversity analyses, analyses of microbial community composition and change and metabolic reconstruction analyses.

BLOCK II: Metagenomics

Unit I: Comparison between Metagenomics: Comparison between Metagenomics and AL, EC, Comparison between LCS and Metagenomics, Symbiotic Evaluations: SANE, Comparison between SANE and Metagenomics, Horizontal Gene Transfer: Microbial GA.

Unit II: Metagenome Sequencing and Analysis: Metagenome Sequencing, Single Cell Analysis, Host-Pathogen Interaction; Shotgun metagenomics; High-throughput sequencing;

Practical's

- Meta genome annotation.
- Analyses of microbial community composition and change and metabolic reconstruction analyses.
- Meta transcriptomics.
- Comparative metagenomics.
- Microarray data analysis; RNA-seq, chip-seq, EST-clustering.

References

- Diana marco. 2010. Metagenomics: Theory, Methods and Applications. Ceister academic press
- Streit WR and Daniel R. 2010. Metagenomics: Methods and Protocols. Springer protocols.
- Yeh WK, Yang H, McCarthy JR. 2010. Enzyme Technologies: Metagenomics, Evolution, Biocatalysis and Biosynthesis.wiley
- Muthukumar V. 2003. Metagenomics for the Identification of Plant Viruses. ProQuest.

BIM 506 BIOLOGICAL DATA MANAGEMENT (2+1)

Objective

To understand the Biological Data Management and languages for Biological Data Management.

Theory

BLOCK I: Biological Data Management

Unit I: Database Management System (DBMS): Need for DBMS - File system vs Database system, Advantages of DBMS - DBMS Architecture – DBMS services - Data abstraction - Overview of Data Models: Hierarchical Model - Network Model - Entity-Relationship (E-R) Model: Symbols - Components of E-R Model: Entities, Attributes, Relationships - Relational Model, Object-oriented Model.

Unit II: Overview of Relational Database Objects – Relation – Tuple - Cardinality – Attribute – Degree - Domain - Primary key – Foreign key - Relational data structure – Relational Data Integrity and Constraints: Domain constraints, Entity integrity, Referential Integrity, Operational constraints - Codd's Rules – Normalization: 1NF, 2NF, 3NF, BCNF, 4NF and 5NF.

BLOCK II: Languages for Biological Data Management

Unit I Structured Query Language (SQL): Overview of SQL – SQL Data types and Literals – SQL Commands: Data Definition Language (DDL), Data Manipulation Language (DML), Data Querying Language (DQL), Data Control Language (DCL), Data Administration Statements (DAS), Transaction Control Statements (TCS), SQL Operators: Arithmetic, Comparison, Logical and Set Operators – SQL Query, Nested Query - SQL Aggregate functions.

Unit II: Biological Data Curation: Curation of genomic, genetic, proteomic data, High-throughput screening, array, qPCR data sets; Quality management of data: tools and techniques. Biological data sources, Data granularity, Schema modelling, architecture, query design, extraction, transformation and loading, Long term data management, storage and security. Bio-chip information system, visualization and reporting, Risk factors for data quality management. Un-structured or noSQL database; AI and BIG data Analytics

Practical's

- Understanding the data sources.
- Data granularity.

- Data modeling and architecture, development of database, Storage, Security.
- Visualization and reporting.

References

- KOZAK, K., 2010, Large scale data handling in biology. Ventus Publishing ApS. ISBN 978-87- 7681-555-4.
- HAROLD, E. AND MEANS, W. S., 2004, XML in a Nutshell, Third Ed. O'Reilly, Sebastopol, CA
- WITTEN, I. H. AND FRANK, E., 2005, Data Mining: Practical Machine Learning Tools and Techniques (WEKA), 2nd Ed. San Francisco, Morgan Kaufmann,
- LODISH, H. *et al.* 2000. Molecular cell biology. New York: Freeman & Co.
- KANEKO, K., 2006, Life: An Introduction to Complex Systems Biology. Springer.

BIM 507 BIOLOGICAL NETWORK MODELLING AND ANALYSIS (2+1)

Objective

To understand Biological modelling and molecular network analysis.

Theory

BLOCK I: Biological Network Modelling

Unit I: Introduction to biological networks: Graph theoretic modelling and analysis of biological networks, Discrete Dynamic modelling (Boolean networks, Petri nets), Continuous dynamic modelling (ODEs, stochastic simulation, etc.)

Unit II: Network modelling methods: Probabilistic modelling (Probabilistic Boolean networks, Bayesian networks, Mutual Information), Network inference from experimental data, Genome-scale modelling and network integration.

Block II: Molecular Networks Analysis

Unit I: Network Analysis: Evolution of molecular networks, Network-guided GWAS studies, FBA and epistasis detection, protein function prediction

Practical's

- Biological networks,
- Graph theoretic modelling and analysis of biological networks,
- Discrete Dynamic modeling;
- Continuous dynamic modeling;
- Probabilistic modeling;
- Genome-scale modelling and network integration;
- Evolution of molecular networks,
- Network-guided GWAS studies,
- FBA and epistasis detection, protein function prediction.

References

- JUNKER, B. H., 2008, Analysis of Biological Networks.
- KOCH, I., REISIG, W., SCHREIBER, F., 2010, Modeling in Systems Biology: The Petri Net Approach.
- RAMADAN, E. Y., 2008, Biological Networks: Modeling and Structural Analysis.
- LAUBENBACHER, R., 2007, Modeling and Simulation of Biological Networks.

BIM 508 COMPUTER PROGRAMMING IN BIOINFORMATICS (2+1)

Objective

To learn different computer programming in Bioinformatics.

Theory

Block 1: Bioinformatics programming for Sequence data analysis

Unit I: BioJava frame work for Bioinformatics

BioJava- Packages, Data Import, Manipulation; Python- Basic Syntax, Loops, Functions; BioPython. Linux

Unit II: Bioperl toolkit for sequence data analysis

Bioperl: Introduction, Modules: SeqIO, SearchIO, Seq Feature, Finding introns, Alignments, LiveSeq and Tree.

Block 2: Introduction to high performance parallel computing in Bioinformatics

Unit I: Introduction to Open MP based parallelization

Open MP: Clauses, Work sharing constructs, Synchronization constructs, Environment variables, Global Data, Runtime functions, Message Passing Interface (MPI): Introduction and programming, Point to point communications, Collective communications, Advanced MPI1 concepts, MPI2 introduction, Hybrid (openMP + MPI) programming.

Unit II: Parallel processing using CUDA

Compute Unified Device Architecture (CUDA): Introduction and Programming, GPU computing.

Practical

- Bio Perlprograming using bioperl modules such as SeqIO, SearchIO, LiveSeq and Tree.
- Open MP programming on Work sharing and Synchronization constructs.
- Environment variables and global data.
- MPI programming on Point-to-point communications and Collective communications.
- Compilation of Open MP and MPI programs
- Execution of Open MP and MPI programs.
- Use of high-performance computing, computing resources and job scheduling.

References

- TISDALL, J., 2001, Beginning Perl for Bioinformatics. O-Reilly.
- SCHWARTZ, R. L., PHOENIX, T., FOY, B. D., 2008, Learning Perl. O-Reilly.
- ORFALI, R. AND HARKEY, H., 1999, Client/Server Programming with JAVA and CORBA. John Wiley.
- SRIRAM SRINIVASAN., 1997, Advanced Perl Programming. O-Reilly.
- BUNCE, T. AND DESCARTES, A., 2000, Programming the Perl DBI. O-Reilly.
- MITCHELL L., MODEL., 2010, Bioinformatics Programming Using Python, O'Reilly media, Cambridge, Bal HP 2003. Perl Programming for Bioinformatics, Tata McGraw Hill.

BIM 509 MACHINE LEARNING TECHNIQUES IN BIOINFORMATICS (2+1)

Objective

To learn Machine Learning Techniques in Bioinformatics.

Theory

BLOCK I: Machine Learning Techniques

Unit I: Introduction to Machine Learning: Introduction to statistical learning theory, Empirical Risk Minimization, Structural Risk Minimization; Classification: Decision tree, Bayesian, Rule based classification, ANN, SVM, KNN; Case based reasoning and Applications in Bioinformatics.

Unit II: Clustering: Partition Methods, Hierarchical methods, Density based methods, Grid based clustering, Model based clustering, clustering of high dimensional data, constraints based clustering, Analysis of MD trajectories, Protein Array data Analysis.

BLOCK II: Methods of Machine Learning

Unit I: Introduction to Machine Learning methods: Dimensional Reduction Techniques, Methods of Feature Selection, Resampling Techniques, Elements of Text Mining and Web Mining, Soft Computing and Fuzzy logic system and application in bioinformatics.

Practical's

- Decision tree, classification techniques: ANN, SVM, KNN,
- Case based reasoning and its applications on biological data.
- Clustering techniques; Clustering of high dimensional data;
- Dimensional reduction techniques;
- Resampling techniques;
- Text mining and Web mining.
- Soft Computing and Fuzzy logic system & application in bioinformatics.

Reference

- Witten, H.I., Frank, E. and Hall, M.A. 2011. Data Mining: Practical Machine Learning Tools and Techniques.
- astie, T., Tibshirani, R., Friedman, J.H. 2009. The Elements of Statistical Learning: Data Mining Interface and Prediction.
- Clarke, S.B., Fokoue, E. and Zhang, H.H. 2009. Principles and Theory for Data Mining and Machine Learning.

BIM 510 ADVANCED BIOINFORMATICS (2+1)

Objective: To equip with advances in Bioinformatics and Bioinformatic tools.

Theory

BLOCK I: Biological databases

Unit I: Genomic databases and analysis of high-throughput data sets

Genomic databases and analysis of high-throughput data sets, Analysis of DNA sequence, Sequence annotation, ESTs, SNPs. BLAST and related sequence comparison methods.

Unit II: Algorithms for biological data analysis

EM algorithm and other statistical methods to discover common motifs in biosequences. Multiple alignment and database search using motif models, ClustalW and others. Concepts in phylogeny. Gene prediction based on codons, Decision trees, Classificatory analysis, Neural Networks, Genetic algorithms, Pattern recognition, Hidden Markov models.

BLOCK II: Protein expression and structure analysis

Unit I: Computational analysis of protein sequence

Computational analysis of protein sequence, structure and function. Modeling protein families. Expression profiling by microarray / gene chip, proteomics etc., Multiple alignment of protein sequences, Modeling and prediction of structure of proteins, Designer proteins, Drug designing. Markov chains (MC with no absorbing states; Higher order Markov dependence; patterns in sequences; Markov chain Monte Carlo - Hastings-Metropolis algorithm, Simulated Annealing, MC with absorbing States), Bayesian techniques and use of Gibbs Sampling, Advanced topics in design and analysis of DNA microarray experiments. Computationally intensive methods (Classical estimation methods, Bootstrap Estimation and Confidence Intervals, Hypothesis testing, Multiple Hypothesis testing).

Unit II: Phylogenetics and Prediction of protein structures

Evolutionary models (Models of Nucleotide substitution), Phylogenetic tree estimation (Distances: Tree reconstruction – Ultrametric and Neighbor-Joining cases, Surrogate distances, Tree reconstruction, Parsimony and Maximum Likelihood, Modeling, Estimation and Hypothesis Testing), Neural Networks (Universal Approximation Properties, Priors and Likelihoods, Learning Algorithms – Back propagation, Sequence encoding and output interpretation, Prediction of Protein Secondary Structure, Prediction of Signal Peptides and their

cleavage sites, Application for DNA and RNA Nucleotide Sequences), Analysis of SNPs and Haplotypes.

Practical

- Genomic databases and analysis of high-throughput data sets, BLAST and related sequence comparison methods.
- Statistical methods to discover common motifs in biosequences, Multiple alignment and database search using motif models, ClustalW, Classificatory analysis.
- Neural Networks, Genetic algorithms, Pattern recognition, Hidden Markov models.
- Computational analysis of protein sequence, Expression profiling by microarray/gene chip, proteomics, Modelling and prediction of structure of proteins, Bayesian techniques and use of Gibbs Sampling.
- Analysis of DNA microarray experiments, Analysis of one DNA sequence.
- Analysis of multiple DNA or protein sequences, Computationally intensive methods, Multiple Hypothesis testing.
- Phylogenetic tree estimation, Analysis of SNPs and Haplotypes.

Reference

- HELDER, I. N., editor. Brisbane (AU): Bioinformatics Exon Publications; 2021 Mar 20.
- HUSI, H., editor. Brisbane (AU) : Computational Biology, Codon Publications; 2019. Nov. 21.

M.Sc. (Agri.) in Entomology

Course Code	Course Title	Credit Hours
ENT 501	Insect Morphology	3 (2+1)
ENT 502	Insect Anatomy and Physiology	3 (2+1)
ENT 503	Insect Taxonomy	3 (2+1)
ENT 504	Insect ecology	3 (2+1)
ENT 505	Biological Control of Insect Pests and Weeds	3 (2+1)
ENT 506	Toxicology of Insecticides	3 (2+1)
ENT 507	Host Plant Resistance	2 (1+1)
ENT 508	Concepts of Integrated Pest Management	2 (2+0)
ENT 509	Pests of Field Crops	3 (2+1)
ENT 510	Pests of Horticultural and Plantation Crops	3 (2+1)
ENT 511	Post-Harvest Entomology	2 (1+1)
ENT 512	Insect Vectors of Plant Pathogens	2 (1+1)
ENT 513	Principles of Acarology	2 (1+1)
ENT 514	Vertebrate Pest Management	2 (1+1)
ENT 515	Techniques in Plant Protection	1 (0+1)
ENT 516	Apiculture	3 (2+1)
ENT 517	Sericulture	3 (2+1)
ENT 518	Lac Culture	3 (2+1)
ENT 519	Molecular Approaches in Entomology	3 (2+1)
ENT 520	Plant Quarantine, Biosafety and Biosecurity	2 (2+0)
ENT 521	Edible and Therapeutic Insects	2 (1+1)
ENT 522	Medical and Veterinary Entomology	2 (1+1)
ENT 523	Forest Entomology	2 (1+1)
	Total	**57 (36+21)**
ENT 580	Qualifying Examination	2 (0+2)
ENT 581	Seminar - I	1 (0+1)
ENT 582	Seminar - II	1 (0+1)
ENT 591	Research - I	13 (0+13)
ENT 592	Research - II	14 (0+14)

ENT 501 INSECT MORPHOLOGY (2+1)

Objective

To acquaint the students with the external morphology of the insect's body and the functioning of various body parts.

Theory

Block – 1: External and internal modifications in insects

Unit 1: External Morphology: Insect body wall structure, cuticular outgrowths, colouration and special integumentary structures in insects, body tagmata, sclerites and segmentation. Head- Origin, structure and modification; mouthparts, antennae, their types and functioning; tentorium and neck sclerites.

Thorax- Areas and sutures of tergum, sternum and pleuron, pterothorax; wings: structure and modifications, venation, wing coupling apparatus and mechanism of flight; legs: structure and modifications. Abdomen- Segmentation and appendages; genitalia and their modifications.

Block – 2: Insect sensory organs and their functions

Unit 1: Insect sense organs (mechano-, photo- and chemo-receptors); organogenesis at pupal stage; insect defence; chaetotaxy; morphological traits in relation to forensic entomology.

Block – 3 : Life history strategies in insects

Unit 1: Types of immature stages in insect orders, morphology of egg, nymph/larva and pupa, identification of different immature stages of crop pests and stored product insects. Comparative study of life history strategies in hemi- metabola and holometabola, immature stages as ecological and evolutionary adaptations, significance of immature stages for pest management.

Practical

Preparation of permanent mounts of different body parts and their appendages of taxonomic importance including male and female genitalia; dissection of genitalia. Types of immature stages in insects;

their collection, rearing and preservation. Identification of immature insects to orders and families, in endopterygote orders *viz.,* Diptera, Lepidoptera, Hymenoptera and Coleoptera using key.

References

- CHAPMAN, R. F., 1998, The Insects: Structure and Function. Cambridge Univ. Press, Cambridge.
- DUNTSON, P. A., 2004, The Insects: Structure, Function and Biodiversity. Kalyani Publ., New Delhi.
- EVANS, J. W., 2004, Outlines of Agricultural Entomology. Asiatic Publ., New Delhi. Gillott, C. 1995. Entomology, 2nd Ed. Plenum Press New York, London.
- GULLAN, P. J. AND CRANSTON, P. S., 2000, The Insects, An Outline of Entomology, 2nd Ed. Blackwell Science, U.K.
- RICHARDS, O. W. AND DAVIES, R. G., 1977, Imm's General Text Book of Entomology. 10th Ed. Chapman and Hall, London.
- SNODGROSS, R. E., 1993, Principles of Insect Morphology. Cornell Univ. Press, Ithaca.
- TEMBHORE, D. B., 2000, Modern Entomology, Himalaya Publishing House, Mumbai.
- CHU, H. F., 1992, How to Know Immature Insects. William Brown Publication, Iowa.
- PETERSON, A., 1962, Larvae of Insects. Ohio University Press, Ohio.
- STEHR, F. W. 1998. Immature Insects. Vols. I, II. Kendall Hunt Publication, Iowa.

ENT 502 INSECT ANATOMY AND PHYSIOLOGY (2+1)

Objective

To impart knowledge about the anatomy and physiology of insect body systems; nutritional physiology; and their applications in entomology.

Theory

Block – 1: Integument and its role in insect biology

Unit –1: Scope and importance of insect physiology; physiology of integument, moulting, chemistry of cuticle, bio-synthesis of chitin; growth, hormonal control, metamorphosis and diapause; pheromone secretion, transmission, perception and reception.

Block–2 : Insect internal systems and their functions

Unit 1: Physiology and mechanism of digestion, circulation, respiration, excretion, reproduction, secretion (exocrine & endocrine glands) and nerve impulse transmission in insects.

Block–3: Insect nutrition physiology

Unit 1: Importance of insect nutrition- role of vitamins, proteins, amino acids, carbohydrates, lipids, minerals and other food constituents; extra and intra-cellular microorganisms and their role in physiology; ar tificial diets. Thermodynamics.

Practical

Dissection of systems in insects; determination of chitin in insect cuticle; examination and count of insect haemocytes; preparation and evaluation of various diets; consumption, utilization and digestion of natural and artificial diets.

References

- CHAPMAN R. F., 1998, Insects: Structure and Function. ELBS Ed., London.
- DUNTSON P. A., 2004, The Insects: Structure, Function and Biodiversity. Kalyani Publ., New Delhi.
- GULLAN, P. J. AND CRANSTON, P. S., 2000, The Insects: An Outline of Entomology, 2ndEd. Blackwell Science, U.K.
- KERKUT, G. A. AND GILBERT, L. I., 1985, Comprehensive Insect Physiology, Biochemistry and Pharmacology. Vols. I- XIII. Pergamon Press, New York.

- PATNAIK, B. D., 2002, Physiology of Insects. Dominant Publishers, New Delhi.
- RICHARDS, O. W. AND DAVIES, R. G., 1977, Imm's General Text Book of Entomology. 10th Ed. Vol. 1. Structure, Physiology and Development. Chapman and Hall, New York.
- SIMPSON, S. J. 2007, Advances in Insect Physiology, Vol. 33, Academic Press (Elsevier), London, UK.
- WIGGLESWORTH, V. B., 1984, Insect Physiology. 8th Ed. Chapman and Hall, New York.

ENT 503 INSECT TAXONOMY (2+1)

Objective

To sensitize the students on the theory and practice of classifying organisms (with special reference to animals) and the rules governing the same. To introduce the students to the classification of insects up to the level of families with hands-on experience in identifying the families of insects with an emphasis on the practical aspects.

Theory

Block – 1 : History and Insect classification

Unit – 1: History of insect classification; principles of systematics and its importance. Identification, purpose, methods character matrix, taxonomic keys. Descriptions- subjects of descriptions, characters, nature of characters, analogy v/s homology, parallel v/s convergent evolution, intraspecific variation in characters, polythetic and polymorphic taxa, sexual dimorphism. Brief evolutionary history of insects- introduction to phylogeny of insects and Classification of Superclass Hexapoda – Classes – Ellipura (Collembola, Protura), Diplura and Insecta- and the Orders contained. International Code of Zoological Nomenclature, Phylocode, its brief explanation and uses. Process of speciation and interbreeding allopatric species. Molecular systematics, DNA barcoding, karyological and biochemical approaches in taxonomy. Insect labelling protocols and procedures.

Block–2: Insect orders and their morphological characteristics

Unit 1: Distinguishing characters, general biology, habits and habitats of insect orders and economically important families contained in them. Collembola, Protura, Diplura. Class Insecta: Subclass Apterygota – Archaeognatha, Thysanura. Subclass: Pterygota, Division Palaeoptera – Odonata and Ephemeroptera. Division: Neoptera: Subdivision: Orthopteroid and Blattoid Orders (=Oligoneoptera: Plecoptera, Blattodea, Isoptera, Mantodea, Grylloblattodea, Dermaptera, Orthoptera, Phasmatodea, Mantophasmatodea, Embioptera, Zoraptera), Subdivision: Hemipteroid Orders (=Paraneoptera): Psocoptera, Phthiraptera, Thysanoptera and Hemiptera.

Block 3-: Insect orders and their economic importance

Unit 1: Distinguishing characters, general biology, habits and habitats of insect orders and economically important families contained in them (Continued). Division Neoptera – Subdivision Endopterygota, Section Neuropteroid- Coleopteroid Orders: Strepsiptera, Megaloptera, Raphidioptera, Neuroptera and Coleoptera, Section Panorpoid Orders Mecoptera, Siphonaptera, Diptera, Trichoptera, Lepidoptera, and Section Hymenopteroid Orders: Hymenoptera.

Practical

Study of Orders of insects and their identification using taxonomic keys. Keying out families of insects of different major Orders: Odonata, Orthoptera, Blattodea, Mantodea, Isoptera, Hemiptera, Thysanoptera, Phthiraptera, Neuroptera, Coleoptera, Diptera, Lepidoptera and Hymenoptera. Field visits to collect insects of different orders.

References

- CSIRO 1990, The Insects of Australia: A Text Book for Students and Researchers. 2nd Ed. Vols. I and II, CSIRO. Cornell Univ. Press, Ithaca.
- FREEMAN, S. AND HERRON, J. C., 1998, Evolutionary Analysis. Prentice Hall, New Delhi.
- GULLAN, P. J. AND CRANSTON, P.S., 2010, The Insects: An outline of Entomology. 4th Ed. Wiley-Blackwell Publications, West Sussex, UK.

- MAYR, E., 1971, Principles of Systematic Zoology. Tata McGraw Hill, New Delhi.
- RICHARDS, O. W. AND DAVIES. R. G., 1977, Imm's General Text Book of Entomology. 10th Ed. Chapman and Hall, London.
- ROSS, H. H.,1974, Biological Systematics. Addison Wesley Publ. Company.
- TRIPLEHORN, C. A. AND JOHNSON, N. F., 1998, Borror and DeLong's Introduction to the Study of Insects. 7th Ed. Thomson/ Brooks/ Cole, USA/Australia.

ENT 504 INSECT ECOLOGY (2+1)

Objective

To teach the concepts of ecology, basic principles of distribution and abundance of organisms and their causes. Study life tables, constructing life tables, organization of communities, diversity indices. Train students in sampling methodology, calculation of diversity indices, relating insect population fluctuation to biotic and /or abiotic causes.

Theory

Block – 1 Evolution, abundance and distribution of insets in relation to abiotic factors

Unit–1: History and definition. Basic Concepts. Organisation of the Biological world. Plato's Natural Balance vs Ecological Dynamics as the modern view. Abundance and diversity of insects, Estimates and Causal factors. Study of abundance and distribution and relation between the two. Basic principles of abiotic factors and their generalised action on insects. Implications for abundance and distribution of organisms including insects- Law of the Minimum, Law of Tolerance, and biocoenosis.

Block- 2 Population ecology of insects

Unit–1: Basic concepts of abundance- Model vs Real world. Population growth basic models – Exponential vs Logistic models.

Discrete vs Continuous growth models. Concepts of Carrying capacity, Environmental Resistance and Optimal yield. Vital Statistics- Life Tables and their application to insect biology. Survivorship curves. Case studies of insect life tables. Population dynamics- Factors affecting abundance- Environmental factors, dispersal and migration, Seasonality in insects. Classification and mechanisms of achieving different seasonality- Diapause (Quiescence) - aestivation, hibernation.

Block – 3 Role of abiotic factors in insect distribution and abundance

Unit- 1: Biotic factors- Food as a limiting factor for distribution and abundance, Nutritional Ecology. Food chain- web and ecological succession. Interspecific interactions- Basic factors governing the interspecific interactions- Classification of interspecific interactions - The argument of cost-benefit ratios. Competition- Lotka-Volterra model, Concept of niche ecological homologues, competitive exclusion. Evolution of mimicry, colouration, concept of predator satiation; evolution of life history strategies.

Block – 4 Community ecology of insects

Unit–1: Community ecology- Concept of guild, Organisation of communities- Hutchinson Ratio, May's d/w, Relation between the two and their association with Dyar's Law and Przibram's law. Relative distribution of organisms, Assessment of diversity. Diversity- stability debate, relevance to pest management. Pest management as applied ecology. Climate change and insect pest/ natural enemy population; ecological engineering.

Practical

Types of distributions of organisms. Methods of sampling insects, estimation of densities of insects and understanding the distribution parameters- Measures of central tendencies, Poisson Distribution, Negative Binomial Distribution. Determination of optimal sample size. Learning to fit basic population growth models and testing the goodness of fit. Fitting Holling's Disc equation, Assessment of prey-predator densities from natural systems and understanding the correlation between the two. Assessing and describing niche of some insects of a single guild.

Calculation of niche breadth, activity breadth and diagrammatic representation of niches of organisms. Calculation of diversity indices- Shannon's, Simpson's and Avalanche Index and understanding their associations and parameters that affect their values. Problem solving in ecology. Field visits to understand different ecosystems and to study insect occurrence in these systems.

References

- BEGON, M., TOWNSEND, C. R. AND HARPER, J. L., 2006, Ecology: From Individuals to Ecosystems. 4thEd. Blackwell Publishing, USA/ UK/ Australia.
- CHAPMAN, J. L. AND REISS, M. J., 2006, Ecology: Principles and Applications. 2nd Ed. Cambridge Univ. Press, Cambridge.
- FOWLER, J., COHEN, L. AND JARVIS, P., 1998, Practical Statistics for Field Biology. 2nd Ed. John Wiley & Sons, Chichester, West Sussex PO19 8SQ, England.
- GOTELLI, N. J. AND ELLISON, A. M., 2004, A Primer of Ecological Statistics. Sinauer Associates, Inc., Sunderland, MA. Gotelli N. J. 2001, A Primer of Ecology. 3rd Ed. Sinauer Associates, Inc., Sunderland, MA
- GUPTA, R. K., 2004, Advances in Insect Biodiversity. Agrobios, Jodhpur.
- KREBS, C. J., 1998, Ecological Methodology. 2nd Ed. Benjamin-Cummings Publ. Co., New York.
- KREBS, C. J., 2001, Ecology: The Experimental Analysis of Distribution and Abundance. 5th Ed. Benjamin- Cummings Publ. Co., New York.
- MAGURRAN, A. E., 1988, Ecological Diversity and its Measurement. Princeton Univ. Press, Princeton. Price PW. 1997. Insect Ecology. 3rd Ed. John Wiley, New York.
- REAL, L. A. AND BROWN, J. H., 1991, Foundations of Ecology: Classic Papers with Commentaries. University of Chicago Press, Chicago.

• SCHOWALTER, T. D., 2011, Insect Ecology - An Ecosystem Approach. 3rd Ed. Academic Press, London, UK/ CA, USA.

ENT 505 BIOLOGICAL CONTROL OF INSECT PESTS AND WEEDS (2+1)

Objective

To train the students with theory and practice of biological control, mass production techniques and field evaluation of various biological control agents like parasitoids, predators and various entomopathogenic microorganisms.

Theory

Block 1: Introduction and principles of biological control

Unit 1: History, principles and scope of biological control; important groups of parasitoids, predators and pathogens; principles of classical biological control- importation, augmentation and conservation. History of insect pathology, infection of insects by bacteria, fungi, viruses, protozoa, rickettsia and nematodes.

Block 2: Host - prey relationship and mass production of bioagents

Unit 1: Biology, adaptation, host seeking behaviour of predatory and parasitic groups of insects. Role of insect pathogenic nematodes, viruses, bacteria, fungi, protozoa etc., their mode of action. Biological control of weeds using insects. Epizootiology, symptomatology and etiology of diseases caused by the above and the factors controlling these. Defense mechanisms in insects against pathogens.

Unit 2: Mass production of quality bio-control agents- techniques, formulations, economics, field release/application and evaluation. Development of insectaries, their maintenance.

Block 3: Successful biological control projects and regulations for import of natural enemies

Unit 1: Successful biological control projects, analysis, trends and future possibilities of biological control. Importation of natural enemies-

Quarantine regulations, molecular approaches in biological control. Semio chemicals in biological control.

Practical

Identification of common natural enemies of crop pests (parasitoids, predators, microbes) and weed killers. Visits to bio-control laboratories to learn rearing and mass production of egg, egg-larval, larval, larval-pupal and pupal parasitoids, common predators, microbes and their laboratory hosts, phytophagous natural enemies of weeds. Field collection of parasitoids and predators. Hands-on training in culturing, identification of common insect pathogens. Quality control and registration standards for biocontrol agents.

References

- BURGES, H. D. AND HUSSEY, N. W., 1971, Microbial Control of Insects and Mites. Academic Press, London.
- DEBACH, P., 1964, Biological Control of Insect Pests and Weeds. Chapman and Hall, New York.
- DHALIWAL, G. S. AND ARORA, R., 2001, Integrated Pest Management: Concepts and Approaches. Kalyani Publ., New Delhi.
- GERSON, H. AND SMILEY. R, L., 1990, Acarine Biocontrol Agents - An Illustrated Key and Manual. Chapman and Hall, New York.
- HUFFAKER, C. B. AND MESSENGER, P. S., 1976, Theory and Practices of Biological Control. Academic Press, London.
- IGNACIMUTHU, S. S. AND JAYARAJ, S., 2003, Biological Control of Insect Pests. Phoenix Publ., New Delhi.
- SAXENA, A. B., 2003, Biological Control of Insect Pests. Anmol Publ., New Delhi.
- VAN DRIESCHE AND BELLOWS T. S. J. R., 1996, Biological Control. Chapman and Hall, New York.

ENT 506 TOXICOLOGY OF INSECTICIDES (2+1)

Objective

To orient the students with structure and mode of action of important insecticides belonging to different groups, development of resistance to insecticides by insects, environmental pollution caused by toxic insecticides and their toxicological aspects.

Theory

Block–1: Insecticides and their classification

Unit 1: Definition and scope of insecticide toxicology; history of chemical control; pesticide use and pesticide industry in India.

Unit 2: Classification of insecticides and acaricides based on mode of entry, mode of action and chemical nature; categorization of insecticides on the basis of toxicity – criteria for bees and other beneficial insects; general structure and mode of action of organochlorines, organophosphates, carbamates, pyrethroids, tertiary amines, neonicotinoids, oxadiazines, phenyl pyrozoles, insect growth regulators, microbials, botanicals, new insecticide molecules; nanopesticides; drawbacks of insecticide abuse.

Block–2: Assessment of insecticides

Unit 1: Principles of toxicology; evaluation of insecticide toxicity; joint action of insecticides- synergism, potentiation and antagonism; factors affecting toxicity of insecticides; insecticide compatibility and phytotoxicity. Insecticide bioassays- definition, objectives, methods.

Unit 2: Insecticide metabolism; insect-pest resistance to insecticides; mechanisms and types of resistance; insecticide resistance management and pest resurgence.

Block – 3: Registration and safe handling of insecticides

Unit 1: Insecticide residues, their significance and environmental implications; procedures of insecticide residue analysis. Insecticide Act, registration procedures and label claim;

Safe use of insecticides; diagnosis and treatment of insecticide poisoning.

Practical

Insecticide groups, formulations and mixtures; laboratory and field evaluation of bio-efficacy of insecticides; bioassay techniques; probit analysis; evaluation of insecticide toxicity. Pesticide appliances. Working out doses and concentrations of pesticides.

References

- CHATTOPADHYAY, S. B., 1985, Principles and Procedures of Plant Protection. Oxford and IBH, New Delhi.
- GUPTA, H. C. L.,1999, Insecticides: Toxicology and Uses. Agrotech Publ., Udaipur.
- ISHAAYA, I. AND DEGHEELE (EDS.)., 1998. Insecticides with Novel Modes of Action. Narosa Publ. House, New Delhi.
- MATSUMURA, F., 1985, Toxicology of Insecticides. Plenum Press, New York.
- PERRY, A. S., YAMAMOTO, I., ISHAAYA, I. AND PERRY, R., 1998, Insecticides in Agriculture and Environment. Narosa Publ. House, New Delhi.
- PRAKASH, A. AND RAO, J., 1997, Botanical Pesticides in Agriculture. Lewis Publication, New York.
- PEDIGO, L.P. AND MARLIN, E. R., 2009, Entomology and Pest Management, 6th Edition, Pearson Education Inc., Upper Saddle River, New Jersey 07458, U.S.A.
- DOVENER, R. A., MUENINGHOFF, J. C. AND VOLGAR, G. C., 2002, Pesticides formulation and delivery systems: meeting the challenges of the current crop protection industry. ASTM, USA
- DODIA, D.A., PETEL, I. S. AND PETAL, G. M., 2008, Botanical Pesticides for Pest Management. Scientific Publisher (India), Jodhpur.
- ISHAAYA, I. AND DEGHEELE, D., 1998, Insecticides with Novel Modes of Action: Mechanism and Application. Norosa Publishing House, New Delhi.

- MATHEWS, G. A., 2002, Pesticide Application Methods. 4th Ed. Intercept. UK.
- OTTO, D. AND WEBER, B., 1991, Insecticides: Mechanism of Action and Resistance. Intercept Ltd., U.K.
- ROY, N. K., 2006, Chemistry of Pesticides. Asia Printograph Shahdara Delhi.
- KRIEGER, R. I., 2001, Handbook of Pesticide Toxicology. Vol-II. Academic Press. Orlando Florida.

ENT 507 HOST PLANT RESISTANCE (1+1)

Objectives

Host plant resistance an effective weapon to minimize the losses due to insect pests. HPR will not only cause a major reduction in pesticide use and slowdown the rate of development of resistance to insecticides in insect populations, but also lead to increased activity of beneficial organisms and reduction in pesticide residues in food and food products.

Theory

Block–1: Plant resistance, classification and theories

Unit 1: History and importance of resistance; principles, classification, components, types and mechanisms of resistance.

Unit 2: Insect-host plant relationships; theories and basis of host plant selection in phytophagous insects.

Block–2: Ecology and resistance mechanisms in host plants

Unit 1: Chemical ecology, tritrophic relations, volatiles and secondary plant substances; basis of resistance. Induced resistance – systemic acquired and induced systemic resistance.

Unit 2: Factors affecting plant resistance including biotypes and measures to combat them.

Block – 3 Breeding for insect resistance and applications of biotechnology in host plant resistance

Unit 1: Screening techniques; breeding for insect resistance in crop plants; exploitation of wild plant species; gene transfer, successful examples of resistant crop varieties in India and world.

Unit 2: Role of biotechnology in plant resistance to insects.

Practical

Screening techniques for measuring resistance; measurement of plant characters and working out their correlations with plant resistance; testing of resistance in important crops; bioassay of plant extracts of susceptible/resistant varieties; demonstration of antibiosis, tolerance and antixenosis.

References

- DHALIWAL, G. S. AND SINGH, R. (Eds)., 2004, Host Plant Resistance to Insects -Concepts and Applications. Panima Publ., New Delhi.
- MAXWELL, F. G. AND JENNINGS, P. R. (Eds)., 1980, Breeding Plants Resistant to Insects. John Wiley and Sons, New York.
- PAINTER, R. H., 1951, Insect Resistance in Crop Plants. MacMillan, London.
- PANDA, N. AND KHUSH, G. S., 1995, Plant Resistance to Insects. CABI, London.
- SMITH, C. M., 2005, Plant Resistance to Arthropods - Molecular and Conventional Approaches.

ENT 508 CONCEPTS OF INTEGRATED PEST MANAGEMENT (2+0)

Objectives

To familiarize the students with principles of insect pest management, including concept and philosophy of IPM. Train students in computation of ETL and implementing IPM programmes.

Theory

Block – 1: IPM and its components

Unit 1: History, origin, definition and evolution of various terminologies. Importance of host plant resistance, principles, classification, components, types and mechanisms of host plant resistance. National and international level crop protection organizations; insecticide regulatory bodies; label claim of pesticides – the pros and cons.

Unit 2: Concept and philosophy IPM, ecological principles, economic threshold concept and economic consideration. Insect- host plant relationships; theories and basis of host plant selection in phytophagous insects.

Block – 2: Tools of IPM and their application in pest management

Unit 1: Tools of pest management and their integration- legislative, quarantine regulations, cultural, physical and mechanical methods; semiochemicals, biotechnological and bio-rational approaches in IPM. Pest survey and surveillance, forecasting, types of surveys including remote sensing methods, political, social and legal implications of IPM; pest risk analysis; pesticide risk analysis; cost-benefit ratios; case studies of successful IPM programmes. ITK-s in IPM, area-wide IPM and IPM for organic farming; components of ecological engineering with successful examples.

Block – 3: Assessment of crop losses due to insect pests

Unit 1: Characterization of agro-ecosystems; sampling methods and factors affecting sampling; population estimation methods; crop loss assessment - direct losses, indirect losses, potential losses, avoidable losses, unavoidable losses; global and Indian scenario of crop losses. Computation of EIL and ETL; designing and implementing IPM system. Screening techniques; breeding for insect resistance in crop plants; exploitation of wild plant species; gene transfer, successful examples of resistant crop varieties in India.

References

- DHALIWAL, G. S. AND ARORA, R., 2003, Integrated Pest Management - Concepts and Approaches. Kalyani Publ., New Delhi.
- HOROWITZ, A. R. AND ISHAAYA, I., 2004, Insect Pest Management: Field and Protected Crops. Springer, New Delhi.
- IGNACIMUTHU, S. S. AND JAYARAJ, S., 2007, Biotechnology and Insect Pest Management. Elite Publ., New Delhi.
- PEDIGO, R. L., 2002, Entomology and Pest Management. 4th Ed. Prentice Hall, New Delhi.
- NORRIS, R. F., CASWELL-CHEN, E. P. AND KOGAN, M., 2002, Concepts in Integrated Pest Management. Prentice Hall, New Delhi.
- SUBRAMANYAM, B. AND HAGSTRUM, D. W., 1995, Integrated Management of Insects in Stored Products. Marcel Dekker, New York.

ENT 509 PESTS OF FIELD CROPS (2+1)

Objective

To familiarize the students about nature of damage and seasonal incidence of pestiferous insects that cause loss to major field crops and their effective management by different methods.

Theory

Block – 1: Bionomics of insect &mite pests

Unit 1: Systematic position, identification, distribution, host-range, bionomics, nature and extent of damage, seasonal abundance and management of insect and mite pests and vectors. Insect pest scenario in relation to climate change.

Block – 2: Management of polyphagous pests and insect pests of cereals

Unit 1: Polyphagous pests: grasshoppers, locusts, termites, white grubs, hairy caterpillars and non-insect pests (mites, birds, rodents, snails, slugs etc.). Insect pests of cereals (Paddy, Maize, Wheat and Bajra) and millets (Ragi and Jowar) and their management.

Block – 3: Management pests of pulses and oil seeds

Unit 1: Insect pests of pulses (Red gram, Chickpea, Black gram, Green gram, Lab-lab, and Cowpea), tobacco, oilseeds (Groundnut, Castor, Sunflower, safflower, Mustard and Soybean) and their management.

Block – 4: Management pests of fibre and forage crops

Unit 1: Insect pests of fibre crops (Cotton, Jute and Mesta), forage crops (Fodder sorghum,Lucerne, Pearl-millet), sugarcane and their management.

Practical

Field visits, collection and identification of important pests and their natural enemies; detection and estimation of infestation and losses in different crops; study of life history of important insect pests.

References

- DAVID, B. V. AND RAMAMURTHY, V. V., 2001, Elements of Economic Entomology. Popular Book Depot, Chennai.
- DHALIWAL, G. S., SINGH R AND CHHILLAR, B. S., 2006, Essentials of Agricultural Entomology. Kalyani Publ., New Delhi.
- DUNSTON, A. P., 2007, The Insects: Beneficial and Harmful Aspects. Kalyani Publ., New Delhi
- EVANS J. W. 2005. Insect Pests and their Control. Asiatic Publ., New Delhi.
- NAIR, MRGK., 1986, Insect and Mites of Crops in India. ICAR, New Delhi.
- PRAKASH, I. AND MATHUR, R. P., 1987, Management of Rodent Pests. ICAR, New Delhi.

• SAXENA, R. C. AND SRIVASTAVA, R. C., 2007, Entomology at a Glance. Agrotech Publ. Academy, Udaipur.

ENT 510 PESTS OF HORTICULTURAL AND PLANTATION CROPS (2+1)

Objective

To impart knowledge on major pests of horticultural and plantation crops regarding the extent and nature of loss, seasonal history, their integrated management.

Theory

Block–1: Bionomics of insect &mite pests

Unit 1: Systematic position, identification, distribution, host range, bionomics and seasonal abundance, nature and extent of damage and management of insect pests of various crops.

Block – 2: Management of insect pests of fruit crops

Unit 1: Fruit Crops- mango, citrus, guava, banana, grapes, pomegranate, ber, papaya, sapota, jack, fig, apple and other temperate fruit like apple included and their management.

Block – 3: Management of insect pests of vegetable crops

Unit 1: Vegetable crops- brinjal, tomato, potato, okra, cole crops, gourds, French beans, chow-chow, radish, carrot, beetroot, gherkin, drumstick, leafy vegetables etc.

Block – 4: Management of insect pests of plantation crops, spices and condiments

Unit 1: Plantation crop-coconut, arecanut, cashew, coffee, tea, rubber, cocoa etc.,

Spices and Condiments- cardamom, pepper, chillies, turmeric, ginger, beetle vine etc.

Block – V: Management of insect pests of ornamental, medicinal & aromatic crops

Unit 1: Ornamental crops (Jasmine, Rose, Chrysanthemum, Gerbera, Marigold etc.,)

Medicinal and Aromaticplants (amla, ashwagandha, coleus (patharchur), kalihari / glory lily, isabgol, pippali (long pepper), safedmusli, senna, shatavari (Indian asperagus), Stevia.

Practical

Collection and identification of important pests and their natural enemies on different crops; study of life history of important insect pests and non-insect pests.

References

- ATWAL, A. S. AND DHALIWAL, G. S., 2002, Agricultural Pests of South Asia and their Management. Kalyani Publ., New Delhi.
- BUTANI, D.K. AND JOTWANI, M. G., 1984, Insects and Vegetables. Periodical Expert Book Agency, New Delhi.
- DHALIWAL, G. S., SINGH, R. AND CHHILLAR, B. S., 2006, Essential of Agricultural Entomology. Kalyani Publ., New Delhi.
- SRIVASTAVA, R. P.,1997, Mango Insect Pest Management. International Book Distr., Dehra Dun.
- VERMA, L. R., VERMA, A. K. AND GOUTHAM, D. C., 2004, Pest Management in Horticulture Crops: Principles and Practices. Asiatech Publ., New Delhi.

ENT 511 POST HARVEST ENTOMOLOGY (1+1)

Objective

To focus on requirement and importance of grain and grain storage, to understand the role of stored grain pests and to acquaint with various stored grain pest management techniques for avoiding losses in storage.

Theory

Block–1: History and concepts in storage entomology

Unit 1: Introduction, history of storage entomology, concepts of storage entomology and significance of insect pests. Post-harvest losses in toto vis-aÌ-vis total production of food grains in India. Scientific and socio-economic factors responsible for grain losses. Concept of seed vault.

Block–2: Insects and non-insect pests, storage structures in post-harvest entomology

Unit 1: Important pests namely insects, mites, rodents, birds and microorganisms associated with stored grain and field conditions including agricultural products; traditional storage structures; association of stored grain insects with mites, their systematic position, identification, distribution, host range, biology, nature and extent of damage, role of field and cross infestations and natural enemies, type of losses in stored grains and their effect on quality including biochemical changes.

Block–3: Role of abiotic factors in storage of food grains and commodities

Unit 1: Ecology of insect pests of stored commodities/grains with special emphasis on role of moisture, temperature and humidity in safe storage of food grains and commodities. Stored grain deterioration process, physical and biochemical changes and consequences. Grain storage- types of storage structures *i.e.,* traditional, improved and modern storage structures in current usage. Ideal seeds and commodities' storage conditions.

Block – 4: Management of insects and non- insects pests of storage

Unit 1: Important rodent pests associated with stored grains and their non-chemical and chemical control including fumigation of rat burrows. Role of bird pests and their management. Control of infestation by insect pests, mites and microorganisms. Preventive measures- Hygiene/ sanitation, disinfestations of stores/receptacles, legal methods. Curative measures- Non-chemical control measures- ecological, mechanical, physical, cultural, biological and engineering. Chemical control-

prophylactic and curative- Characteristics of pesticides, their use and precautions in their handling with special emphasis on fumigants. Insecticide resistance in stored product pests and its management; recent advances (MAS, PPP, HS) in storage pest management; integrated approaches to stored grain pest management.

Practical

Collection, identification and familiarization with the stored grains/ seed insect pests and nature of damage caused by them; detection of hidden insect infestation in stored food grains; estimation of uric acid content in infested produce; estimation of losses in stored food grains; determination of moisture content in stored food grains; familiarization of storage structures, demonstration of preventive and curative measures including fumigation techniques; treatment of packing materials and their effect on seed quality. Field visits to save grain campaign, central warehouse and FCI warehouses and institutions engaged in research or practice of grain storage like CFTRI, IGSMRI, Hapur etc. (only where logistically feasible).

References

- HALL, D. W., 1970, Handling and Storage of Food Grains in Tropical and Subtropical Areas. FAO. Agricultural Development Paper No. 90 and FAO, Plant Production and Protection Series No. 19, FAO, Rome.
- JAYAS, D. V, WHITE, N.D.G. AND MUIR, W. E., 1995, Stored Grain Ecosystem. Marcel Dekker, New York.
- KHADER, V., 2004, Textbook on Food Storage and Preservation. Kalyani Publ., New Delhi.
- KHARE, B. P., 1994, Stored Grain Pests and Their Management. Kalyani Publ., New Delhi.
- SUBRAMANYAM, B. AND HAGSTRUM, D.W., 1995, Interrelated Management of Insects in Stored Products. Marcel Dekker, New York.

ENT 512 INSECT VECTORS OF PLANT PATHOGENS (1+1)

Objective

To teach the students about the different groups of insects that act as vectors of plant pathogens, vector-plant pathogen interaction, and management of vectors for controlling diseases.

Theory

Block–1: History, Characteristics and Feeding processes of important insect vectors

Unit 1: History of developments in the area of insects as vectors of plant pathogens. Important insect vectors and their characteristics; mouth parts and feeding processes of important insect vectors. Efficiency of transmission.

Unit 2: Transmission of plant viruses and fungal pathogens. Relation between viruses and their vectors.

Block–2: Transmission of plant viruses and mycoplasma by sap feeding insects

Unit 1: Transmission of plant viruses by aphids, whiteflies, mealy bugs and thrips.

Unit 2: Transmission of mycoplasma and bacteria by leaf hoppers and plant hoppers.

Unit 3: Transmission of plant viruses by psyllids, beetles and mites. Epidemiology and management of insect transmitted diseases through vector management.

Practical

Identification of common vectors of plant pathogens- aphids, leafhoppers, whiteflies, thrips, beetles, nematodes; culturing and handling of vectors; demonstration of virus transmission through vectors- aphids, leafhoppers and whiteflies. Vector rearing and maintenance; estimating vector transmission efficiency, studying vector-virus host interaction.

References

- BASU, A. N. 1995, Bemisia tabaci (Gennadius) - Crop Pest and Principal Whitefly Vector of Plant Viruses. Oxford and IBH, New Delhi.
- HARRIS, K. F. AND MARAMAROSH, K. (Eds.).,1980, Vectors of Plant Pathogens. Academic Press, London.
- MARAMOROSCH, K. AND HARRIS, K. F. (Eds.)., 1979, Leafhopper Vectors and Plant Disease Agents. Academic Press, London.
- YOUDEOVEI, A. AND SERVICE, M. W., 1983, Pest and Vector Management in the Tropics. English Language Books Series, Longman, London.

ENT 513 PRINCIPLES OF ACAROLOGY (1+1)

Objective

To acquaint the students with external morphology of different groups of mites, train in identification of commonly occurring families of plant associated mites, provide information about important mite pests of crops and their management.

Theory

Block–1: History and importance of mites and other soil arthropods

Unit 1: History of Acarology; importance of mites as a group; habitat, collection and preservation of mites. Soil arthropods and their classification, habitats and their identification.

Block–2: Morphology and biology of major orders & families of mites and ticks

Unit 1: Introduction to morphology and biology of mites and ticks. Broad classification- major orders and important families of Acari including diagnostic characteristics. Estimation of populations; sampling and extraction methods for soil arthropods.

Block–3: Economic importance of mites and their management

Unit 1: Economic importance, seasonal occurrence, nature of damage, host range of mite pests of different crops, mite pests in polyhouses, mite pests of stored products and honeybees. Management of mites using acaricides, phytoseiid predators, fungal pathogens *etc.* Culturing of phytophagous, parasitic and predatory mites. Mode of action of acaricides, resistance of mites and ticks to acaricides, its management.

Practical

Collection of mites from plants, soil and animals; extraction of mites from soil, plants and stored products; preparation of mounting media and slide mounts; external morphology of mites; identification of mites up to family level using keys; studying different rearing techniques for mites.

References

- ANDERSON, J. M AND INGRAM, J. S. I., 1993, Tropical Soil Biology and Fertility: A Handbook of Methods. CABI, London.
- CHHILLAR, B. S., GULATI, R. AND BHATNAGAR, P., 2007, Agricultural Acarology. Daya Publ. House, New Delhi.
- DINDAL, D. L.,1990, Soil Biology Guide. A Wiley-InterScience Publ., John Wiley and Sons, New York.
- GERSON, U. AND SMILEY, R. L., 1990, Acarine Biocontrol Agents - An Illustrated Key and Manual. Chapman and Hall, NewYork.
- GUPTA, S. K., 1985, Handbook of Plant Mites of India. Zoological Survey of India, Calcutta.
- GWILYN, O. AND EVANS, G. O., 1998, Principles of Acarology. CABI, London.
- JEPPSON, L. R., KEIFER, H. H. AND BAKER, E. W., 1975, Mites Injurious to Economic Plants. University of California Press, Berkeley.

- KRANTZ, G.W., 1970, A Manual of Acarology. Oregon State Univ. Book Stores, Corvallis, Oregon.
- PANKHURST, C., DUBE, B. AND GUPTA, V., 1997, Biological Indicators of Soil Health. CSIRO, Australia.
- QIANGZHIANG, Z., 2003, Mites of Green Houses- Identification, Biology and Control. CABI, London.
- SADANA, G. L., 1997, False Spider Mites Infesting Crops in India. Kalyani Publ. House, New Delhi.
- WALTER, D. E. AND PROCTOR, H. C., 1999, Mites- Ecology, Evolution and Behaviour. CABI, London.

ENT 514 VERTEBRATE PEST MANAGEMENT (1+1)

Objective

To impart knowledge on vertebrate pests like birds, rodents, mammals and others of different crops, their biology, damage they cause and management strategies.

Theory

Block–1: Introduction and biology of vertebrate pests

Unit 1: Introduction to vertebrate pests of different crops; biology of vertebrate pests such as rodents, birds and other mammals.

Block–2: Bio ecology and management of pestiferous birds

Unit 1: Bio-ecology of birds of agricultural importance, patterns of pest damage and assessment, roosting and nesting systems in birds; management of pestiferous birds; conservation of predatory birds.

Block–3: Bio ecology and management of pestiferous rodents

Unit 1: Bio-ecology of rodents of agricultural importance, patterns of pest damage and assessment, burrowing pattern and habitat of rodents; management of pestiferous rodents.

Block–4: Bio ecology and management of pestiferous higher vertebrates

Unit 1: Bio-ecology of higher vertebrates of agricultural importance, patterns of damage and assessment, their habitat; management of pestiferous vertebrates.

Block–5: Management of vertebrate pests in Agricultural eco system

Unit 1: Management strategies- physical (trapping, acoustics and visual), chemical (poisons, repellents, fumigants and anticoagulants), biological (predators, parasites), cropping practices, alteration of habitats, diversion baiting and other eco-friendly methods - Operational practices-baiting, equipments and educative programmes.

Practical

Identification of important rodents, birds and other vertebrate pests of agriculture, food preference and hoarding, social behaviour, damage assessment, field survey, population estimation, management strategies: preventive and curative methods.

References

- RAHMAN, A., 2020, Protective and Productive Entomology Narendra Publishing House, New Delhi
- FITZWATER, W. D. AND PRAKASH, I., 1989, Handbook of Vertebrate Pest Control. ICAR, New Delhi.
- PRAKASH, I. AND GHOSH, P. K., 1997, Rodents in Indian Agriculture. Vol. I. State of Art Scientific Publ., Jodhpur.
- PRAKASH, I. AND GHOSH, R. P., 1987, Management of Rodent Pests. ICAR, New Delhi.
- PRATER, S. H., 1971, The Book of Indian Animals. The Bombay Natural History Society, Bombay.

• ALI, S., 1965, The Book of Indian Birds. The Bombay Natural History Society, Bombay.

ENT 515 TECHNIQUES IN PLANT PROTECTION (0+1)

Objective

To acquaint the students with appropriate use of plant protection equipments and techniques related to microscopy, computation, pest forecasting, etc.

Practical

Block–1: Spraying appliances and pesticide application

Unit 1: Pest control equipments, principles, operation, maintenance, selection, and application of pesticides; release of bio-control agents; seed dressing, soaking, root-dip treatment, dusting, spraying, and pesticide application through irrigation water; application of drones in plant protection.

Block - 2: Different methods of pest management

Unit 1: Soil sterilization, solarization, deep ploughing, flooding, techniques to check the spread of pests through seed, bulbs, corms, cuttings and cut flowers.

Unit 2: Uses of light, transmission and scanning electron microscopy.

Block–3: Isolation, characterisation of proteins and tissue culture and computer applications

Unit 1: Protein isolation from the pest and host plant and its quantification using spectrophotometer and molecular weight determination using SDS/PAGE.

Unit 2: Use of tissue culture techniques in plant protection. Computer application for predicting/ forecasting pest attack and identification.

References

- ALFORD, D. V., 1999, A Textbook of Agricultural Entomology. Blackwell Science, London.
- CRAMPTON, J. M. AND EGGLESTON, P., 1992, Insect Molecular Science. Academic Press, London.

ENT 516 APICULTURE (2+1)

Objective

To impart knowledge about the honey bees, and their behaviour and activities; bee husbandry, bee multiplication, bee enemies and diseases and their management; hive products, apitherapy; and managed bee pollination of crops.

Theory

Block–1: History and development of Apiculture in India

Unit 1: Historical development of apiculture at global level and in India; Classification of bees; global distribution of genus Aphis and races; Morphology and anatomy of honey bee; Honey bee biology, ecology, adaptations; Honey bee behaviour – nest founding, comb construction, brood care, defence, other in-house and foraging activities; Bee pheromones; Honey bee communication.

Block–2: Commercial bee keeping

Unit 1: Commercial beekeeping as an enterprise; Design and use of bee hives; Apicultural equipment; Seasonal bee husbandry; Honey bee nutrition and artificial diets; Absconding, swarming, drifting – causes and management; Curbing drone rearing; Laying worker menace – causes, signs and management.

Block–3: Reproductive biology of bees

Unit 1: Bee genetics; Principles and procedures of bee breeding; Screening of honey bee colonies; Techniques in mass queen bee rearing; Mating nuclei and their establishment; Selective mating; Queen bee management; Bee packages

Block–4: Parasites and predators of Bees

Unit 1: Ectoparasitic and endoparasitic bee mites – biology, ecology, nature and symptoms of damage, management tactics; Wax moths, wasps and ants - biology, ecology, nature and symptoms of damage, management tactics; Predatory birds, their damage potential and management tactics; Pesticide poisoning to honey bees, signs and protection; Protocols in evaluation of pesticide toxicity to honey bees

Block – 5: Honey and its value addition

Unit 1: Honey – composition, properties, crystallization, post-harvest handling and processing; Honey quality standards and assessment; Apicultural diversification – potential and profitability; Production/ collection of bee pollen, propolis, royal jelly, bee venom and beeswax and their post-harvest handling; Apitherapy; Value addition of hive products; Development of apiculture project.

Block–6: Pollination ecology

Unit 1: Non-Apis pollinators, their augmentation and conservation; Role of bee pollinators in augmenting crop productivity; Managed bee pollination of crops.

Practical

Morphological characteristics of honey bee; mouthparts; digestive, respiratory and reproductive adaptations in different castes of honey bees; recording of colony performance; seasonal bee husbandry practices; swarming, queenlessness, swarming, laying workers menaces, etc. & their remedies; innovative techniques in mass queen bee rearing; selection and breeding of honey bees; instrumental insemination; formulation of artificial diets and their feeding; production technologies for various hive products; bee enemies and diseases and their management; recording pollination efficiency; application of various models for determining pollination requirement of crop; developing a beekeeping project.

References

- ABROL, D. P. AND SHARMA, D., 2009, Honey Bee Mites & Their Management. Kalyani Publishers, New Delhi, India.
- ABROL, D. P., 2009, Honey bee Diseases & Their Management. Kalyani Publishers, New Delhi, India.
- ATWAL, A. S., 2001, World of Honey Bees. Kalyani Publishers, New Delhi- Ludhiana, India.
- ATWAL, A. S., 2000, Essentials of Beekeeping and Pollination. Kalyani Publishers, New Delhi-Ludhiana, India.
- BAILEY, L. AND BALL, B. V., 1991, Honey Bee Pathology. Academic Press, London.
- CRANE, E. AND WALKER, P., 1983, The Impact of Pest Management on Bees and Pollination. Tropical Development and Research and Institute, London.
- FREE, J. B., 1987, Pheromones of Social Bees. Chapman and Hall, London.
- GATORIA, G. S., GUPTA, J. K., THAKUR, R. K AND SINGH, J., 2011, Mass Multiplication of Honey Bee Colonies. ICAR, New Delhi, India.
- GRAHM, J. M., 1992, Hive and the Honey Bee. Dadant& Sons, Hamilton, Illinois, USA.
- GROUT, R. A., 1975, Hive and the Honey Bee. Dadant& Sons, Hamilton, Illinois, USA.
- HOLM, E., 1995, Queen Rearing Genetics & Breeding of Honey Bees. Gedved, Denmark.
- LAIDLAW, H. H JR AND ECKERT, J. E., 1962, Queen Rearing. Berkeley, University of California Press.

- ABROL, D. P., 2010, Beekeeping: A Compressive Guide to Bees and Beekeeping. Scientific Publishers, India.
- ABROL, D. P., 2010, Bees and Beekeeping in India. Kalyani Publishers, New Delhi, India.
- ABROL, D. P., 2012, Pollination Biology: Biodiversity Conservation and Agricultural Production. Springer
- LAIDLAW, H. H., 1979, Contemporary Queen Rearing. Dadant& Sons, Hamilton, Illinois, USA.
- MISHRA, R. C., 2002, Perspectives in Indian Apiculture. Agro-Botanica, Jodhpur, India.
- MISHRA, R. C., 1995, Honey Bees and their Management in India. I.C.A.R., New Delhi, India.
- MORSE AA., 1978, Honey Bee Pests, Predators and Diseases. Cornell University Press, Ithaca and London.
- RAHMAN, A., 2017, Apiculture in India, ICAR, New Delhi
- RIBBANDS, C. R., 1953, The Behaviour and Social Life of Honey Bees. Bee Research Association Ltd., London, UK.
- RINDERER, T. E., 1986, Bee Genetics and Breeding. Academic Press, Orlando.
- SINGH, S., 1962, Beekeeping in India. I.C.A.R., New Delhi, India (Reprint: 1982).
- SEELEY, T. D., 1985, Honey Bee Ecology. Princeton University Press, 216 pp.
- SNODGRASS, R. E., 1925, Anatomy and Physiology of the Honey Bee. Mc Graw Hill Book Co., New York & London.
- SNODGRASS, R. E., 1956, Anatomy of the Honey Bee. Comstock Publishing Associates, Cornell Univ. Press, Ithaca, New York.

ENT 517 SERICULTURE (2+1)

Objective

To familiarize the students with entrepreneurial opportunities in entomology, sericulture in particular, and providing information on silk worm rearing, production and management.

Theory

Block–1: History and importance of Sericulture in India

Unit 1: History of Sericulture, importance, organizations involved in sericulture activities, silkworm types, distribution, area and silk production.

Block–2: Mulberry cultivation and species of silkworm

Unit 1: Mulberry species, ecological requirements, cultivation, improved varieties, propagation methods, sapling production, planting and pruning techniques; pest and diseases, management strategies; intercropping, water and weed management. Food plants of eri silkworm, castor cultivation, intercultural operations, nutrient and water management; method of harvest; host plants of Tasar, nursery and cultivation, selection of seed, soaking and heap making, pruning techniques. Food plants of Muga silkworm, Som and Soalu propagation methods; nursery techniques; intercultural operations and weed management.

Block–3: Silkworm classification and bioeology

Unit 1: Silkworm origin – classification based on voltinism, moultinism, geographical distribution and genetic nature – pure races – multivoltine and bivoltine races –cross breeds – bivoltine hybrids –Races and hybrids of mulberry, eri, tasar and muga silkworm- Morphology and biology of silkworm, sex limited characters; anatomy of digestive and excretory systems of larva; structure and function of silk glands.

Block– 4: Rearing, pest and diseases of Silk worm

Unit 1: Rearing house, types, disinfection, room and bed disinfectants; egg incubation methods, Chawki rearing, feeding, cleaning and spacing; rearing of late age worms, feeding, cleaning, spacing and

moulting care; mountages, cocoon harvesting and marketing; pests and diseases of silkworms and their management.

Block–5: Cocoon technology

Unit 1: Post cocoon technology, stifling, cocoon cooking, brushing, reeling, re-reeling, bleaching, degumming, dyeing, printing and weaving, different reeling machines; value addition in sericulture; economics of sericulture.

Practical

Morphology of mulberry plants – Identification of popular mulberry genotypes – Nursery bed and main field preparation – planting methods – Identification of nutrient deficiency symptoms – Identification of weeds– pruning and harvesting methods – Identification of pests and diseases of mulberry–Terminalia arjuna, Terminalia tomentosa, Som and Soalu- Nursery and pruning techniques – Intercultural operations.

Morphology of silkworm – Identification of races – Dissection of mouth parts and silk glands – Disinfection techniques – rearing facilities – silkworm rearing – feeding, cleaning and spacing – Identification of pests and diseases of mulberry silkworm – hyperparasitoids and mass multiplication techniques – silkworm egg production technology –Tasar, Eri and muga silkworms – rearing methods–pests and diseases of non-mulberry silkworms - Visit to grainage, cocoon market and silk reeling centre – Economics of silkworm rearing.

References

- DANDIN, S. B. AND GIRIDHAR, K., 2014, Hand book of Sericulture Technologies. Central Silk Board, Bangalore, 423p.
- GOVINDAIAH., G, V. P., SHARMA, D. D., RAJADURAI, S. AND NISHITA, N. V., 2005, A text book on mulberry crop protection. Central Silk Board, Bangalore.450 p.
- NATARAJU, B., SATHYAPRASAD, K., MANJUNATH, D. AND ASWANI KUMAR., 2005, Silkworm crop protection. CSB, Bangalore. 412 pp.
- MOHANTY., PRAFULLA, K., 2003, Tropical wild cocoons of India. Daya Publications, Tri Nagar, New Delhi, 197 p.

- MAHADEVAPPA, D., HALLIYAL, V.G., SHANKAR, D.G. AND RAVINDRA, B., 2000, Mulberry Silk Reeling Technology. Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi. 234 p.
- JOLLY, M. S., SEN S. K., SONWALKAR, T. N. AND PRASAD, G. K., 1980, Non-mulberry Silks. FAO Agicultural Services Bulletin 29. Food and Agriculture Organization of the United Nations, Rome, 178 p.
- RANGASWAMI, G., NARASIMHANNA, M. N., KASI VISWANATHAN. K., SASTRY, C. R. AND JOLLY. M. S., 1976, Food Plants of non-mulberry silkworms. In: Mulberry cultivation. FAO Agricultural Services Bulletin .Vol.1, Chapter-13. Rome, Italy. 96 p.
- TRIBHUVAN, S. AND SARATCHANDRA, B., 2004, Principles and Techniques of silkworm seed production. Discovery publishing House, New Delhi, 360 pp.

ENT 518 LAC CULTURE (2+1)

Objective

To familiarize the students with entrepreneurial opportunities in entomology with an emphasis on lac culture in particular. To provide information on lac insect rearing, production and management.

Theory

Block–1: Importance of lac in India

Unit 1: History of lac production; importance, potential of lac production in India; organizations involved in lac production activities; strains of lac insects and lac crops – distribution, area and production of different strains of lac.

Block-2: Cultivation of lac in India

Unit 1: Steps and operation of lac production; lac host plant species, ecological requirements, their cultivation; seasons of host plants, harvest time of host plants, rearing seasons; grouping of host trees, pruning

methods, timing; lac host plant pests and diseases; management strategies.

Block–3: Biosystematics and biology of lac insect

Unit 1: Basic morphology and taxonomy of lac insect, strains of lac insect and their characteristics; composition of lac; biology of lac insect, species diversity and distribution

Block–4: Production technologies of lac

Unit 1: Introduction, lac insect-host plant interaction; selection of brood lac, local practices, improved alternatives, coupe system; propagation of lac insects: natural self inoculation, artificial inoculation; inoculation process and duration; removal of phunki, harvesting of lac, immature harvesting, mature harvesting and time of harvesting. Predators and parasitoids of lac insect, hyperparasites, diseases and their management.

Block–5: Host plants and value addition of lac

Unit 1: Lac production stages; factors affecting yield and quality of shellac. Pure stock of host plants (kusum, palas, ber, pigeonpea, semialata); alternative method; technology of brood preserving. Host-specific technologies - cultivation on specific host plants; integration of lac cultivation with agro-forestry and horticulture; socio- economic potential of lac; export-import of lac/ lac products; marketing of lac and its products. Lac processing and value addition; entrepreneurship development.

Practical

Lac host cultivation and lac production practices; equipments for lac production; conventional and advanced methods; coupe system of lac production; cultivation of suitable host plants; pruning of host trees; herbarium of host plants; strains of lac insects; brood lac selection and treatment for pest management; slide preparation of adult and immature stages; inoculation of host tree; identification of natural enemies of lac insect and their management; molecular characterization of lac insect where possible; harvesting; process of manufacture of seed lac, shell lac from stick lac; grading of seed lac and shellac; marketing of lac products and by products.

References

- DAVID, B. V. AND RAMAMURTHY, V. V. 2011. Elements of Economic Entomology, 6thEdition, Namrutha Publications, Chennai.
- SHARMA, K.K. AND RAMANI, S. 2010. Recent advances in lac culture. ICAR – IINRG, Ranchi.

ENT 519 MOLECULAR APPROACHES IN ENTOMOLOGY (1+1)

Objective

To acquaint students the latest techniques used in molecular biology.

Theory

Block–1: Importance of molecular biology and DNA recombinant technology

Unit 1: Introduction to molecular biology, techniques used in molecular biology.

Unit 2: DNA recombinant technology, identification of genes/ nucleotide sequences for traits of interest, techniques of interest in plants and microbes.

Block–2: Transgenics in Entomology

Unit 1: Molecular approaches in entomological research - peptides and neuropeptides, JH esterase, toxins and venoms, chitinase, Plant-derived enzyme inhibitors, protease inhibitors, trypsin inhibitors, á-amylase inhibitors, lectins, terepenes and terpenoids; genes of non-plant origin, *Bacillus thuringiensis* endotoxins, mode of action of cry genes, classification and properties, synthetic Bt toxin genes, Other toxin genes, transgenic plants for pest resistance.

Block–3: Genetic engineering of microbes and parasitoids

Unit 1: Genetically engineered microbes and parasitoids in biological control-Genetic engineering in baculoviruses and fungal bio control agents for greater efficacy against insect pests. Effects of transgenic plants on pest biology and development, resistance

management strategies in transgenic crops, molecular mechanism of insecticide resistance.

Block–4: Genetics based insect pest management

Unit 1: Genetic-based methods for agricultural insect pest management-insect pest management through sterile insect technique. Methods and application of insect trangenesis, transgenics in silkworm and honeybees. Molecular tools for taxonomy and phylogeny of insect-pests, DNA-based diagnostics. Nano technology and its application.

Practical

Isolation of DNA/RNA; agarose gel electrophoresis of DNA, quantification of DNA by Nanopore / spectrophotometirc and agarose gel analysis, PCR amplification of mitochondrial cytochrome oxidase subunit I gene (cox1) and 16S r RNA gene, PCR machine applications, BLAST analysis and multiple sequence alignment of the sequence with sequences already available in Gen Bank.

References

- BHATTACHARYA T. K., KUMAR, P. AND SHARMA, A. 2007. Animal Biotechnology. 1stEd., Kalyani Publication, New Delhi.
- HAGEDON, H. H., HILDERBRAND, J. G., KIDWELL, M. G. AND LAW, J. H. 1990. Molecular Insect Science. Plenum Press, New York.
- OAKESHOTT, J. AND WHITTEN, M. A. 1994. Molecular Approaches to Fundamental and Applied Entomology. Springer Verlag.
- RECHCIGL, J. E. AND RECHCIGL, N. A. 1998. Biological and Biotechnological Control of Insect Pests. Lewis Publ., North Carolina.
- Roy, U. And Saxena, V. 2007. A Hand Book of Genetic Engineering. 1stEd., Kalyani Publ., New Delhi.
- SINGH, B. D. 2008. Biotechnology (Expanding Horizons). Kalyani Publ., New Delhi.

- SINGH, P. 2007. Introductory to Biotechnology. 2ndEd. Kalyani Publ., New Delhi.
- HOY, M. A. 2003. Insect Molecular Genetics: An Introduction to Principles and Applications. 2ndEd. Academic Press, New York.

ENT 520 PLANT QUARANTINE, BIO-SAFETY AND BIO-SECURITY (2+0)

Objective

To acquaint the learners about the principles and the role of Plant Quarantine in containment of pests and diseases, plant quarantine regulations and set-up. Also, to facilitate students to have a good understanding of the aspects of biosafety and biosecurity.

Theory

Block–1: Quarantine and legal management

Unit 1: Definition of pest, pesticides and transgenics as per Govt. notification; relative importance; quarantine – domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material; case histories of exotic pests/diseases and their status.

Block–2: Plant protection organisation in India

Unit 1: Plant protection organization in India. Acts related to registration of pesticides and transgenics. Insecticide regulatory bodies, synthetic insecticides, bio-pesticides and pheromone registration procedures. History of quarantine legislations, PQ Order 2003. Environmental Acts, Industrial registration; APEDA, Import and Export of bio-control agents.

Block–3: Diagnostic techniques for pest and diseases

Unit 1: Identification of pest/disease free areas; contamination of food with toxicgens, microorganisms and their elimination; Symptomatic diagnosis and other techniques to detect pest/pathogen infestations; VHT and other safer techniques of disinfestation/salvaging of infected material.

Block–4: Concepts in biosecurity and biosafety

Unit 1: WTO regulations; non-tariff barriers; pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; sanitary and phytosanitary measures. Global Positioning System (GPS) and Geographic Information System (GIS) for plant biosecurity, pest/ disease and epidemic management, strategies for combating risks and costs associated with agroterrorism event, mitigation planning, integrated approach for biosecurity. Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, issues related to release of genetically modified crops.

References

- RAJEEV, K. AND MUKHERJEE, R. C. 1996. Role of Plant Quarantine in IPM. Aditya Books.
- RHOWER, G. G. 1991. Regulatory Plant Pest Management. In: Handbook of Pest Management in Agriculture. 2nd Ed. Vol. II. (Ed. David Pimental), CRC Press.
- SHUKLA, A. AND VEDA, O. P. 2007. Introduction to Plant Quarantine. SamayPrakashan, New Delhi.

ENT 521 EDIBLE AND THERAPEUTIC INSECTS (1+1)

Objectives

To create awareness and acquaint students about the contribution that insects make to ecosystems, diets, food security and livelihoods in developed and developing countries.

Theory

Block–1: Introduction and importance of edible insects

Unit-1: Edible and therapeutic insects: the concept, definition, and importance.

Unit 2: History and origin of insects as food, feed and medication; important insect species and insect products consumed

Unit- 3: Edible insect ecology, conservation and management of edible insect resources; environmental opportunities of insect rearing.

Block–2: Conservation and management of edible insects

Unit 1: Nutritional composition and role insects in food security.

Block-3: Farming and processing of edible insects

Unit 1: Insect farming: the concept, definitions, and rearing techniques.

Unit 2: Processing edible insects for food and feed

Unit 3: Food safety and preservation, edible insects for livelihood security.

Practical

Survey and identification of edible and therapeutic insect species; collection and preservation of edible and therapeutic insect specimens; rearing techniques of edible insect species; harvesting techniques of edible insects from natural environment; analysis of proximate elemental composition, antioxidant and anti-nutritional properties and microbial aspects of preservation.

References

- VAN HUIS, A, ITTERBEECK, J. K, KLUNDER, H, MERTENS, E, HALLORAN, A, MUIR, G. AND VANTOMME, 2013, Edible insects: future prospects for food and feed security. Food and Agricultural Organization of the United Nations, Rome.
- Halloran, A, Flore, R, Vantomme, P and Roos, N. 2018. Edible insects in sustainable food systems.

ENT 522 MEDICAL AND VETERINARY ENTOMOLOGY (1+1)

Objective

To study the major insect, mite, and tick vectors of disease to man and animals. Students will learn to identify and understand the life cycles, morphology, and behaviour of mosquitoes, ticks, mites, lice, fleas, and other disease vectors.

Theory

Block–1: Medical and veterinary importance of insects

Unit 1: Introduction to medical, veterinary and forensic entomology;

Classification of Arthropod-borne diseases; Hematophagy, disease transmission and epidemiology; flies (Diptera) of medical and veterinary Importance; moth flies: Leishmaniasis and Bartonellosis; biting midges (Ceratapogonidae).

Block–2: Mosquitoes and flies as a vectors of disease

Unit 1: Mosquito taxonomy, biology, and behavior; mosquito viruses: EEE, VEE, SLE, yellow fever,mosquito surveillance; malaria; horse flies, deer flies: EIA, anaplasmosis; muscid flies; Myiasis (Muscoidea); myiasis and louse flies; black flies of medical and veterinary Importance; filariasis: mansonellosis, onchocerciasis.

Block–3: Role of lice and fleas in disease transmission

Unit 1: Lice of medical and veterinary importance; rickettsial diseases: epidemic typhus, etc.; mites: rickettsial pox; mites and acariasis: mange, scabies, chiggers; spiders and scorpions; fleas (Siphonaptera) of medical and veterinary importance; plague and murine typhus.

Block–4: Insects and ticks as vectors of disease

Unit 1: Ticks of medical and veterinary importance; lyme disease, rocky mountain spotted fever, tularemia; true bugs (Hemiptera): kissing bugs and bedbugs; chagas disease; tsetse flies; Lepidoptera and Hymenoptera of medical and veterinary importance.

Practical

Identification of arthropod Classes, Orders and Families of medical and veterinary importance; collection, segregation, curing insect and arachnid specimens, their preservation; management of insect and mite pests of medical and veterinary importance; study of some practical aspects in forensic entomology.

References

- GARY MULLEN LANCE DURDEN 2018. Medical and Veterinary Entomology, 3rdEdition, Academic Press.
- GULLAN. P. J. AND CRANSTON, P. S. 2010. The Insects: An Outline of Entomology. 4thEdition, Wiley-Blackwell,
- West Sussex, UK & New Jersey, US.

• DAVID, B. V. AND RAMAMURTHY, V. V. 2011. Elements of Economic Entomology, 6thEdition, Namrutha Publications, Chennai.

ENT 523 FOREST ENTOMOLOGY (1+1)

Objectives

To promote a more global theoretical understanding of pest population dynamics and the causes of forest insect outbreaks: covering pests of both natural forests and plantations, the diversity of tropical forest insects, their ecological functions, the concept of pests and the incidence of pests in natural forests, plantations and stored timber.

Theory

Block–1: Introduction and classification of forests

Unit 1: Introduction to forestry in the tropics, tropical forests: characteristics and types of tropical forests, management of tropical forests and the problems in their management; plantation forestry: beginnings, expansion and current status.

Block–2: Principles and concepts in forest entomology

Unit 1: History of tropical forest entomology, diversity of forest insects: structural and functional diversity – the feeding guilds, concept of pests, ecology of insects in forest environment, concept and functioning of ecosystem, role of insects in ecosystem processes of tropical forests: insects as primary consumers, secondary and tertiary consumers, as decomposers, as food, pollinators and other ecological interactions.

Block–3: Insect pests of major forest tree species

Unit 1: Insect pests in natural forests, general pest incidence, pest outbreaks: Lepidoptera, Coleoptera, Hemiptera, and Hymenoptera; insect pests in plantations, nursery pests, sapling pests, pests of older plantations and their impact; insect pests of stored timber, categories of wood destroying insects and their damage: termites and beetles.

Block–4: Population dynamics of forest insect pests

Unit 1: Population dynamics, characteristics of population growth, factors affection population growth, principles governing population

dynamics, types and causes of forest insect outbreaks; general issues in forest entomology: enemies' hypothesis, resource concentration hypothesis, pest evolution hypothesis; pest problems in plantations of indigenous vs exotic species; pest problems in monocultures vs mixed plantations.

Block–5: Pest management in forest ecosystem

Unit 1: Management of tropical forest insect pests, historical development and present status of tropical forest pest management, overview of pest management options: preventive measures, remedial measures; unique features of forest pest management; constraints to forest pest management in the tropics; guidelines for the practice of forest pest management in the tropics.

Block–6: Case studies on forest insect pest management

Unit 1: Insect pests in plantations: Location-specific case studies.

Practical

Collection, identification and preservation of important insect pest specimens of forest plants and some damage material; detection of insect infestation and assessment of losses due to insect pests; habitat management for vertebrate and insects pests; fire control methods and devices. Familiarization with the meteorological and plant protection equipment, application of pesticides and bio-control agents in the management of insect pests in nurseries and plantations.

References

- NAIR, K. S. S. 2007 Tropical Forest Insect Pests: Ecology, Impact, and Management, Cambridge University Press, Edinburgh/ New York.
- JHA, L. K. AND SEN SARNA P. K. 1994. Forest Entomology. Ashish Publishing House, Delhi. Stebbings, E. P. 1977. Indian Forest Insects. JK Jain Brothers.

M.Sc. (Agri.) in Forestry and Environmental Science

Course Code	Course Title	Credit Hours
FES 501	Silviculture	2 (2+0)
FES 502	Forest Policy and Law	2 (2+0)
FES 503	Ecology and Environment	2 (1+1)
FES 504	Solid Waste Management	2 (1+1)
FES 505	Principles of Environmental Impact Assessment	2 (1+1)
FES 506	Environment Policy, Law and International Conventions	2 (2+0)
FES 507	Biodiversity and Conservation	2 (1+1)
FES 508	Environmental Pollution	2 (1+1)
FES 509	Remote Sensing and GIS Application in Biodiversity Conservation	3 (2+1)
FES 510	Global Climate Change and Environment	2 (2+0)
FES 511	Forest Management	2 (2+0)
FES 512	Natural Resource and Environmental Economics	2 (1+1)
FES 513	Management of Degraded Ecosystems	2 (1+1)
FES 514	Forest Biometry	2 (1+1)
FES 515	Floral Biology and Ecology	2 (1+1)
FES 516	Environmental Analytical Techniques	2 (1+1)
FES 517	Plantation Forestry	2 (1+1)
FES 518	Environmental Biotechnology	2 (2+0)
FES 519	Environmental Engineering	2 (1+1)
FES 520	Agro-forestry Systems	2 (1+1)
FES 521	Forest Protection	2 (1+1)
FES 522	Ecotourism - Concept and Modern Approaches	2 (1+1)
FES 523	Biofuel Production Technologies	2 (1+1)
	Total	**47 (30+17)**

Course Code	Course Title	Credit Hours
FES 580	Qualifying Examination	2 (0+2)
FES 581	Seminar-I	1 (0+1)
FES 582	Seminar-II	1 (0+1)
FES 591	Research-I	13 (0+13)
FES 592	Research-II	14 (0+14)

FES 501 SILVICULTURE (2+0)

Objective

Silviculture helps to maintain or retain sufficient number of trees per unit area so that by optimum use of soil, maximum wood production is ensured. Substantial increase in production can be ensured by thinning dense prop through salvaging the trees otherwise these trees would have died.

Theory

Block 1: Forest ecosystem

Unit 1: Concept, locality factors, stand dynamics

Unit 2: Eco-physiology of tree growth, effect of radiation & water on plant function

Unit 3: Forest succession, competition and tolerance

Unit 4: Classification of world's forest vegetation

Block 2: Silviculture and productivity

Unit 1 - Introduction to Silviculture and silviculture systems

Unit 2 - Precision silviculture

Unit 3 - Productivity and vegetation forms of India

Unit 4 - Forest composition and structure

Block 3: Natural regeneration of species

Unit 1 - Types including uneven-aged silviculture

Unit 2 - Advanced thinning practices

Unit 3 - Effect of thinning on wood yield and quality

Unit 4 - Stand protection and management

Unit 5 - Under storey regeneration

References

- CHAMPION, G.H., 2012. General Silviculture for India. Natraj Publishers, ISBN: 9788181580603.
- CHAUDARI, B.S., AND GAUHALT, M., 2015, Notes on silviculture of Indian Trees. International Book Distributors. ISBN-10: ý8170893720 and ISBN-13þ : 978- 8170893721
- KHANNA, L.S., 2018. Principles and Practice of silviculture. K. B. Publishers, ISBN: 9788195973217.
- KHANNA, L.S.AND CHATURVEDI, A.N., Silviculture of useful trees. ISBN-10: ý 8185933413 and ISBN-13: 978-8185933412.

FES 502 FOREST POLICY AND LAW (2+0)

Objective

The principal aim of forest policy must be to ensure environmental stability and maintenance of ecological balance including atmospheric equilibrium, which are vital for sustenance of all life forms, human, animals and plants. The derivation of direct economic benefit must be subordinated to this principal aim. Further, forest laws are intended to protect resources and prevent forest clearing, logging, hunting, and collecting vegetation. However, there are no clear limitations set within these laws in regards to allowable cuts, harvesting rotations, and minimum harvesting diameters.

Theory

Block 1: Forest policy

Unit 1 - Relevance and scope of Forest policy

Unit 2 - National Forest Policy – 1894, 1952 and 1988

Unit 3 - General principles of criminal law

Unit 4 - National Forest Commission 2006

Block 2: Forest laws

Unit 1 - Indian Penal Code

Unit 2 - Criminal procedure code

Unit 3 - Indian evidence act applied to forestry matters

Unit 4 - Forest laws

Block 3: Indian Forest Acts

Unit 1 - Indian Forest Act –1927

Unit 2 - General provision and detailed study

Unit 3 - Forest Conservation Act 1980

Unit 4 - Wildlife Protect Act 1972

Unit 5 - Important Forest Rules and Guidelines

Unit 6 - Karnataka Forest Act 1963

Unit 7 - Case studies -Important case studies and landmark judgments

References

- GIRISH B., SHAHAPURMATH, HANUMANTA, M., 2020, Forest policy, laws, legislation and constitution of India, Satish Serial publishing House.
- JOSHI, A. K., PANT, P., KUMAR, P., GIRIRAJ, A., JOSHI, P.K., 2011, National Forest Policy in India: Critique of Targets and Implementation. 10(1), 83-96.
- KASHWAN, P., 2015., Forest policy, institutions, and REDD+ in India, Tanzania, and Mexico. Global Environmental Politics, 15(3), pp.95- 117.
- NEGI S.S., 2007, Forest policy and Law (applied Forestry Series No.1). International book distributors, Dehradun
- PARIKH, M., 2013. The Forest Conservation in India and the Role of Indian Supreme Court: A Critical Analysis. IOSR Journal of Humanities and Social Science, 13(4), p.58.

FES 503 ECOLOGY AND ENVIRONMENT (1+1)

Objective

The main aim of ecology is to understand the distribution of biotic and abiotic factors of living things in the environment. The biotic and abiotic factors include the living and non-living factors and their interaction with the environment.

Theory

Block 1: Ecology

Unit 1 - Habitat ecology, Systems ecology, Synecology, Autecology, etc.

Unit 2 - Biotic communities: Community structure and composition

Unit 3 - Communities and Environment

Unit 4 - Structure and patterns in diversity

Unit 5 - Habitats and niches

Unit 6 - Basic population genetic principles

Block 2: Evolution and natural selection

Unit 1 - Evolution and natural selection

Unit 2 - Evolutionary principles

Unit 3 - Definition of species, Populations, Growth, regulation

Unit 4 - Interaction, species interactions, Population consequence of selection, species formation and evolution

Unit 5 - Allopatric, sympatric and parapatric species, species losses, population losses and declines

Unit 6 - The shifting balance theory, peripheral diversity, static and changing patterns

Block 3: Competition and community structure

Unit 1 - Inter-specific interactions and Intra-specific competition

Unit 2 - Life tables and their use in population models

Unit 3 - Construction of life tables

Unit 4 - Ecological Succession

Unit 5 - Adaptation: Niche and limiting factors habitat ecology

Unit 6 - Behavioural ecology

Practical

Niche and Niche models. Enumeration of plants in different environments - study of interrelationships among plants: Associations, Spatial Structure, Spatial Distribution. Construction of life tables - Interaction among species - Tour to different ecological regions. Hardy Weinberg law, Lotkavolterra model. Selection forces. Inter-specific interactions.

References

- AGRAHARI, R.P., 2020. Environmental Ecology, Bio-Diversity, Climate Change & Disaster Management. Mc-Graw Hill Publication, ISBN: 9789390185337.
- AWADHUTWAR, P.N., KUTE, V.S, AND SHEWALE, R., 2022. Environment, Ecology & Nature Conservation. Narendra shewales Sankalp publication.
- SHEWALE,R AND KUTE,V.S., 2022. Environment, Ecology & Nature Conservation. Sankalp Publication, ASIN: B0B191CJWN
- SRIVASTAVA, S., 2013, Environmental & Ecology. S. K. Kataria & Sons Publication, ISBN: 9789380027067.

FES 504 SOLID WASTE MANAGEMENT (1+1)

Objective

The objective of this course is to get on broader understandings on various aspects of solid waste management (starting from its generation to processing with options for reuse and recycle, transport, and disposal) practiced in different municipalities.

Theory

Block 1: Solid waste

Unit 1 - Definition, sources and types

Unit 2 - Characteristics and classification

Unit 3 - Collection and handling – processing and segregation

Unit 4 - Treatment and disposal: physical, chemical and thermal treatment

Unit 5 - Incineration –types of incinerators, sanitary land fill leachate management, open dumping

Unit 6 - Soil and ground water contamination and management

Block 2: Integrated eco-friendly recycling of solid wastes

Unit 1 - Advantages and disadvantages of composting methods

Unit 2 - Agricultural wastes: farm waste, plant residues, weeds

Unit 3 - Food processing wastes – vermin composting - impact on agro-ecosystem

Unit 4 - Domestic and municipal solid wastes: Night soil-characteristics

Unit 5 - Disposal techniques, impact on agro-eco system

Block 3: Industrial waste management and their impact on eco-system

Unit 1 - Toxic wastes classification and management

Unit 2 - Impact on human health and agro-eco system

Unit 3 - Treatment and disposal of hospital waste

Unit 4 - Recent advances in solid waste management

Practical

Solid waste materials collection - characterization of different solid wastes - treatments and disposal methods. Visit to nearby compost yard, open dumps and landfills - leach ate collection and ground water analysis. Different methods of composting - Vermi-composting techniques. Impact of compost on agricultural and horticultural crops. Visit to agro-based industries (paper mill, sugar factory). Hospital waste - characteristics and disposal methods.

References

- EWEIS, J.B, ERGAS S.J, CHANGE D.P.Y AND SCHROEDER E.D. , Bioremediation- Principles, McGraw-Hill Inc.-Hill International Edition.
- LIE, D.H.F AND LIPTAK B.G., 2000, Hazardous Wastes and Solid Wastes- Lewis publishers, NewYork.
- WENTZ, A.C., 1996, Hazardous waste Management. McGraw
- Who Manual on solid waste management.

FES 505 PRINCIPLES OF ENVIRONMENTAL IMPACT ASSESSMENT (1+1)

Objective

The main aim of EIA is to conserve the environment and bring out the best combination of economic and environmental costs and benefits.

Theory

Block 1: Concept of Environmental Impact Assessment

Unit 1 - Types of environmental impacts - natural impacts - impacts due to developmental activities

Unit 2 - Economic, environmental and ecological consequences of common property ecosystem degradation

Unit 3 - Current status of EIA

Unit 4 - EIA in developed countries

Block 2: Steps and processes in EIA study

Unit 1 - Prediction and assessment of different environments- soil, air, water, noise

Unit 2 - Biological, socioeconomic and cultural appraisal of EIA

Unit 3 - Criteria for evaluating environment related projects

Unit 4 - Review of EIA status in India

Block 3: Methods of EIA

Unit 1- Conventional and advanced methods

Unit 2- Use of RS & GIS as tools in overlaying approach

Unit 3- Case studies for EIA

Unit 4- Conflict between industrialization and environmental preservation

Unit 5- Effect of global trade on environment

Unit 6- Role of Government in resource and natural management

Practical

Defining the problem in different ecosystems - quarry mining - coastal catchment ecosystem - deforestation - industrial conservation - highways - study on physical, chemical and biological properties - EIA: assessing the economic loss due to land, water and resources degradation - visit to coal mine area - industrial area and silent valley - management aspects of EIA.

References

- ANJENEYULU, Y. AND MANICKAM, V., 2007, Environmental Impact Assessment Methodologies. B.S. Publications, Hyderabad. Pp. 428.
- GLASSON, J., THERIVEL, R. AND CHADWICK, A., 1999., Introduction to Environmental Impact Assessment: Principles and procedures, process, practice and prospects, 2ndedition. Taylor & Francis e- Library, UK. Pp. 477.
- MORRIS, P. AND THERIVEL, R., 2005, Methods of Environmental Impact Assessment. 2nd edition. Taylor and Francis e-Library, UK. Pp. 492.
- RATHI, A. K. A., 2021, Handbook of Environmental Impact Assessment: Concepts and Practice. Cambridge Scholars Publishing, UK. Pp. 521.

FES 506 ENVIRONMENT POLICY, LAW AND INTERNATIONAL CONVENTIONS (2+0)

Objective

Principles of good governance (transparency, rationality, accountability, reduction in time and costs, participation, and regulatory independence) to the management and regulation of use of environmental resources. Further, the objectives of Environmental Law and International Conventions shall be: 1. Preservation, protection, restoration and improvement of the quality of the environment; 2. Protection of human life and health; 3. Protection of biological diversity.

Theory

Block 1: Environmental Education and Organisation

Unit 1 - Goal, objectives and guiding principles of Environmental Education

Unit 2 - Programmes through formal and non-formal systems

Unit 3 - Role of Environmental organization - Government and NGO's

Unit 4 - Visit to Forest Departments

Unit 5 - Visit to Social organizations and Non-governmental organizations work on Environment issues

Block 2: Environmental Legislation

Unit 1 - Environment policies of the government

Unit 2 - Remedies for Environmental pollution

Unit 3 - Environmental Legislation - Law relating to control of pollution.

Unit 4 - Water Act-1974- Air Act - 1981,

Unit 5 - Convention on Biodiversity-1992 and Ramsor Treaty

Block 3: Environmental protection Act

Unit 1 - Environmental protection Act, (1986)

Unit 2 - Rules and notifications made there under-laws to prevent land and ground water pollution

Unit 3 - Law relating to conservation of forest and wildlife

Unit 4 - Emergence of environmental standards

Unit 5 - Any act and polices introduced from time to time

References

- BOYLE, A.E. AND REDGWELL, C., 2021. Birnie, Boyle, and Redgwell's international Law and the environment. Oxford University Press.
- CAMERON, J. AND ABOUCHAR, J., 1991. The precautionary principle: a fundamental principle of law and policy for the protection of the global environment. BC Int'l & Comp. L. Rev., 14, p.1.
- CHURCHILL, R., LOWE, V. AND SANDER, A., 2022, The law of the sea. In The law of the sea. Manchester University Press.
- DIMENTO, J.F., 2003, The global environment and international law. University of Texas Press.
- FREESTONE, D. AND HEY, E. Eds., 1996, The precautionary principle and international law: the challenge of implementation (Vol. 31). Kluwer Law International BV.

FES 507 BIODIVERSITY AND CONSERVATION (1+1)

Objective

Biodiversity conservation has three main objectives: To preserve the diversity of species. Sustainable utilization of species and ecosystem. To maintain life-supporting systems and essential ecological processes.

Theory

Block 1: Elements of Biodiversity

Unit 1- Measuring biodiversity - Species abundance -Species diversity (number and difference, habitat distribution)

Unit 2- Biodiversity through time - the fossil record history of Biodiversity - diversification -extinction

Unit 3 - Mapping biodiversity: Species - Area relationships, Local, regional diversity relationships

Unit 4 - Extremes of high and low diversity

Unit 5 - Gradients in biodiversity- latitudinal, altitudinal and depth gradients in biodiversity

Unit 6 - Importance of biodiversity - Use value

Unit 7 - Maintaining biodiversity: the scale of human enterprise

Block 2: Biodiversity conservation

Unit 1 - Objectives and general measures for conservation and sustainable use

Unit 2 - *In situ* and *Ex situ* Conservation

Unit 3 - Tropical forests and their conservation

Unit 4 - Deforestation

Unit 5 - The pressure on wildlife

Unit 6 - Conservation of species - species extinction

Unit 7 - Genetic diversity in rare species

Block 3: Conservation of ecosystems

Unit 1 - Habitat conservation

Unit 2 - Design and Maintenance of conservation areas

Unit 3 - Conservation of the biosphere

Unit 4 - Special projects for endangered species

Unit 5 - Man and Biosphere programs -Viable conservation

Unit 6 - The Convention on Biological Diversity

Practical

Species abundance- species richness- Interrelationships. Populations- growth regulation and interaction. Habitat distribution - Natural selection - Genetic variability in natural populations - Conservation - tropical forests - wildlife ecosystems- Endangered species- viable conservation.

References

- NEGI, S. S., 1993, Biodiversity and Its Conservation in India. Indus

Publishing Company, New Delhi

- WILSON, E. O., 1999, The Diversity of Life. W. W. Norton Company. Pp. 432.
- WILSON, E. O., 1988, Biodiversity. National Academy Press, Washington, D.C

FES 508 ENVIRONMENTAL POLLUTION (1+1)

Objective

Environmental pollution influences both soil and agriculture which are the two facets of valuable resource necessary for our sustenance. For agriculture, soil is generally assumed as an inexhaustible resource, which is used and overused continually for increasing production.

Theory

Block 1: Air and Water pollution

Unit 1 - Sources of major air pollutants (SO_2, NO_2, O_3, CO)

Unit 2 - Effect of gaseous air pollutants on plants and on animals

Unit 3 - TSP and their effects on plants and animals

Unit 4 - Air pollution tolerance index; Air quality standards; Euro standards

Unit 5 - Air pollution control

Unit 6 - Sources of water pollution

Unit 7 - Classification of water pollutants

Unit 8 - Water quality standards

Unit 9 - Water pollution control

Unit 10 -Marine pollution and its control

Block 2: Soil and noise pollution

Unit 1 - Sources of soil pollution

Unit 2 - Heavy metals: sources and effect on biological systems

Unit 3 - Pesticides: sources and effect on biological systems

Unit 4 - Detrimental effects of soil pollutants on soil micro biota

Unit 5 - Ecological consequences

Unit 6 - Soil pollution control

Unit 7 - Types of noise pollution

Unit 8 - Sources and measurement of noise pollution

Unit 9 - Noise pollution control

Block 3: Pollution monitoring techniques and methodology

Unit 1 - Chemical Analysis; principles of air monitoring

Unit 2 - Air sampling methods

Unit 3 - Air sampling instruments and sampling operation

Unit 4 - Methods of water sampling

Unit 5 - Water sampling Instruments and Physicochemical analysis of water

Practical

Analysis of air samples-(i) Dust fall (ii) CO_2, Analysis of Water samples-(i) BOD, (ii) COD, (iii) pH, (iv) Conductivity, (v) Dissolved organic matter, (i) Carbonates and bicarbonates Analysis of soil samples – Texture, (ii) Moisture contents, (iii) pH (iv) Conductivity (v) Water holding capacity. To compare the soil erosion and water runoff from bare and plant covered plots. Qualitative and quantitative analysis of planktons in polluted waters. Study of footprints and demarcation of territorial limits of few wild animals. Local field visits.

References

- HILL, M. K., 2010, Understanding Environmental Pollution (3rd edition), Cambridge University.
- KHOPKAR, S.M., 2004, Environmental pollution monitoring and control. New Age International Publisher
- KUMAR, C, A., BOHRA, L.K. SINGH., 2003, Environmental Pollution & Management. APH Publishers Corporation.

- PE, A.K., 1994, Environmental chemistry third edition New Age International (P) limited publishers New Delhi.
- SHERMA, P.D., 2000, Ecology and Environment by Rakesh Kumar Rastogi for Rastogi publication Meerut

FES 509 REMOTE SENSING AND GIS APPLICATION (2+1) IN BIODIVERSITY CONSERVATION

Objective

Remote sensing is a useful tool in data collection. To ease the process of biodiversity conservation, remote sensors are used to take and record data of the environment, which is further used in analysis and surveys. Through this data, the environment is conserved, and natural resources are used sustainably.

Theory

Block 1: Remote sensing

Unit 1 - Introduction, physics of remote sensing

Unit 2 - Electromagnetic spectrum, effects of atmosphere, spectral reflections of earth object

Unit 3 - GPS- introduction basic principles, definition of map

Unit 4 - Computer assisted cartography, hardware requirements

Unit 5 - Types of data. Spatial and non-spatial data

Unit 6 - Raster and Vector data conversion

Block 2: Geographic information system

Unit 1 - Introduction, analysis and modelling

Unit 2 - Digital counter modelling, errors, elimination

Unit 3 - GIS software packages, capabilities

Unit 4 - Creating base maps, raster and vector conversions

Unit 5 - Digitizing-linking data files

Unit 6 - Tools for mapping and GIS

Block 3: Use of GIS in policy and planning.

Unit 1 - Various platforms for data acquisitions, aerial photography

Unit 2 - Satellite sensors; optical, thermal and microwave

Unit 3 - Different types of data products and their characteristics

Unit 4 - Satellite data acquisitions

Unit 5 - Storage and retrieval

Unit 6 - Visual interpretations, digital image processing

Practical

Introductions to software's used in remote sensing and GIS Study of land use planning and equipments used in aerial photography. Study of scales of serial photography and interpretation. Case studies on application of satellite imageries an GIS.LULUC mapping, Change detection. Biodiversity detection. Carbon mapping. Water shed delineation and mapping. Wild - life habitat mapping.

References

- ANONYMOUS, 2006, Biodiversity Characterization at Landscape Level Using Satellite Remote Sensing and
- Geographic Information System. Department of Space & Department of Biotechnology
- FRANKLIN,S.E., 2009. Remote Sensing for Biodiversity and Wildlife Management: Synthesis and Applications. McGraw-Hill Education.
- SAMPLE,V.A., 1994, Remote Sensing and GIS in Ecosystem Management. Island Press
- SKOMORE, A., 2002, Environmental Modelling with Gis and Remote Sensing. Taylor & Francis Ltd

FES 510 GLOBAL CLIMATE CHANGE AND ENVIRONMENT (2+0)

Objective

The main objectives of the climate change awareness campaign are: To improve awareness and understanding of climate change amongst citizens; To demonstrate that daily activities can collectively make a big

difference and that each individual has a role to play in the fight against climate change.

Theory

Block 1: Issues on global climate change

Unit 1 - Climate change and biodiversity

Unit 2 - IPCC assessment on climate change

Unit 3 - International conventions: Kyotoprotocol, Paris agreement and its recent developments

Unit 4 - EI-Nino effect

Unit 5 - Climatic fluctuations over India

Block 2: Climate change and global desertification process

Unit 1 - Ongoing efforts on climate change research

Unit 2 - Greenhouse gases – CO_2, CH_4, NO_2, CFCs etc

Unit 3 - Greenhouse gases in atmosphere

Unit 4 - Global warming potential

Unit 5 - Source – sink ratios and atmospheric loading rates etc

Block 3: Mitigation options of greenhouse gases

Unit 1 - CO_2 enrichment studies and plant response

Unit 2 - O_3 depletion and CFC's

Unit 3 - Climate change mitigation in polar regions

Unit 4 - Montreal protocol, Kigali agreement and its recent developments

Unit 5 - Causes and control measures- mitigation and adaptations, Impact on different ecosystem

Unit 6 - Role of mathematical models in predicting climate change

Unit 7 - Its impact on productivity and soil fertility

References

- BYERS, H.R., General Meteorology Tata McGraw Hill Publications, New Delhi.
- GADEKAR, S.R., 2000, Meteorology: Agromate Publishers,

Nagpur.

- LAL, D.S., 2001, Climatology, Shraddha Pustak Bhavan Allahabad.
- SIDDDHARTHA, K., 2000, Atmosphere, Weather and Climate Kisalaya Publication Pvt. Ltd.

FES 511 FOREST MANAGEMENT (2+0)

Objective

Management of forests broadly involves three main tasks *viz,* (i) Control of composition and structure of the growing stock, (ii) Harvesting and marketing of forest produce, and (iii) Administration of forest property and personnel.

Theory

Block 1: Principles of forest management

Unit 1- Scope and Objectives of forest management

Unit 1- Ecosystem management

Unit 3- Development of forest management in India

Unit 4 - Site quality evaluation and importance

Unit 5 - Stand density

Unit 6- Classical approaches to yield regulation in forest management

Unit 7- Salient features and strategies

Block 2: Forest valuation and appraisal in regulated forests.

Unit 1- Forest organization

Unit 2 - Increment

Unit 3 - Rotation and growing stock

Unit 4 - Working plan: objectives, definitions and scope

Unit 5 - Preparation of Working plan maps

Unit 6 - Management plant presentations

Block 3: Sustainable forest management (SFM)

Unit 1- Principle and concept

Unit 2- Criteria and indicators for sustainable forest management

Reference

- ANONYMOUS, 2000, IIFM, Bhopal-India process for sustainable management of Indian forests. Indian Institute of Forest Management, Bhopal.
- BALOONI, K, 2002, Participatory Forest Management in India an Analysis of Policy Trends amid 'Management Change'. Policy Trend Report pp 88-102.
- RAWAT, S.T., MENARIA, B. L., DUGAYA, D., AND KOTWAL, P.C., 2008, Sustainable forest management in India. Current science, 94(8):
- SAXENA, N. C., 1997, The Saga of Participatory Forestry Management in India, CIFOR, Jakarta, Indonesia.
- SHAHAPURMATH, G.B., HANUMANTHA, M, 2020, Forest Management, Satish Serial Publishing House, New Delhi.

FES 512 NATURAL RESOURCE AND ENVIRONMENTAL ECONOMICS (1+1)

Objective

To understand about economics of environment and social costs incurred due to economic development. Work out methods to maintain environment quality and reduce social costs.

Block 1- Introduction to natural resource and environmental economics

Unit 1: Basic Foundation

Concepts, Classification and Problems of Natural Resource Economics–Economy Environment interaction – The Material Balance principle, Entropy law-Resources Scarcity – Limits to Growth – Measuring and mitigating natural resource scarcity – Malthusian and Recardian scarcity – scarcity indices – Resource Scarcity and Technical Change.

Block 2- Insights of the subject

Unit 1- Theories and economics of natural resources

Theory of optimal extraction renewable resources –economic models of oil extraction efficiency – time path of prices and extraction – Theory of mine – Gray's model Hotelling'srule, Solow-Harwick's Rule Theory of optimal extraction exhaustible resources – economic models of forestry and fishery.

Unit 2: Functioning of Market

Efficiency and markets – market failures – externalities – types – property rights – transaction costs – Coase's theorem and its critique – public goods – common property and open access resource management – Collective action.

Tragedy of commons: Characteristics of property rights, emergence of different forms of property rights to Natural Resources, Land use and rent under private property and disappearance of rent under common property; Hardin's Tragedy of Commons.

Block 3- Dealing with the issues and sustainability

Unit 1: Environmental Issues

Environmental perspectives – biocentrism, sustainability, anthropocentrism – Environmental problems and quality of environment – Sources and types of pollution – air, water, solid waste, land degradation – environmental and economic impacts – Economics of pollution control – efficient reduction in environmental pollution.

Unit 2: Regulations

Environmental regulation – economic instruments – pollution charges – Pigoviantax– tradable permits – indirect instruments – environmental legislations in India.

Unit 3: Sustainability aspects

Concept of sustainable development – Economic Perspective – Indicators of sustainability Relation between development and environment stress-Environmental Kuznet's curve Environmental Accounting – resource accounting methods – International

Environmental Issues – climate change – likely impacts – mitigation efforts and international treaties.

Practical

Exhaustible resource management – optimum rate of oil extraction; Theory of mine – Gray's model, Hotelling's rule; Renewable resource management – optimum harvest of Forestry/fishery; Exercise on pollution abatement-I; Exercise on pollution abatement-II; Costing of irrigation water: Surface and ground water for irrigation using natural resource cost concepts; Estimation of Externalities: Positive and negative externalities; Concepts in valuing the environment; Taxonomy of valuation techniques; Productivity change method – substitute cost method – Hedonic price method – Travel cost method – Contingent valuation methods; Discount rate in natural resource management; Environment impact assessment; Visit to Pollution Control Board.

References

- KWAK J., Economism: Bad Economics and the Rise of Inequality
- PEARCE, D.W. AND TURNER, R. K., Economics of Natural Resource and Environment.
- SCHWARZ, P.M., Energy Economics
- TIETENBERG, T. AND LEWIS L., Environmental and Natural Resource Economics

FES 513 MANAGEMENT OF DEGRADED ECOSYSTEMS (1+1)

Objective

Ways to restore them include reducing tillage, using more natural fertilizer and pest control, and growing more diverse crops, including trees. These steps can rebuild carbon stores in soils, making them more fertile so countries can feed their growing populations without using even more land.

Theory

Block 1: Degraded ecosystems

Unit 1-Ecological theory

Unit 2 - Factors leading to degraded ecosystems - erosion due to wind and water-physical and chemical properties- biological communities

Unit 3 - Nature of degraded ecosystems

Unit 4 - Wasteland-Arid, water logged, salt affected soils

Unit 5- Dynamics of wasteland changes

Unit 6 - Desertification and deserts

Unit 7 - Mining and environment

Unit 8- Degraded forest- nutrient enrichment

Unit 9 - Eutrophic aquatic ecosystem

Block 2: Degraded ecosystem management

Unit -1 Conservation of wetlands

Unit 2- Coastal ecosystem

Unit 3- Mangrove ecosystem

Unit 4 - Degraded Ecosystem Restoration ecology, approaches

Unit 5 - Reintroduction of species and conservation of biodiversity

Block 3: Reclamation of land and mine spoils

Unit 1 - Vegetation -Amelioration

Unit 2 - Afforestation

Unit 3 - Restored forests

Unit 4 - Succession - community dynamics

Unit 5 -Strategies for combating desertification

Practical

Characterization of degraded soils, mine spoils - physical, chemical and biological properties. Indicator species of degraded lands. Studies on various ameliorants on reclamation of polluted and contaminated soils. Assessment of heavy metal contamination - bioremediation. Effect

of dust pollution on crops. Visit to degraded areas - waterlogged / saline soils.

References

- CRISTINA, I., LEINIG ARAUJO MAURÍCIO DZIEDZIC LEILA TERESINHA MARANHO, 2014, Management of the environmental restoration of degraded areas. Environmental Sciences. Braz. arch. biol. technol. ,57 (2) :
- TRIVEDI, T.P., SHARMA R.P., AND VERMA, S.A., 2010, Degraded and Wastelands of India Status and Spatial Distribution.
- WARRIER S, G., ATULBAGAI, GERGAN, R., 2021, India holds great promise in this Decade on Ecosystem Restoration. Mongabay.com
- GADGIL, M., 1993, Biodiversity and India's degraded lands. AMBIO, 72(2).
- SINGH, K., 2022, Ecological Restoration of Degraded Ecosystems in India: Science and Practices. Ecological Engineering.

FES 514 FOREST BIOMETRY (1+1)

Objective

It is important whether the forests are to be managed for commercial purposes such as wood production and energy production, or for non-commercial purposes. Forest biometry forms the foundation for the preparation of working plans that are technical documents for the working of any forest in India.

Theory

Block 1: Measurement of tree parameters

Unit1- Estimation of volume, growth and yield of individual tree and forest stands.

Unit 2 - Preparation of volume tables and its application

Unit3 - Yield snd stand tables.

Block 2: Forest inventor

Unit 1 - Sampling methods adopted in forestry

Unit 2 - Use of GPS in forest inventory

Unit 3 - Stand density measurement

Unit 4 - Simulation techniques

Block 3: Growth and yield prediction models

Unit 1 - Their preparation and applications

Practical

Calculations of volume of felled as well as standing trees., Volume table preparation, Application of sampling procedures., Handling of GPS., preparation of yield and stand table.

References

- MASANI.N.J., KEUFFEL Company and Esser. Instruments for Forest Work. Forgotten Books.Forest Engineering without Tears. Bookworm publishers.
- HIBBERED, B.G., 1991, Forestry Practice. Publication - TSO, England.
- PANWARAND, P., AND BHARDWAJ, S.D. Handbook of Practical Forestry.

FES 515 FLORAL BIOLOGY AND ECOLOGY (1+1)

Objective

Floral biology is an area of ecological research that studies the evolutionary factors that have moulded the structures, behaviour and physiological aspects involved in the flowering of plants.

Theory

Block 1: Floral biology

Unit 1- Its scope in breeding

Unit 2- Floral Morphology

Unit 3- Inflorescence types

Unit 4- Flower morphology and development

Unit 5- Sexuality in plants, Anthesis

Block 2: Pollination ecology

Unit 1- Cross pollination

Unit 2- Pre Darwinian, Darwinian and modern studies and pollination ecology

Unit 3- Biotic pollination & Abiotic pollination

Unit 4 - Structural blossom classes

Unit 5- Pollination syndromes and Role of animals in pollination

Unit 6- Floral development in relation to mode of pollination

Unit 7- Applied pollination ecology

Block 3: In-vitro flower culture and abiotic pollination

Unit 1- In-vitro flower culture and morphogenetic studies

Unit 2- Retrog rade development reversal to abiotic pollination

Unit 3- Autogamy, apomixes and vegetative propagation

Unit 4 - Role of pollination in evolution and speciation

Practical

The Study of different types of inflorescence, flower structure, Anthesis. Methods of study of stigma receptivity and pollen fertility. Study of flora biology of a typical example.

References

- FAEGRI, K. AND PIJIL, L. V. D.,1979, The Principles of Pollination Ecology. Pergamon Press, UK.
- LAWRENCE D. H. AND SPENCER C. H. B., 2006, Ecology and Evolution of Flowers. Oxford University Press. UK.
- PERCIVAL. 1965. Floral Biology. Pergamon Press, UK.

FES 516 ENVIRONMENTAL ANALYTICAL TECHNIQUES (1+1)

Objective

Environmental analysis makes use of a wide range of instrumental techniques: gas chromatography (GC) and liquid chromatography, mass spectrometry (MS), UV/VIS/IR-spectroscopy, and fluorescence spectroscopy, or, regarding heavy metals, by atomic absorption spectroscopy or inductively coupled plasma to mass spectrometry.

Theory

Block 1: Environment and its importance

Unit 1 - Study of physico-chemical and biological parameters

Unit 2 - Instrumentations, Microscopy and microbiological techniques

Block 2: Study of water quality parameters

Unit 1 - Study of Water-Acidity, Alkalinity, hardness, TDS & EC

Unit 2 - Organic acids, phenolics, metals. BOD, COD

Block 3: Study of Gases

Unit 1 - Study of carbon dioxide, methane

Unit 2 - Oxides of nitrogen, CFC

Unit 3 - Particulates

Practical

Techniques for monitoring the quality of the environment - Collection of solid, water and air samples. Principles - UV - VIS Spectrophotometry - IR Spectrophotometry - Flame photometry - Atomic Absorption Spectrophotometry -Paper chromatography - Gas chromatography - High pressure liquid Chromatography(HPLC) and EC. Bioassay, Waste treatment technologies.

References

- ARORA, P. N., MALHAN, P. K., 2008, Biostatistics. Himalaya publishing House, Delhi.

- GOPI, A., MEENA, A., ARUMUGAM, N., 2003, evolution biostatistics and computer applications, Saras Publications, Kanyakumari.
- RAJARAMAN, V., 2008, Fundamentals of Computer: Prentice Hall of India, New Delhi.
- SAHA, T. K., 1992, Biostatistics in theory and Practice: Emkay Publications, Delhi.
- SINHA, K. P., SINHA, P., 2007, Computer Fundamentals: BPB Publications, New Delhi.

FES 517 PLANTATION FORESTRY (1+1)

Objective

Plantation forests can provide most goods and services that are provided by natural forests. These include timber, nontimber forest products, protection of clean water and clean air, soil erosion control, biodiversity, esthetics, carbon sequestration, and climate control.

Theory

Block 1: Plantation forestry

Unit 1- Role in meeting the wood demand

Unit 2 - Plantation forestry in India and abroad

Unit 3- Purpose of plantation

Unit 4 - Factors determining scale and rate of plantation

Unit 5 - Land suitability and choice of plantation species

Unit 6- Production technology for quality planting stock

Unit 7- Preliminary site preparation for establishing plantation

Block 2: Planting programme

Unit 1- Time of planting and planting pattern

Unit 2 - Spacing and plating method

Unit 3 - Protection and after care of plantation

Unit 4 - Pruning and thinning of plantation for quality wood J production

Unit 5 - Different thinning practices

Block 3: Protective Afforestation

Unit 1- Afforestation of inhospitable sites

Unit 2- Ecological factors and long term productivity

Unit 3- Sustainable yield from plantation

Unit 4 - Case studies of different plantations

Unit 5- Wasteland plantation and Industrial Plantation

Unit 6 - Plantation journals & its importance

Practical

Analysis of plantation problems in Asia and India - Preparation of plantation calendar - Preliminary arrangement for a plantation programme - Planting geometry and calculation of planting stock - Study of different cultural operations and site preparation for plantation - Studies on wood based industries - Problems and prospects - Management of Timber and energy plantations.

References

- KUMAR V, 2011, Nursery and Plantation Practices in Forestry. scientific publisher; ISBN-10: 8172337167 and ISBN-13þ: 978-8172337162.
- LUNA, R.K., 2008, Plantation Forestry in India International Book Distributors, ISBN-10: 8170891078 and ISBN-13: 978-8170891079.
- PANWAR, P., 2007, Practical Manual on Plantation Forestry. Scientific Publishers Journals Dept., ISBN-10 :817233429X and ISBN-13: 978-8172334291.
- PRICE, W.C., RANA, N. AND SAMPLE, A., 2006, Plantations and Protected Areas in Sustainable Forestry. CRC Press. ISBN-10: ý 1560221399 and ISBN-13 þ: ý 978- 1560221395.
- SEDJO, R.A., 2015, The Comparative Economics of Plantation Forestry: A Global Assessment (Rout ledge Revivals). Rout ledge.

ISBN- 10: 1138101494 and I 3: 978-1138101494

FES 518 ENVIRONMENTAL BIOTECHNOLOGY (2+0)

Objective

The aim of environmental biotechnology is to prevent, arrest and reverse environmental degradation through the appropriate use of biotechnology in combination with other technologies, while supporting safety procedures as a primary component of the programme.

Theory

Block 1: Environmental Biotechnology

Unit 1 - Basic concepts and environmental issues

Unit 2 - Types of environmental pollution

Unit 3 - Problems arising from high-input agriculture

Unit 4 - Methodology of environmental management

Unit 5 - Air and water pollution and its control

Unit 6 - Waste water treatment – physical, chemical and biological process

Unit 7 - Need for water and natural resource management

Unit 8 - Microbiology and use of micro-organisms in waste treatment

Block 2: Biodegradation

Unit 1 - Biodegradation; degradation of Xeno-biotic, surfactants

Unit 2 - Bioremediation of soil and water contaminated with oils, pesticides and toxic chemicals, detergents etc

Unit 3 - Aerobic processes (activated sludge, oxidation ditches, trickling filter, rotating drums, etc.)

Unit 4 - Anaerobic processes; digestion, filtration, etc

Unit 5 - Renewable and non-Renewable resources of energy

Unit 6 - Energy from solid waste; conventional fuels and their environmental impact

Unit 7 - Biogas; microbial hydrogen production, conversion of

sugar to alcohol; gasohol; biodegradation of lignin and cellulose

Unit 8 - Bio-pesticides; bio-fertilizers; composting. vermiculture, etc.

Block 3: Treatment schemes of domestic waste and industrial effluents

Unit 1 - Food, feed and energy from solid waste

Unit 2 - Bioleaching; enrichment of ores by microorganisms

Unit 3 - Global environmental problems; ozone depletion, UV-B, greenhouse effects, and acid rain

Unit 4 - Biodiversity and its conservation

Unit 5 - Biotechnological approaches for the management environmental problems

Reference

- BHAGI, A.K., AND CHATWAL, G.R., Environmental Chemistry
- DUBEY, R.C., Biotechnology
- MOHAPATRA, P.K., Environmental Biotechnology
- SINGH, S.D., Environmental Biotechnology
- THAKUR, I.S., Environmental Biotechnology

FES 519 ENVIRONMENTAL ENGINEERING (1+1)

Objective

Environmental Engineering is the application of science and engineering principles that provide a better environment, to give healthy water, air and land for human habitation and other living things, and to rehabilitate polluted areas.

Theory

Block 1: Environmental issues

Unit 1 - Green house gases (CO_2, CO, CH_4, NO_2, CFC, water vapour)

Unit 2 - Major sources of air pollutants

Unit 3 - Chemistry of secondary pollutants

Unit 4 - Air pollution and meteorology

Unit 5 -Photochemical smog and acid rain, Indoor and outdoor air pollution

Block 2: Plant water exchange

Unit 1 - Gas exchange (CO_2& O_2)

Unit 2 - Stomatal function, distribution and stomatal mechanism

Unit 3 - Carbon assimilation (C3, C4 and CAM), plant pigments

Unit 4 - Bio-monitoring of air, water and soil environment

Unit 5 - Concept of indicator species and their environmental significance

Unit 6 - Sources and measurement of noise pollution, noise exposure levels and standards, noise pollution control and abatement measures

Block 3: Principles of water quality monitoring

Unit 1 - Methods of water sampling, instruments

Unit 2 - Physico-chemical analysis of water and analysis of water quality

Unit 3 - Sources of soil pollution, heavy metals and sources

Unit 4 - Effect on biological system, pesticide sources, agricultural inputs and its effect on soil

Unit 5 - Waste land development and its management

Practical

Techniques for monitoring quality of the environment, collection of soil, water and air samples- Analysis of physic-chemical and Biological parameters. Instrumentation- Principles of UV-VIS spectrophotometer, gas chromatography, HPLC, and Microscopy. Plant analysis- Separation and quantification of plant pigments CO_2 and O_2evolution, Stomata-distribution, anatomy, function and mechanism. Water analysis- Acidity, Alkalinity, hardness, TDS and ES, phenols, pH, BOD, COD- analysis of air samples, CO_2, CH_4, NO_2 and particulates. Methods of reclamation of Perennial swamps, water logged area, saline and rocky outlets plugging

with suitable tree species. Methane evolution.

References

- BIRDIE.,1999, Water Supply and Sanitary Engineering Dhanpat Rai Pub.Co. Charotal Publishing House, New Delhi.
- CORBITT, R.A., Standard Handbook of Environmental Engineering, McGraw - Hill.
- GARG S.K. Sewage disposal and air Pollution Engineering Khanna Publication.
- MASTERS. G.M., Introduction to Environmental Engineering and Science, Prentice - Hall of India Pvt., Ltd.
- METCALF AND EDDY Inc. Waste Water Engineering: Treatment, Disposal, Reuse, Tata., McGraw-Hill Publishing Company Ltd

FES 520 AGROFORESTRY SYSTEMS (1+1)

Objective

To manage land efficiently so that its productivity is increased and restored. To generate employment opportunities for rural peoples. To provide raw material for small cottage industries in rural areas. To raise the supply of fuel in the rural areas at convenient distance for consumer.

Theory

Block 1: Agro-forestry

Unit 1- Definition– land use systems related to agroforestry

Unit 2- Classification of agroforestry systems structural, functional, ecological and socio-economic basis for grouping

Unit 3 - Species selection for agroforestry

Unit 4- Principles &criteria of species selection for agroforestry

Unit 5 - Indigenous v/s.exotic

Unit 6 - Intra-specific variations and ideotype

Unit 7- crown architecture of tropical trees

Block 2: Multipurpose tree species

Unit 1- criteria for selection of multipurpose trees

Unit 2- case studies for different Agroforestry systems

Unit 3 - N fixing trees

Unit 4 - Economic aspects of agroforestry

Unit 5- Introduction to NTFP's and its classification

Unit 6- Technologies for extraction of NTFP's

Block 3: Utilization of various non-wood forest products

Unit 1 - NWFP's scientific management for processing

Unit 2- Value addition, marketing and disposal

Unit 3- Quality assessment of important products

Practical

Survey and analysis of land use systems in the adjoining areas. Diagnosis and Design exercise for the selection and refinement of relevant agroforestry systems and practices. Visit to successful agroforestry system models and study their functional dynamics.

References

- HANDA A.K, DEV, I., RAZVI, R.H., KUMAR, N., RAM, A., KUMAR, D., KUMAR, A., BHASKAR, S., DHYANI, S.K., RAZVI, J., 2019, Successful agro-forestry models for different agro-ecological regions in India. New Delhi, India: World Agro forestry South Asia Regional Programme.
- DAGAR, J.C., SINGH, A.K, ARUNACHALAM, A., 2013, Agro-forestry Systems in India: Livelihood Security & Ecosystem Services. Springer Publication, I SBN: 978- 81-322-1662-9.
- JHA, L.K., AND SARMA, P.K., 2009, Agro forestry - Indian Perspective. APH Publishing, ISBN No. 8131303438, 9788131303436
- NAIR, P.K.R., RAO, M.R., AND BUCK, L.E., 2004, New Vistas in Agro forestry: A Compendium for the 1st World Congress of Agro forestry. Kluwer Academic Publishers, Dordrecht, The Netherlands. ISBN: 1-4020-2412-6.

FES 521 FOREST PROTECTION (1+1)

Objective

The main objective is to reverse the loss of forest cover worldwide through sustainable forest management, including protection, restoration, afforestation and reforestation, and increase efforts to prevent forest degradation.

Theory

Block 1: Forest protection

Unit 1 - Definition and History

Unit 2 - Importance of forest protection in India

Unit 3 - Damages to forests in nurseries and plantations and their management

Unit 4- By biotic agencies such as human, domestic animals, wildlife

Unit 5- Phanerogamic parasites, weeds, climbers and epiphytes

Block 2: Impact of Natural calamities in relation to forest health

Unit 1- Impact of fire & drought

Unit 2- Excessive rains, floods, acid rains

Unit 3 - Wind and storm, frost and freeze

Unit 4- Deficiency of nutrients, salinity and acidic soils

Block 3: Species suitability

Unit 1 - For drought & water logged

Unit 2- Saline and salt affected areas

Unit 3- Sand dunes and fire resistant

Practical

Assessment of damages caused by animals; seedling and plantation protection structures. Forest fire detection and suppression; impact of fire on forest ecosystem, soil and vegetation, effect of excessive lopping, study of Elephant proof trench (EPT), cattle proof trench (CPT), and

solar fencing. Study of Fire line and visit to nearby forests.

References

- ANONYMUS A Handbook of Forest Protection, 2018. Franklin Classics Trade Press, ISBN: 9780353270565, 0353270563.
- ALARIC, V., 2016. Forest Conservation in the Anthropocene: Science, Policy, and Practice. University Press of Colorado, Library of Congress SD390.7.C55F6635 2016 | Dewey Decimal 634.9.
- MANIKANDAN, K., AND PRABHU, S., 2021. Indian Forestry a Breakthrough Approach to Forest Service. Jain Brothers press and ASIN þ: ý B08WC9DYNJ.
- PARTHIBAN, K.T., 2019, Forest protection Principles and Applications. Jian Brother Publication, ISBN-10: ý8183602959 and ISBN-13: 978-8183602952

FES 522 ECOTOURISM - CONCEPT AND MODERN APPROACHES

(1+1)

Objective

The primary goal of ecotourism is to enable tourists to enjoy nature and wilderness areas in its full glory without causing any disturbance, such that it fosters sustainable use through resource conservation, cultural revival, and economic development and diversification.

Theory

Block 1: Ecotourism

Unit 1: Definition and need of ecotourism, Social and ecological impacts of tourism

Unit 2: Concept of ecotourism: Ecotourism and related sub-sectors of the tourism industry, Ecotourism criteria & Quebec declaration on ecotourism

Unit 3: Ecotourism Resources: Identifying, listing and understanding ecotourism resource categories (natural, built, and events) Protected Areas: Definition, categories and roles

Unit 4: Identifying and describing ecotourism products: Components of ecotourism. Ecotourism and the environment Ecotourism and conservation Ecotourism and protected areas Ecotourism and economic benefits Ecotourism and social benefits Ecotourism and local community Ecotourism and education.

Block 2: Ecotourism practices

Unit 1: Transportation facilities (reduce, replace, reuse, recycle) Services (types, activities, and code of ethics) The eco tourists (types, and code of ethics) Eco-labelling and green washing Examples and case studies of ecotourism in practice Best practice guidance Certification Identify existing examples and case studies of eco friendly practices in the tourism industry

Unit 2: Community based tourism management Monitoring the success and impacts of community based tourism.

Block 3: Developing an ecotourism product

Unit 1: Identifying products, developing partnerships, tapping local knowledge, incorporating research, zoning, developing policies and guidelines, educating & marketing •Knowledge, skills, attitude and commitment of ecotourism service providers

Unit 2: Ecotourism in the national/global context Convention on Biological Diversity Millennium Development Goals Ecotourism based/ related employment: Scope and areas of employment.

Practical

Visit to various ecotourism areas and identify the tourism components- suggested modifications. Evaluation and monitoring of the various ecotourism activities of the region such as Nature Walk - The guided day trek, The Tiger Trail, Border Hiking, Bamboo Rafting, Jungle Patrol, Tribal Heritage, Jungle Inn, The Soared groves, Bamboo Grove,

Green Mansions,. Identify an area where ecotourism in vogue- Identity the various ecosystem activities in the selected area, evaluate in terms of economic feasibility, ecological adaptability and social acceptance. Study the carrying capacity and impact of ecotourism activity on the ecosystem.

References

- DAVID L. EDGELLSR, 2019. Managing Sustainable Tourism. Routledge Publisher, Isbn: 9780367331382
- OLIVA CABRAL, 2017. Responsible Tourism: Concepts Theory And Practice. Scitus Academics Press, Isbn:9781681176215
- STEPHEN WEARING, AND STEPHEN SCHWEINSBERG, 2018. Ecotourism Transitioning To The 22nd Century. Taylor & Francis Ltd Press, Isbn: 9781138202108.
- SATISH CHANDRA NIGAM. Eco Tourism And Sustainable Development. Rajat Publications, Isbn: 9788178802602.

FES 523 BIO FUEL PRODUCTION TECHNOLOGIES (1+1)

Objective

Bio fuels are at the center of intensive discussion. It is viewed by many as a tool to help reduce greenhouse gas emissions and fossil fuel use, to foster rural development, and to create new markets for agricultural products.

Theory

Block 1: Different feed stocks for bio fuel production

Unit 1- Bio fuels and Bio-energy: definitions, scope, Indian and world scenario. Types of Bio fuels: first generation, second generation, third generation and fourth generation bio fuels. Feed stock for bio fuel production: types and characteristics. Bio fuel feed stocks - plant species and their derivatives, characterization.

Unit 2 - Biomass as energy: types, composition and conversion technologies, Gasification, Pyrolysis process.

Unit 3 - Biodiesel: feed stocks, trans-esterification, by products and utilization.

Block 2: Production technology and utilization

Unit 1- Bio-ethanol: feed stocks and their processing, Microorganisms involved, fermentation process.

Unit 2 - Biogas production technology, feed stocks, additives and alternatives, Bio-methane Applications.

Unit 3 – Bio fuels from microorganisms: Microorganisms involved different techniques of algal culture and production technology.

Block 3: Quality parameters and economics

Unit 1 - Modern bio fuels: Bio-hydrogen, Drop in fuels, Syngas, Fischer-Tropsch fuels, Bio-oils, Bio-alcohols.

Unit 2- Bio fuel policies in India and other countries, Environmental implications of bio fuels: Life Cycle Assessment (LCA) of bio fuel production, bio fuels and climate change, Socio-economic implications of bio fuel production. Feed stock aggregation, marketing and rural enterprises.

Unit 3- Economics of biofuel production, Biofuel quality parameters and standards. Byproducts of bio fuel production and their utilization.

Practical

Study of Biofuel plants species, study and characterization of different feed stocks for bio - fuel production, oil content estimation in seeds, study of bio diesel product and purification, acid esterification, alkali catalyzed Tras- esterification, by product characterization and utilization Glycerol purification, spent water purification and utilization, ethanol production protocol. Biogas production Demonstration and Electricity production. Study of quality parameters of biofuels: Flash point, cloud point, calorific value, viscosity, Density etc. Pyrolysis of Biomass. Life cycle assessment of biofuel production.

Referencess

- BIO FUEL TECHNOLOGY HANDBOOK, DOMINIK RUTZ & RAINER JANSSEN 2008, Publication Wip Renewable Energies.
- HANDBOOK OF PLANT-BASED BIO FUELS, MALAYA KUMAR NAIK 2008, Crc Press
- BIO FUELS: PRODUCTION AND FUTURE PERSPECTIVES, 2017, Ram S. Singh Et Al, Crc Press Taylor & Francis Group.

M.Sc. (Agri.) in Food Science & Nutrition

Course Code	Course Title	Credit Hours
FSN 501	Principles of Food Science	2 (1+1)
FSN 502	Principles of Nutrition	3 (3+0)
FSN 503	Food Analysis	3 (1+2)
FSN 504	Principles of Community Nutrition	2 (1+1)
FSN 505	Food Processing Technology	2 (2+0)
FSN 506	Clinical Nutrition	2 (1+1)
FSN 507	Nutrition during Life cycle	2 (2+0)
FSN 508	Nutrition and Physical Fitness	2 (1+1)
FSN 509	Principles of Diet Therapy	3 (2+1)
FSN 510	Food Toxicology	2 (2+0)
FSN 511	Principles of Human Physiology	2 (1+1)
FSN 512	Food Service Management	2 (1+1)
FSN 513	Food Product Development	2 (1+1)
FSN 514	Nutrition and Immunity	1 (1+0)
FSN 515	Functional Foods	1 (0+1)
	Total	**31 (20+11)**
FSN 580	Qualifying Examination	2 (0+2)
FSN 581	Seminar - I	1 (0+1)
FSN 582	Seminar - II	1 (0+1)
FSN 591	Research - I	13 (0+13)
FSN 592	Research - II	14 (0+14)

FSN 501 PRINCIPLES OF FOOD SCIENCE (1+1)

Objective

To expose the students in understanding the changes in foods during various processing methods.

Theory

Block 1: Food chemistry

Unit I: Evaluation of food

Concepts in Food Science: Colloidal chemistry as related to foods; evaluation of food by subjective and objective methods.

Unit II: Carbohydrates

Sources and characteristics of sugar, starch, cellulose, pectin and gums in foods; effect of cooking and processing techniques.

Unit III: Proteins

Plant and animal foods; chemical and physical properties related to foods; effect of cooking and processing techniques. Properties, uses, processing techniques, changes during heating

Unit IV: Fats and oils

Classification, Processing and storage of fats and oils.

Unit V: Fruits and vegetables

Importance, composition of fruits and vegetables and effect of cooking and other processing on their nutritive value. Classification and importance of beverages.

Blocl: 2 Additives

Unit 1: Food additives

Definition, classification, uses and legal aspects of food additives.

Unit II: Pigments

Food pigments; browning reaction.

Unit III: Leavening agents

Classification, nature and uses of leavening agents.

Practical

1: Microscopic structure of different starch granules

2-3: Evaluation of food by subjective and objective methods

4-5-6: Changes in colour, texture and flavor of foods due to processing

7-8: Effect of cooking on protein, fat and carbohydrates

9-10: Effect of cooking on fat

11-12: Effect of cooking on carbohydrates

13: Product preparation using leavening agents

14-15: Project work related to work

References

1. SRILAKSHMI, B., 2019, Food Science, New age international publishers.
2. STONE H, 2004, Sensory Evaluation Practices (Food Science and Technology). 3rd Edition, Academic Press, Cambridge.
3. SHARMA, A, 2005, Textbook of Food Science and Technology. 3rd Edition, CBS, New Delhi.
4. SUBBALAKSHMI, G. AND UDIPI, S. A. 2006, Food Processing and Preservation. New Age International, New Delhi.
5. POTTER, N. N. AND HOTCHKISS, J. H., 2007 Food Science. 5th Edition, CBS, New Delhi.
6. VACLAVIK, V. A. AND CHRISTIAN, E. W., 2014 Essentials of Food Science. 4th Edition, Springer-Verlag, New York.
7. RODAY, S., 2018, Food Science and Nutrition. 3rd Edition, Oxford University Press, UK.
8. Sofia Jan., 2013, Elements of Food Science. New India Publishing Agency, New Delhi
9. BELLE LOWE., 2019Experimental Cookery from the Chemical and Physical Standpoint. Facsimile Pub.

FSN 502 PRINCIPLES OF NUTRITION (3+0)

Objective

To provide in depth understanding related to macro and micro nutrients

Theory

Block 1: Macro nutrients

Unit I: Carbohydrates

Functions, sources, requirements, digestion and absorption of carbohydrates; definition, composition, classification, functions and role of dietary fibre in various physiological disorders.

Unit II: Proteins

Basis of requirement, functions, sources, digestion and absorption of protein; Methods of assessing protein quality.

Unit III Lipids

Basis of requirement, functions, sources, digestion and absorption of protein; Methods of assessing protein quality.

Block 2: Micro nutrients

Unit **1: Vitamins**

Classification. Requirements, functions, sources, deficiencies and toxicities, of fat and water soluble vitamins.

Unit II: Minerals

Classification. Requirements, functions, sources, deficiencies and toxicities. Factors affecting absorption and utilization of macro and micro minerals.

Block 3: Water

Distribution of water in the body.

Water balance; acid and base balance.

References

- WILDMAN, R. E. C. AND MEDEIROS, D. M., 2000 Advanced Human Nutrition. CRC Press, Boca Raton, Florida.

- BAMJI, M. S., RAO, N. P. AND REDDY, V., 2003, Textbook of Human Nutrition. 2nd Edition, Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
- Eastwood, M. A., 1997, Principles of Human Nutrition. London ; Chapman & Hall.
- FAO, 2004, Human Energy Requirements - Report of a Joint FAO/ WHO/UNU Expert Consultation. Technical Report Series 1. Food and Agriculture Organization, Geneva.
- FAO, 2007, Protein and Amino Acid Requirements - Report of a Joint FAO/WHO/UNU Expert Consultation

FSN 503 FOOD ANALYSIS (1+2)

Objective

To provide the students an opportunity to develop precision with the principles, techniques and application of different methods

Theory

Block 1: Analytical techniques

Unit I: Sampling techniques

Familiarization to terms and calculations used in preparation of various standard solutions. Sample and sampling techniques

Unit II: Analytical techniques

Principles, techniques and applications of colorimetric, spectrophotometer and atomic absorption spectrophotometer.

Unit III: Photometry and Electrophoresis.

Principles, techniques sand applications of fluorimetry, flame photometry and electrophoresis.

Unit IV: Chromatography

Principles techniques and application of chromatography (paper chromatography, TLC, GLC, HPLC).

Block II: Animal study

Unit I: Animal assay

Introduction to animal assay

Practicals

1-2: Handling of equipment and instruments

3-5: Preparation of samples, solutions and buffers

6-11: Quantitative estimation of proximate principles

12-15: Minerals and vitamins by use of calorimetry

16-17: Flame photometry

18-19: UV spectrophotometer

20-21: Chromatography

22-23: Atomic absorption spectrophotometer

24: Photofluorometry

25-27: Analysis of anti-nutritional factors

28-29: Estimation of protein and starch digestibility; fractionation of protein

30: Food adulteration

References

- SAWHNEY, S. K. AND SINGH, R., 2000, Introductory Practical Biochemistry. Narosa Publishing House, New Delhi.
- KALIA, M., 2002, Food Analysis and Quality Control. Kalyani Publishers, New Delhi.
- RAGHURAMULU, N., MAHAVAN AND KALYANA SUNDARAM, S. K., 2003, A Manual of Laboratory Techniques. 2nd Edition, NIN Press, Hyderabad.
- WOOD, R., FOSTER, L., DAMAND, A. AND KEY, P., 2004, Analytical Methods for Food Additives. CRC Press, London.
- SADASIVAM, A. AND MANICKAM, A., 2004, Biochemical Methods. 2nd Edition, New Age
- INTERNATIONAL PUBLISHERS, New Delhi.

- VEERAKUMAR, L., 2006, Bio-instrumentation. MIP Publishers. Chennai.
- AOAC International, 2016, AOAC Official Methods of Analysis. 20th Edition, Association of Official Analytical Chemists. Washington DC.
- AOAC, 1995, Association of Official Analytical Chemists. Washington, DC.
- GRUENWEDELS, D. W. & WHITAKOR, J. R., 1984, FoodAnalysis: Principles and Techniques. Vols. I-VIII. Marcel Dekker.
- JOSLYN, M. A., 1970, Methods in Food Analysis: Physical, Chemical and******

FSN 504 PRINCIPLES OF COMMUNITY NUTRITION (1+1)

Objective

To provide both theory and practical exposure to the students on different assessment methods, nutritional problems and programmes.

Theory

Block I: Nutritional status

Unit I: Nutritional status assessment

Assessment of the nutritional status at individual, household and institutional level: direct and indirect methods.

Unit II: Malnutrition

Ecological, socio-cultural, economic and demographic correlations of malnutrition

Unit III: Deficiency Diseases

Prevalence, etiology, biochemical and metabolic changes in vitamin A deficiency, PEM, iron deficiency anemia, IDD. Major nutritional problems of the state, nation and world. Nutrition Intervention-Definition, importance, methods of nutrition intervention and their

impact evaluation.

Block II: Nutrition Programmess

Unit I: Programmes

National programmes and policies

Unit II: Monitoring and Surveillance

Nutrition monitoring and Surveillance. Role of Epidemiology in public health. National programmes and policies. regarding food production and distribution.

Practicals

1-2: Market survey for food availability and their cost

3, 4, 5, 6 and 7: Development of low cost nutritious recipes suitable for various vulnerable groups; portion size

8-9-10: Visit to the ongoing public health nutrition programme and report writing

11-12: Techniques of assessment of nutritional status.

Project Work

13-15: Study of existing diet and nutrition practices, planning and conducting survey, analyzing data and writing report Development, implementation and evaluation of community nutrition and health programmes.

References

- JELLIFFE, D. B., 1966, The Assessment of the Nutritional Status of the Community. WHO, Geneva.
- ENDRES, J. B., 1990, Community Nutrition Challenges and Opportunities. Pearson EducationInc. London.
- PARK, J. E. AND PARK, K., 2007, Park's Text Book of Preventive and Social Medicine. 19thEdition, BanarsidasBhanot Publishers, Jabalpur.
- FRANK, G. C., 2008, Nutrition: Applying Epidemiology to Contemporary Practice . 2ndEdition, Jonts and Bartlett Publishers, Sadbury, MA.

- LONGWAH, T., ANANTHAN, R., BHASKARACHARY, K. AND VENKALAH, K. 2017, Indian Food Composition Tables. National Institute of Nutrition, Hyderabad.
- Rosalind, S. Gibson., 2005, Principles of Nutritional Assessment. 2nd Edition, Oxford University Press Inc.
- MARIE, A. B. AND DAVID, H. H., 2012, Community Nutrition in Action: An Entrepreneurial Approach, Cengage Learning Inc. USA.
- SURYATAPA DAS., 2018, Textbook of Community Nutrition. 3rd Edn., Academic Publishers.
- PRABHA, B., 2017, Community Nutrition in India. 1st Edition, Star Publications, Agra.Salil S and Rita SR (2007) Textbook of Community Nutrition. ICAR publication, New Delhi.
- Bamji, M. S., Kamala, K. and Brhmam, G. N. V., 2017, Textbook of Human Nutrition. 4thEdition, Oxford & IBH.
- JEANNETTE, B. E., 1990, Community Nutrition: Challenges and Opportunities. 1st Edition, Merrill
- GOPALDAS, T. AND SESHADARI, S., 1987, Nutrition Monitoring and Assessment. Oxford University Press McLaren DS (1977) Nutrition in the Community. John Wiley & Sons.

FSN 505 FOOD PROCESSING TECHNOLOGY (2+0)

Objective

To give exposure to the newer techniques in food processing procedures for safe consumption and business.

Theory

Block I: Food processing techniques

Unit I: Principles and processing operations

Principles underlying food processing operations including thermal, radiation, refrigeration, freezing and dehydration.

Unit II: Processing and quality

Effect of processing on physico- chemical characteristics.

Unit III: Processing of foods

Processing technology for preservation and production of variety food products, losses during storage, handling and processing of cereals and legumes, oilseeds, fruits and vegetables. Processing technology for milk and milk products, egg, meat, poultry and fish, convenience foods, processed foods.

Block II Food fortification and supplementation

Unit I: Fortification techniques

Technologies underlying in mutual supplementation, enrichment and fortification, fermentation, malting, germination.

Unit II: Food additives

Food additives commonly used in food industries for color, flavor, and as preservatives.

Unit III: Quality control

Quality control in food industry: raw material, finished products, waste management and sanitation in food industries.

Unit IV: Packaging and marketing

Packaging of foods. Storage and Marketing of processed foods.

Practicals

1-10: Biochemical analysis of blood under normal and diseased conditions for glucose, calcium, iron, creatinine, urea, uric acid Albumin, globulin, cholesterol phosphate glutamate oxaloacetate transaminase, glutamate pyruvate transaminase; phospholipids;

11- 13: analysis of urine for specific metabolites under normal and diseased conditions.

References

- CARPENTER, R. P., LYON, D. H. AND HASDELL, T. A., 2002, Guidelines for Sensory Analysis in Food Product

- DEVELOPMENT AND QUALITY CONTROL. 2nd Edition, Aspen Publishers Inc. New York.
- EARLE, M. AND EARLE, R. L., 2008, Case Studies in Food Product Development. Woodhead Publishing Limited and CRC Press, New York.
- MOSKOWITZ, H. R., STRAUS, T. AND SAGUY, S., 2009, An Integrated Approach to New Food Product Development. CRC Press, Boca Raton, Florida.
- PUCKETT, R. P., 2012, Food Service Manual for Health Care Institutions. 4th Edition, John Wiley and Sons Inc. Hoboken, New Jersey.
- BECKLEY, J. H., HERZOG, L. J. AND FOLEY, M. M., 2017, Accelerating New Food Product Design and Development. 2nd Edition, John Wiley and Sons Inc. Hoboken, New Jersey.
- SETHI, M., 2018, Catering Management- An Integral Approach. 3rd Edition, New Age International, New Delhi.
- NANCY, L. S., 2007, Catering Management. John Wiley & Sons.
- ARORA, R. S., 2012, Banquet and Catering Management. Abhijeet Publications.
- HARISH BHAT., 2008, Hotel Management. Crescent Publishing Corporation.
- MUDIT BHAJWANI., 2007, Food Service Management: Principles and Practice. Rajat publications, New Delhi. https://www.ferrerofoodservice.com

FSN 506 CLINICAL NUTRITION (1+1)

Objective

To equip the students to identify the inter-relationship, etiology and techniques for better management of diseases

Theory

Block I: Macro and micro nutrients

Unit I: Macro nutrients

Methods for estimated average requirements and recommended allowances of energy, protein, minerals and vitamins for different age groups and physiological status. Nutrient interrelationship; historical background, epidemiology, preventive and therapeutic measures of protein energy malnutrition.

Unit II: Micro nutrients

Interrelationship, etiology and preventive measures of vitamin and mineral deficiencies; toxicities.

Block II: laboratory methods and interpretation

Uitn I: Principles and interpretation

Principles and interpretation of clinical laboratory methods with particular emphasis on their interpretation relative to nutritional status and disease

Unit II: Drug and nutrients

Interaction between nutrients, infections and drugs.

Practicals

1-10: Biochemical analysis of blood under normal and diseased conditions for glucose, calcium, iron, creatinine, urea, uric acid Albumin, globulin, cholesterol phosphate glutamate oxaloacetate transaminase, glutamate pyruvate transaminase; phospholipids;

11- 13: analysis of urine for specific metabolites under normal and diseased conditions

References

- FAO, 2004, *Human Energy Requirements-Report of a Joint FAO / WHO / UNU Expert Consultation.* Technical Report Series1. Food and Agriculture Organization, Geneva.
- JOSHI, Y. K., 2009, *Basics of Clinical Nutrition.* 2nd Edition, Jaypee Brothers Medical Publishers Private Limited, New Delhi.
- NARASINGA RAO, B. S. AND SIVAKUMAR, B., 2010, *Nutrient Requirements and Recommended Dietary Allowances.* 2nd Edition,

National Institute of Nutrition, Hyderabad.

- MACDONALD, I. A. AND MICHAEL, J. GIBNEY, M. J., 2011, *Nutrition and Metabolism*. Wiley-Blackwell Publishing Company, Boston.
- GIBNEY, M. J., ELIA, M., LJUNGQVIST, O. AND DOWSETT, J., 2013, *Clinical Nutrition*.Wiley-Blackwell Publishing Company, Boston.
- SCOTT, A. S. AND GEORGE, L. B., 1997, *Nutrition Support-Theory and Therapeutics*. Chapmanand Hall Series, International Thomson Publications.
- GIBNEY, M. J., MACDONALD, I. A. AND ROCHE, H. M., 2011, *Nutrition and Metabolism*. Wiley-Blackwell Publishing Company, Boston.
- GIBNEY, M. J., ELIA, M., LJUNGQVIST, O. AND DOWSETT, J., 2013, *Clinical Nutrition*. Wiley-Blackwell Publishing Company, Boston.

FSN 507 NUTRITION DURING LIFE CYCLE (2+0)

Objective

To give an exposure to the students regarding nutritional challenges during various stages of life cycle and to equip students address nutritional challenge.

Theory

Block I: Maternal nutrition

Unit I: Importance of Maternal nutrition in pregnancy

First 1000 days of life. Physiological changes in pregnancy, weight gain during pregnancy, food and nutrient requirements, storage of nutrients during pregnancy and impact of good nutrition on the outcome of pregnancy, complications of pregnancy and their nutritional management.

Unit II: Importance of Maternal nutrition in Lactation

Physiology of lactation, impact of nutrition on efficiency and milk

production, food and nutrient requirements during lactation.

Block II: Infancy and child nutrition

Unit I: Infancy

Role of nutrition on physical and mental development, rate of growth-weight as an indicator, assessment of growth, nutrient requirement during infancy

Unit II: Feeding of infants

Value of breast feeding, breast milk composition, breast feeding Vs artificial feeding, types of milk and their use in infant feeding.

Unit III: Weaning foods

Methods of formula preparation, weaning and supplementary foods, weaning practices in the community, special nutritional concern in infant feeding, feeding the premature and low birth weight infants.

Unit IV: Nutritional disorders

Nutritional disorders and common ailments in infancy, feeding the sick child, immunization schedule and growth charts.

Block III: Nutrition during different stages of life

Unit I: Preschool children

Preschool years and food habits, nutritional requirements during preschool year and supplementary foods.

Unit II: School age children

Growth and development, nutritional requirements of school age children, specific problems in feeding school children.

Unit III: Adolescence

Physical and physiological changes, nutritional requirements of adolescents, food preferences and nutritional problems.

Unit IV: Adulthood

Adulthood: sex, occupation, income.

Unit V: Elderly

Elderly: physical and physiological changes, nutritional requirement,

problems of old age, nutrients influencing aging process

References

- CHERNOFF, R., 2003., Geriatric Nutrition: The Health Professional's Handbook. 2nd Edition Jones & Bartlett Learning, Burlington, Massachusetts.
- WORLD HEALTH ORGANIZATION, 2005, WHO Library Cataloguing-in-Publication Data. Nutrition in Adolescence –Issues and Challenges for the Health Sector. WHO, Geneva.
- KLEINMAN, R. E., 2008, Paediatric Nutrition Handbook. 6th Edition, American Academy of Paediatrics Committee on Nutrition.
- SHARBAUGH, C. AND BROWN, J. E., 2013, Nutrition Through the Life Cycle. 5th Edition, Wadsworth Co Inc. Belmont, CA.
- BALES, C. W., RITCHIE, C., 2013 Handbook of Clinical Nutrition and Aging. 2nd Edition, Springer Science & Business Media, Humana Press Inc. New York.
- SACHDEV, H. P. S. AND CHOUDHURY, P., 2004, Nutrition in Children - Developing Country Concerns. B I Publications.
- SCHLENKER, E. AND GILBERT, J. A., 2014, Williams' Essentials of Nutrition and Diet Therapy. 11th Edition, e- book.
- SRILAKSHMI, B., 2019, Dietetics. 8th Edition, New Age International Publisher.
- CATALDO, C. B., DE BRAYAE, L. K. AND WHITNEY, E. N., 2012, Nutrition and Diet Therapy. 6th Edn., Wadsworth/Thomson Learning Inc.

FSN 508 NUTRITION AND PHYSICAL FITNESS (1+1)

Objective

To provide exposure to understand the concept of physical fitness and recent techniques of measuring body composition and energy metabolism to ascertain the nutritional stature

Theory

Block I: Fitness and body composition

Unit I: Nutrition management

Overview of nutritional management vis-a-vis physical fitness, body composition and physical fitness

Unit II: Methods of measurement

Methods of measuring body composition: direct and indirect. Body composition in different physiological conditions and factors affecting it.

Block II: Energy metabolism and physical fitness

Unit I: Energy metabolism

Concept, importance, influencing factors. Techniques to measure energy expenditure and energy intake

Unit II: Physical fitness

Techniques to assess physical fitness. Sports nutrition. Aging theories, physiology, mechanism and role of nutrients in arresting aging process.

Practicals

1-3: Project relevant to text- selection of topic

4-6: Planning of project

7-10: Development and standardization of tool

11-13: Collection of data

14-15: Report writing

References

- FAO, 2004, Human Energy Requirements. -Report of a Joint FAO/ WHO/UNU Expert Consultation. Technical Report Series 1. Food and Agriculture Organization, Geneva.
- BENARDOT, D., 2005, Advanced Sports Nutrition. 2nd Edition, Human Kinetics Publishers, Champaign, IL.

- BAUMGARTNER, R., 2006, Body Composition in Healthy Aging. Annals of the New York Academy of Sciences.
- GEISSLER, C. AND POWERS, H., 2009, Fundamentals of Human Nutrition. Churchill Livingstone, London.
- ROSS, A. C., CABALLERO, B., COUSINS, R. J., TUCKER, K. L. AND ZIEGLER T. R., 2012, Modern Nutrition in Health and Disease. Eleventh Edition, LWW, Philadelphia.
- SRILAKSHMI, B., SUGANTHI, V. AND KALAIVANI, C. ASHOK., 2017., Exercise Physiology Fitness and Sports Nutrition. New Age International Publishers.
- GEETANJALI, B. AND SUBHADRA, M., 2018, Nutritional Guidelines for Sportspersons. Jaypee Health Books Publishers.

FSN 509 PRINCIPLES OF DIET THERAPY (2+1)

Objective

To provide exposure to students on disease management through appropriate approaches from a multi disciplinary perspective.

Theory

Block I: Introduction to diet therapy

Unit I: Importance and scope of diet therapy

Role of dietician in a healthcare team in hospital and community.

Unit II: Dietary management

Newer concepts in dietary management of various nutritional disorders and disease conditions.

Block II Diet in different diseases

Unit I: Fevers, infections.

Dietary management in Fevers, infections

Unit II: Burns and allergy.

Dietary management during burns, allergy

Unit III: Gastro intestinal and liver diseases.

Dietary management of Gastrointestinal and liver diseases.

Unit IV: Cardiovascular diseases

Dietary management of cardio vascular diseases

Unit V: Renal disorders

Dietary management of renal disorders

Unit VI Diabetes

Diabetes and dietary management in diabetes

Unit VII Other diseases

Dietary management in cancer and HIV. Nutrition in critical care. COVID-19

Practical

1: Formulation of food exchanges

2-10: Therapeutic modifications of diet in terms of nutrients, consistency and composition for various disorders and diseases.

11-13: Preparation of notes on case studies.

14-15: Visits to hospitals.

References

- SKIPPER, A., 2008, *Advanced Medical Nutrition Therapy Practice.* 1st Edition, Jones & Bartlett Learning, Burlington, Massachusetts.
- ROSS, A. C., CABALLERO, B., COUSINS, R. J., TUCKER, K. L. AND ZIEGLER, T. R., 2012, *Modern Nutrition in Health and Disease.* 11th Edition, LWW, Philadelphia.
- KATHLEEN, M. L. AND J. L. RAYMOND, 2016 *Krause's Food and the Nutrition Care Process.* 14th Edition, Saunders, Philadelphia.
- MCINTOSH, S. N., 2016, *Williams' Basic Nutrition and Diet Therapy.* 15th Edition, Mosby, Maryland.
- MAZUR, E. E. AND LITCH, N. A., 2018, *Lutz's Nutrition and Diet Therapy.* 7th Edition, F.A.Davis Company, Philadelphia.

- SCHLENKER, E. AND GILBERT, J. A., 2014, *Williams' Essentials of Nutrition and Diet Therapy.* 11th edition, e-book.
- SRILAKSHMI, B., 2019, *Dietetics* .8th Edition, New Age Internatioanal Publisher. Cataldo CB, DeBrayaeLK and Whitney EN (2012) *Nutrition and Diet Therapy.* 6th Edn., Wadsworth / Thomson Learning Inc.

FSN 510 FOOD TOXICOLOGY (2+0)

Objective

To expose students on the concept of different food toxins, its impact on health and preventive measures.

Theory

Block I: Importance of food toxicology

Unit I: Significance of food toxicology

Introduction and significance of food toxicology. Food poisoning: types, causative factors, preventive symptoms

Unit II: Food toxins

Natural food toxins, anti-nutritional factors, other food toxins, harmful effects, methods of removal. Microbial toxins and food intoxications. Source of contamination

Block II: Health and different food toxins

Unit I: Impact on health

Effect of food toxins on health, preventive measures, methods of inactivation/destruction.

Unit II: Chemical toxins

Pesticides, insecticides metallic and others, residual effects, preventive measures, methods of removal

Unit III: Food packaging, Food loss and standards

Food packaging material: potential contaminants from food packaging material. Food laws and standards: FSSAI, ISI, AGMARK, Codex Alimentarius, ISO mark for vegetarian and non-vegetarian foods,

ecofriendly products and others in operation.

References

- G. G. GIBSON. AND R. WALKER, TAYLOR. AND FRANCIS., 1985, Food toxicology , Real or Imaginary Problems, London.
- K. MILLER, 1987, Toxicological aspects of food Elsevier Applied Science, London, 987.
- R. L. ORY, 1981, Antinutrients and Natural Toxicants in Foods' Food and Nutrition Press. Westport, CT,U.S.A.,.
- CARTUS, A. & SCHRENK, D. 2017, Chemical contaminants and residues in food. Woodhead publishing series. United Kingdom.
- BHATIA, B. B AND JUYAL, P. D., 1989, Incidence of parasitic infections in human population in traiarea of Uttar Pradesh. Indian J. Parasitol. 13: 323-324.

FSN 511 PRINCIPLES OF HUMAN PHYSIOLOGY (1+1)

Objective

To give theoretical concepts to complex physiological systems of the human body through scientific approach into the nature of physical and biochemical function of humans, their organs and cells of which they are composed

Theory

Block I: Overview of anatomy and functions of human body

Unit I: Reticulo-endothelial and Circulatory System

Reticulo-endothelial system: functions, classification. Lymphatic system: functions, circulation. Circulatory System: blood-composition blood cells-development and function of blood cells, blood grouping and hemoglobin, Heart: anatomy, cardiac cycle, blood pressure and factors affecting blood pressure.

Unit II: Respiratory system

Respiratory system - anatomy, physiology and mechanism of respiration, regulation of respiration

Unit III: Digestive system

Anatomy of gastrointestinal tract and accessory organs, digestion and absorption of food, regulation of appetite

Unit IV: Excretory system

Anatomy and functions of kidney, formation, composition and excretion of urine. Endocrine glands, mode of action of hormones.

Unit V: Reproductive system

Structure and functions of male and female reproductive organs.

Unit VI: Nervous system and Musculo - skeletal system

Anatomy and functions of Musculo skeletal system and anatomy and functions.

Practicals

1: Estimation of hemoglobin.

2: Identification of blood groups.

3-5: Preparation of blood slide, identification and counting of blood cells. Hematocrit and sedimentation rate

6: Measurement of blood pressure

7 -8: Examination of abnormal constituents of urine

8-12: Estimation of glucose and cholesterol in blood

References

- MARIEB, E. N., 2004, Human Anatomy and Physiology 6th Edition. Pearson Education, Inc. London
- DONNERSBERGER, A. B. AND SCOTT, A. L., 2005, Laboratory Textbook of Anatomy and Physiology. 8th Edition, Jones and Bartlett Learning, Burlington, Massachusetts
- JAIN, A. K., 2009, Human Physiology for BD. 3rd Edition, Avichal Publishing Company, New Delhi.
- WAUGH, A. AND GRANT, A., 2014, Ross and Wilson Anatomy

and Physiology in Health and Illness. 6th Edition, Elsevier Ltd. Churchill Livinstone, London

- HALL, J. E., 2016, Gayton and Hall Text Book of Medical Physiology. 13th Edition, Elsevier India.
- DAVID, F., STACIA, B. M. AND CHARLES, L. S., 1993, Human Physiology- Foundations and Frontiers. 2nd Edn., Mosby Pub
- CHATERJEE, C. C., 2012, Human Physiology Vol. I and Vol. II. CBS Publications.

FSN 512 FOOD SERVICE MANAGEMENT (1+1)

Objective

To equip the students with the multi-dimensional knowledge associated with institutional food service in a given setup and to enable them in planning, execution and control of the management of institutes with ease and profit.

Block I: Food Services

Unit I: Introduction to food services

Types of food services. Organization Definition, types. Management: tools of management. Personnel management

Unit II: Record keeping

Books, records and record keeping. Cost control in food services.

Block II: Food Planning and Production

Unit I: Food Production

Menu planning. Meal services management: types of services. Quantity food production: Principles involved in development to of recipes in large scale cooking, standardization of recipes, utilization of left over foods.

Unit II: Planning of food service unit

Planning of layout and equipment for food services. Sanitation and hygiene in handling foods. Personnel hygiene and its importance.

Practical

1-3: Standardization of recipes:

4-7: Planning and preparation,

8-10: Modification in basic recipe,

11-12: Preparation of standard recipe.

13. Use of left over foods.

14-15: Visit to different types of food service institutions and study the following: Organization, physical plan and layout, food service equipment, sanitation and hygiene.

16: Practical experience in organization and management of a college cafeteria/ hotels.

References

- CARPENTER, R. P., LYON, D. H. AND HASDELL, T. A., 2002, Guidelines for Sensory Analysis in Food Product Development and Quality Control. 2nd Edition, Aspen Publishers Inc. New York.
- EARLE, M. AND EARLE, R. L., 2008, Case Studies in Food Product Development. Woodhead Publishing Limited and CRC Press, New York.
- MOSKOWITZ, H. R., STRAUS, T. AND SAGUY, S., 2009, An Integrated Approach to New Food Product Development. CRC Press, Boca Raton, Florida.
- PUCKETT, R. P., 2012, Food Service Manual for Health Care Institutions. 4th Edition, John Wiley and Sons Inc. Hoboken, New Jersey.
- BECKLEY, J. H., HERZOG, L. J. AND FOLEY, M. M., 2017, Accelerating New Food Product Design and Development. 2nd Edition, John Wiley and Sons Inc. Hoboken, New Jersey.
- SETHI, M., 2018, Catering Management- An Integral Approach. 3rd Edition, New Age International, New Delhi.

- NANCY, L. S., 2007, Catering Management. John Wiley & Sons.
- ARORA, R. S., 2012, Banquet and Catering Management. Abhijeet Publications.

9. HARISH BHAT., 2008, Hotel Management. Crescent Publishing Corporation.

FSN 513 FOOD PRODUCT DEVELOPMENT (1+1)

Objective

To expose students to the basic principles of food product development, sensory properties, food packaging and labelling and their role in product development.

Theory

Block I: Development of product

Unit I: Formulation and evaluation

Basic Principles of food product development. Sensory properties of food and their role in product development. Formulation and evaluation of recipes at laboratory level. Bulk food preparation for food institutions and enterprises: servings, nutritive value and costing. Evaluation of food.

Unit II: Selection and training

Selection and training of judges, development of score cards and analysis of data.

Unit III: Data analysis

Consumer evaluation-development of scheduleand data analysis.

Block II: Packaging and labelling

Unit I: Food packaging

Packaging material, types for different products. Food labelling.

Unit II: Food safety

Food safety issues in product development, food quality regulations and standards, quality control and HACCP.

Unt III: Product development

Product formulation and development for general and therapeutic use.

Practical

1-3: Sensory evaluation methods, training of judges, score card preparation.

4-7: Selection and modification of food product to be developed. Formulation and standardization of products.

8:Objective and subjective evaluation of the products.

9:Evaluation of consumer acceptability.

10-12: Packaging and sale of products.

13-16: Preparation of video film for media.

References

- VERMA, R. C. AND JAIN, S. K. Value addition of Agricultural produce, Himanshu publication.
- HOWARD, R. MOSKOWITZ, SAGUY, I. S. AND STRAUS. T., New product Development, CRC Publication.
- MRIDULA PATIL, R. T., MANIKANTAN, M. R., Food Processing Technology Co-Product utilization and quality assurance. Satish serial publishing house.
- SUDEER, K. P. AND INDIRA, V. Entreprenuership development in food processing, New India publishing agency.

FSN 514 NUTRITION AND IMMUNITY (1+0)

Objective

To impart knowledge about role of macro and micronutrients and phytochemicals in improving immune systems and about nutrition and immunity in disease management.

Theory

Block I: Effect of nutrition on Immunity

Unit I: Basics of nutrition and immunity

Immunity: definition, history, classification, immunological responses, cell types involved. Mechanism of phagocytosis and antigen-antibody reactions. Regulation of immunity. Mucosal defense system-effect of nutrients.

Unit II: Malnutrition and immunity.

Effect of malnutrition on immunity. Carbohydrates and immune system. Fat and immune system- factors affecting acquired immunity. Protein and immune functions- effect of arginine, glutamine and Sulphur amino acids. Glutathione and immune system

Unit III: Protective nutrients and immunity

Role of vitamins in immune functions-effect of deficiency. Role of minerals-effect of deficiency and excess on immune cell functions.

Block II: Probiotics and antioxidants.

Unit I: Role of Probiotics and antioxidants on immunity.

Effect of Probiotics and antioxidants on immune function. Immunity against infection – role of immunization

References

1. GERSHWIN, M. E., GERMAN, J. B. AND KEEN, C. L., 2000, *Nutrition and Immunology–Principles and Practice*. Humana Press Inc. New York.
2. GERSHWIN, M. E., NESTEL, P. AND KEEN, C. L, 2004, *Handbook of Nutrition and Immunity*. Humana Press Inc. New York.
3. SHETTY, P. S., 2010, *Nutrition, Immunity and Infection*. CABI Publishers, Oxfordshire, UK.
4. CALDER, P. AND YAQOOB, P., 2013, *Diet, Immunity and Inflammation*. Wood head Publishing Ltd. Cambridge.
5. PAMMI, M.,VALLEJO, J. G. AND ABRAMS, S. A., 2016, *Nutrition-Infection Interactions and Impacts on Human Health*.

CRC Press, Boca Raton, Florida.

6. PHILIP, C. CALDER, ANIL, D. KULKARNI, 2017, *Nutrition, Immunity, and Infection*. CRC press, London

7. IVAN, M. ROITT. & PETER, J. DEVES., 2004, *Essential Immunology.* Black well Science Ltd.

FSN 515 FUNCTIONAL FOODS (0+1)

Objective

To expose students on different functional foods in daily dietary

Practical

1-2: Functional properties of food components in food systems with suitable applications.

3-4: Traditional Foods: Selection of a product and study of preparation variables.

5-6: Convenience Foods - Identification of technologies used in different groups of foods. Advances in product formulation and techniques. Use of unconventional cereals and pulses in products.

7: Biotechnology in food processing. Microwave technology

8-11: Nutraceuticals: Definition, need, importance, classification / types – sources – processing of nutraceutical products – role in health – therapeutic applications. Pharma Foods: Diabetic foods – confectioneries, sodium free, lactose free, phenylalanine free, fiber rich-nutritional implications.

12-14: Dietary supplements, fortification of nutrients in the processed foods, role in health. Nonnutritive sweeteners: Definition, need, importance, types, development of sugar free products, nutritional implication, current market trend, artificial sweeteners therapeutic applications.

M.Sc. (Agri.) in Genetics and Plant Breeding

Course Code	Course Title	Credit Hours
GPB 501	Principles of Genetics	3 (2+1)
GPB 502	Principles of Plant Breeding	3 (2+1)
GPB503	Fundamentals of Quantitative Genetics	3 (2+1)
GPB 504	Varietal Development and Maintenance Breeding	2 (1+1)
GPB 505	Principles of Cytogenetics	3 (2+1)
GPB 506	Molecular Breeding and Bioinformatics	3 (2+1)
GPB 507	Breeding for Quality and Special Traits	3 (2+1)
GPB 508	Mutagenesis and Mutation breeding	3 (2+1)
GPB 509	Hybrid Breeding	3 (2+1)
GPB 510	Seed Production and Certification	2 (1+1)
GPB 511	Crop Breeding, I (*Kharif* Crops)	3 (2+1)
GPB 512	Crop Breeding II (*Rabi* Crops)	3 (2+1)
GPB 513	Breeding Vegetable Crops	3 (2+1)
GPB 514	Breeding Fruit Crops	3 (2+1)
GPB 515	Breeding Ornamental Crops	3 (2+1)
GPB 516	Breeding for Stress Resistance and Climate Change	3 (2+1)
GPB 517	Germplasm Characterization and Evaluation	2 (1+1)
GPB 518	Genetic Enhancement in PGR utilization	2 (1+1)
	Total	**50 (32+18)**
GPB 580	Qualifying Examination	2 (0+2)
GPB 581	Seminar - I	1 (0+1)
GPB 582	Seminar - II	1 (0+1)
GPB 591	Research - I	13 (0+13)
GPB 592	Research - II	14 (0+14)

GPB 501 PRINCIPLES OF GENETICS 3 (2+1)

Theory

Block I Classical/Mendelian Genetics

Unit I: Beginning of genetics**,** early concepts of inheritance, Mendel's laws; Discussion on Mendel's paper, Multiple alleles, Epistatic and non-epistatic gene interactions

Unit II: Chromosomal theory of inheritance, Sex determination, differentiation and sex-linkage, Sex-influenced and sex-limited traits

Unit III: Linkage-detection, estimation; Recombination and genetic mapping in eukaryotes,

Unit IV: Extra chromosomal inheritance, genetics of mitochondria and chloroplasts, Haploid Genetics and Genetics of DNA Markers.

Block II Population Genetics

Unit I: Mendelian population, Random mating population, Frequencies of genes and genotypes, Causes of change: Hardy-Weinberg equilibrium.

Block III: Cell and Molecular Genetics

Unit I: Nature, structure and replication of the genetic material; Organization of DNA in chromosomes, Genetic fine structure analysis, Allelic complementation, Split genes, overlapping genes, Pseudogenes, Oncogenes, Gene families and clusters;

Unit II: Transcription, Translation, Genetic code; Protein biosynthesis, Regulation of gene activity in prokaryotes and eukaryotes; Molecular mechanisms of mutation, repair and suppression;

Unit III: Synthesis and cloning, genomic and cDNA libraries, PCR based cloning, positional cloning; Concepts of Eugenics, Epigenetics, Genetic disorders.

Practical's

Laboratory exercises in probability and chi-square; Demonstration of genetic principles (Monohybrid ratios, Dihybrid ratios) using

laboratory organisms; Chromosome mapping using three-point test cross; Tetrad analysis; Induction and detection of mutations through genetic tests; DNA extraction and PCR amplification; Electrophoresis: basic principles and running of amplified DNA;

References

- DANIEL LH AND MARYELLEN R. 2011. *Genetics:* "*Analysis of Genes and Genomes*".
- KLUG WS AND CUMMINGS MR. 2003. *Concepts of Genetics*. Peterson Edu. Pearson Education India; Tenth edition
- PETER SNUSTAD & MICHAEL J. SIMMONDS, 2017, Principles of Genetics, John Wiley & Sons.
- ROBERT H TAMARIN, 2017, Principles of Genetics, Tata McGraw-Hill, 609 Pp.
- STANSFIELD WD.1991. *Genetics.*Schaum Outline Series Mc Graw Hill
- STRICKBERGER MW. 2005. *Genetics* (*III Ed*). Prentice Hall, New Delhi, India; 3rd ed., 2015.

GPB 502 PRINCIPLES OF PLANT BREEDING 3 (2+1)

Objective of the course

To impart theoretical knowledge and practical skills about plant breeding objectives, genetic consequences, breeding methods for crop improvement.

Theory

Block I: History, objectives and accomplishments of plant breeding, genetic resources and pre-breeding

Unit I: History, objectives and accomplishments of plant breeding; international agriculture research centers engaged in plant breeding; centers of origin and diversity of crop plants, plant genetic resources (PGR) and their significance in plant breeding; pre-breeding **-** plant introduction, germplasm conversion, wide hybridization, etc.

Block II: Genetic basis of plant breeding

Unit I: Modes of reproduction and cultivar options; determination of modes of reproduction; consequences of selfing and crossing; genetic structure of different types of cultivars; quantitative inheritance, nature of variability, components of variation; heritability and genetic advance; general and specific combining ability; modes of gene actions (additive, dominance and epistasis) and their implications in plant breeding; probability of fixation of desirable genotypes and identifying transgressive genotypes.

Block III: Selection in plant breeding

Unit I: Breeding methods in self pollinated crops; pure line theory; selection methods in genetically variable natural populations - pure line and mass selection methods; selection of parents to develop breeding populations (segregating populations); selection among breeding populations; selection methods within selected breeding populations - pedigree, bulk, single seed descent selections; backcross breeding and its applications - multiline breeding, concepts of marker-assisted selection; improvement of source breeding populations in self – pollinated crops with special reference to diallel selective mating for enhancing selection gain.

Unit II: Breeding methods in cross pollinated crops; population breeding: mass selection and ear-to-row methods; S_1 and S_2 progeny testing, progeny selection schemes, rationale of recurrent selection (RS), RS schemes for intra and inter-population improvement and development of synthetics and composites. Hybrid breeding, genetical and physiological basis of heterosis and inbreeding; concept of heterotic groups and heterotic patterns; use of synthetics and composites and their improved versions (by RS schemes) for developing inbred lines for use in developing hybrids; recycling inbred parental lines of elite hybrids; selection of combinations of parents and testers for selecting inbred lines from breeding populations for use in hybrid cultivar development; methods of shortening breeding cycle (double haploid and rapid generation advancement) for developing inbred lines for use in hybrid

cultivar development; approaches for improvement of inbred lines of elite hybrids, predicting hybrid performance; seed production of hybrid and their parent varieties/inbreds; pollination control systems (self-incompatibility, male sterility and apomixes) in crop plants and their commercial exploitation.

Unit III: Clonal selection in asexually propagated crops; objectives of breeding cultivars for use as scion; objectives of breeding cultivars for use as root stock

Block IV: Special breeding techniques

Unit I: Mutation breeding - exploitation of natural and induced mutation-generated variability, polyploidy breeding – phenotypic effects of polyploidy; exploitation of natural and induced polyploidy-generated variability; participatory varietal selection and plant breeding

Block V: Post-plant breeding

Unit I: Cultivar testing, genotype × environment interaction (GEI) - types of GEI (crossover and non-crossover), detection, quantification and approaches to exploit GEI in plant breeding; release and notification, maintenance breeding, plant breeders' rights and regulations for plant variety protection and farmers rights.

Practical

- Floral biology in self- and cross-pollinated species; selfing and crossing techniques
- Analysis of variance (ANOVA) - detection and quantification of variability attributable to different sources
- Estimation of heritability, and general and specific combining ability and prediction of genetic advance
- Prediction of *per se* and test cross performances of inbred lines based on *per se* mid parental and test cross performance
- Theoretical identification of best breeding population (F_2/ backcross) to be used to develop inbred lines for use as pure-line cultivar or in F_1 hybrid cultivar development

- Theoretical demonstration of the effect of independent assortment and linkage of genes on probability of fixation of combination of desirable alleles; prediction of performance of three-way and double cross hybrids.

References

- ALLARD RW. 1981. *Principles of Plant Breeding*. John Wiley & Sons.
- SIMMONDS NW.1990. *Principles of Crop Improvement*. English Language Book Society.
- SHARMA JR. 2001. *Principles and Practice of Plant Breeding*. Tata McGraw-Hill.
- CHAHAL GS AND GOSSAL, SS. 2002. *Principles and Procedures of Plant Breeding Biotechnological and Conventional Approaches.* Narosa Publishing House.
- ROY D. 2003. *Plant Breeding, Analysis and Exploitation of Variation*. Narosa Publ. House.
- CHOPRA VL. 2004. *Plant Breeding*. Oxford & IBH.
- JAIN HK AND KHARAKWAL MC. 2004. *Plant Breeding and–Mendelian to Molecular Approach*, Narosa Publications, New Delhi
- GUPTA SK. 2005. *Practical Plant Breeding*. Agribios.
- SINGH BD. 2006. *Plant Breeding*. Kalyani Publishers, New Delhi.
- SHARMA JP. 2010. Principles of Vegetable Breeding. Kalyani Publ, New Delhi.
- REX BERNARDO. 2014. *Essentials of Plant Breeding*. Stemma Press, Woodbury, Minnesota
- GEORGE ACCQUAAH. 2020. *Principles of Plant Genetics and Breeding*. Third Edition, Wiley-Blackwell, USA.

GPB 503 FUNDAMENTALS OF QUANTITATIVE GENETICS 3 (2+1)

Objective of the course

To impart theoretical knowledge and computation skills regarding components of variation and variances, scales, mating designs and gene effects.

Theory

Block I: History and conceptual framework of classical quantitative genetics

Unit I: Introduction and historical background of quantitative genetics, multiple factor hypothesis, qualitative and quantitative traits, modeling quantitative traits' variation using first degree statistics (such as mean and range), and second degree statistics (such as standard deviation, variance, covariance); scaling and joint scaling tests for examining the adequacy of additive-dominance model; concepts of average effect of alleles, average effect of allelic substitution and breeding value; epistasis and parameters specifying epistasis at first-degree statistics level; perfect-fit solution to detect and testing the significance of parameters specifying epistasis; components of phenotypic and genotypic variation; estimation of phenotypic and genotypic variation using basic ANOVA (based on expected variance components) and using variances of segregating and non-segregating basic generations; concept of random and fixed effect models; methods of estimation of heritability-parent-progeny regression, half-sib covariance and full-sib covariance analysis.

Unit II: Concept of combining ability; types of combining ability at first and second degree statistics levels; estimation of gca and sca effects and their variances using mating designs such as diallel, line × tester; G × E interaction – types and their detection and exploitation in plant breeding; concepts of adaptability and stability; basic models and methods for stability analysis and interpretation; bi-plot analysis; designs for plant breeding experiments- principles and applications.

Block II: Quantitative genetic basis of selection

Unit I: Concept of selection, direct and indirect selection; correlated response to selection.

Unit II: Association analysis - genotype and phenotypic correlation, path analysis; methods of groping genotypes - principal component analysis and Toacher's method, genetic divergence analysis based on D^2 statistic.

Block III: Marker-assisted quantitative genetics

Unit I: DNA markers - types and inheritance; concept of linkage map and its construction; principles of QTL mapping; mapping populations, and approaches and analytical tools for QTL mapping; marker assisted selection and factors influencing the MAS.

Practical

- Analysis and interpretation of variability parameters.
- Clustering and interpretation of D^2 analysis
- Genotypic and phenotypic correlation analysis and interpretation
- Path coefficient analysis and interpretation, Estimation of different types of heterosis, inbreeding depression and interpretation
- A, B, C and D scaling tests, estimation of genetic components of generation means, joint scaling tests; estimation of components of variance using basic generations data.
- Line × Tester and diallel analysis and interpretation, Use of computer packages for line × tester and diallel analysis.
- G×E interaction and stability analysis.
- Single marker and marker-regression approaches for QTL detection.

References

- MATHER K AND JINKS JL.1982. *Biometrical Genetics* (3rd Ed.). Chapman and Hall, London.
- WEIR DS. 1990. *Genetic Data Analysis. Methods for Discrete Population Genetic Data*. Sinauer Associates.

- WRICKE G AND WEBER WE. 1986. *Quantitative Genetics and Selection in Plant Breeding*. Walter de Gruyter.
- SINGH RK AND CHAUDHARY BD. 1987. *Biometrical Methods in Quantitative Genetic* analysis. Kalyani Publishers, New Delhi.
- BOS I AND CALIGARI P. 1995. *Selection Methods in Plant Breeding*. Chapman & Hall.
- FALCONER DS AND MACKAY J. 1998. *Introduction to Quantitative Genetics* (3rd Ed.). Longman, London.
- ROY D. 2000. *Plant Breeding: Analysis and Exploitation of Variation*. Narosa Publishing House, New Delhi.
- SHARMA JR. 2006. *Statistical and Biometrical Techniques in Plant Breeding*. New Age, International Pvt. Ltd.
- REX BERNARDO. 2020. *Breeding for Quantitative Traits in Plants.* Third edition, Stemma Press, Woodbury, Minnesota, USA
- GEORGE ACCQUAAH. 2020. *Principles of Plant Genetics and Breeding*. Third Edition, Wiley-Blackwell, USA.

GPB 504 VARIETAL DEVELOPMENT AND MAINTENANCE BREEDING 2(1+1)

Objectives

It is an indispensable course which apprise the students about various practices and procedures in the development of a variety and steps to maintain the purity of varieties/ hybrids. Further, it provides basics of nucleus and breeder seed production techniques.

Aim of the course

The purpose of this course is to make students well acquainted with the techniques and procedures of varietal development. He will be associated with development of variety so the course aims is to provide knowledge on DUS testing, protocols of various breeding techniques, procedures of release of variety, maintenance of the variety and production of nucleus and breeder seed of variety/ hybrids.

Theory

Unit I: Variety Development systems and Maintenance; Definition- variety, cultivar, extant variety, essentially derived variety, independently derived variety, reference variety, farmers' variety, landraces, hybrid, and population; Variety testing, release and notification systems and norms in India and abroad.

Unit II: DUS testing- DUS Descriptors for major crops; Genetic purity concept and maintenance breeding. Factors responsible for genetic deterioration of varieties - safeguards during seed production.

Maintenance of varieties in self and cross pollinated crops, isolation distance; Principles of seed production; Methods of nucleus and breeder seed production; Generation system of seed multiplication -nucleus, breeders, foundation, certified.

Unit III: Quality seed production technology of self and cross-pollinated crop varieties, viz., cereals and millets (wheat, barley, paddy, pearlmillet, sorghum, maize and ragi, etc.); Pulses (greengram, blackgram, cowpea, pigeonpea, chickpea, fieldpea, lentil); Oilseeds (groundnut, soybean, sesame, castor, sunflower, safflower, linseed, rapeseed and mustard); fibres (cotton/ jute) and forages (guar, forage sorghum, teosinte, oats, berseem, lucerne).

Unit IV: Seed certification procedures; Seed laws and acts, plant variety protection regulations in India and international systems.

Practical

a. Identification of suitable areas/ locations for seed production;

b. Ear-to-row method and nucleus seed production;

c. Main characteristics of released and notified varieties, hybrids and parental lines;

d. PGMS and TGMS;

e. Identification of important weeds/ objectionable weeds;

f. Determination of isolation distance and planting ratios in different crops; Seed production techniques of varieties in different crops;

g. Hybrid seed production technology of important crops;

h. DUS testing and descriptors in major crops;

i. Variety release proposal formats in different crops.

References

- AGARWAL RL. 1997. *Seed Technology*. 2nd Ed. Oxford & IBH.
- KELLY AF. 1988. *Seed Production of Agricultural Crops*. Longman.
- MCDONALD MB JR AND COPELAND LO. 1997. *Seed Production: Principles and Practices*. Chapman & Hall.
- POEHLMAN JM AND BORTHAKUR D. 1969. *Breeding Asian Field Crops*. Oxford & IBH.
- SINGH BD. 2005. *Plant Breeding: Principles and Methods*. Kalyani. 2015.
- THOMPSON JR. 1979. *An Introduction to Seed Technology*. Leonard Hill.

GPB 505 PRINCIPLES OF CYTOGENETICS 3 (2+1)

Objective of the Course

To provide insight into structure and functions of chromosomes, chromosome mapping, polyploidy and cytogenetic aspects of crop evolution.

Theory:

Block 1: Chromosome: its parts, functions and types

Unit I: Cell cycle and architecture of chromosome in prokaryotes and eukaryotes; Chromonemata, chromosome matrix, chromomeres, centromere, secondary constriction and telomere; artificial chromosome construction and its uses; Special types of chromosomes. Variation in chromosome structure: Evolutionary significance; Introduction to techniques for karyotyping; Chromosome banding and painting -*In situ* hybridization and various applications.

Block 2: Chromosomal variations and their inheritance

Unit I: Structural and numerical variations of chromosomes and their implications; Symbols and terminologies for chromosome numbers, euploidy, haploids, diploids and polyploids; Utilization of aneuploids in gene location; Variation in chromosome behaviour, somatic segregation and chimeras, endomitosis and somatic reduction; Evolutionary significance of chromosomal aberrations, balanced lethal and chromosome complexes; Inter-varietal chromosome substitutions.

Block 3: Polyploidy and its application in plant breeding

Unit I: Fertilization barriers in crop plants at pre- and postfertilization levels; *In-vitro* techniques to overcome the fertilization barriers in crops; Polyploidy. Genetic consequences of polyploidization and role of polyploids in crop breeding; Evolutionary advantages of autopolyploid vs allopolyploids; Role of aneuploids in basic and applied aspects of crop breeding, their maintenance and utilization in gene mapping and gene blocks transfer; Alien addition and substitution lines, creation and utilization; Apomixis, evolutionary and genetic problems in crops with apomixes.

Unit II: Reversion of autopolyploid to diploids; Genome mapping in polyploids; Interspecific hybridization and allopolyploids; Synthesis of new crops (wheat, Triticale, Brassica, and cotton); Hybrids between species with same chromosome number, alien translocations; Hybrids between species with different chromosome number; Gene transfer using amphidiploids, bridge species.

Unit III: Chromosome manipulations in wide hybridization; case studies; Production and use of haploids, dihaploids and doubled haploids in genetics and breeding.

Practical

- Learning the cytogenetical laboratory techniques, various chemicals to be used for fixation, dehydration, embedding, staining, cleaning, etc.;
- Microscopy: various types of microscopes;

- Preparing specimen for observation;
- Fixative preparation and fixing specimen for light microscopy studies in cereals;
- Studies on mitosis and meiosis in crop plants;
- Using micrometres and studying the pollen grain size in various crops.

References

- BECKER K AND HARDIN J. 2004. World of the Cell. 5th Ed. Pearson Edu. 9th edition.
- CARROLL M. 1989. Organelles. The Guilford Press.
- CHARLES B. 1993. Discussions in Cytogenetics. Prentice Hall Publications.
- DARLINGTON CD AND LA COUR LF. 1969. The Handling of Chromosomes. George Allen & Unwin Ltd.
- ELGIN SCR. 1995. Chromatin Structure and Gene Expression. IRL Press,Oxford.
- GUPTA PK AND TSUCHIYA T. 1991. Chromosome Engineering in Plants: Genetics, Breeding and Evolution. Part A.
- GUPTA PK. 2010. Cytogenetics. Rastogi Publishers.
- JOHANNSON DA. 1975. Plant Micro technique. McGraw Hill.
- KARP G. 1996. Cell and Molecular Biology: Concepts and Experiments. John Wiley & Sons.
- KHUSH GS. 1973. Cytogenetics of aneuploids. Elsevier. 1 edition.
- ROY D.2009. Cytogenetics. Alpha Science Intl Ltd.
- SCHULZ SJ.1980. Cytogenetics- Plant, animals and Humans. Springer.
- SHARMA AK AND SHARMA A. 1988. Chromosome Techniques: Theory and Practice. Butterworth- Heinemann publisher 2014. 3rd edition
- SINGH RJ. 2016. Plant Cytogenetics 3rd Edition. CRC Press.

- SUMNER AT. 1982. Chromosome Banding. Unwin Hyman Publ. 1 edition, Springer pub.
- SWANSON CP. 1960. Cytology and Cytogenetics. Macmillan & Co.

GPB 506 MOLECULAR BREEDING AND BIOINFORMATICS 3 (2+1)

Objective of the course

To impart knowledge and practical skills to use innovative approaches and Bioinformatics in Plant Breeding

Theory

Block I: Markers: types, genetics/inheritance and their application in plant breeding

Unit I: Types of markers - morphological, biochemical and DNA-based markers and importance in plant breeding; concept, working principle and role of DNA-based markers (RFLP, RAPD, AFLP, SSR, SNPs, ESTs etc.,) in plant breeding

Unit II: Concept of linkage, concepts of DNA-based linkage map construction, relevance and use of mapping functions (Haldane and Kosambi) in map construction; tagging and mapping genomic regions/ quantitative traits loci (QTL): mapping populations (F_2s, backcrosses, RILs, NILs and DH); Approaches (Single marker, two markers and multiple markers) and analytical (statistical) tools (ANOVA, T test, F test and Regression) for mapping QTL controlling agronomicaly important traits.

Marker-assisted backcross breeding for introgression/pyramiding genomic regions controlling qualitative and quantitative traits; concept of EDVs. Concepts of gene editing and their application in plant breeding

Block II: Concept of bioinformatics and its application in plant breeding

Unit I: Methods to use genomic tools such as markers and candidate genes in breeding crops where such tools not available; Concept of allele mining, comparative genomics;

Introduction to bioinformatics; bioinformatics tools, biological data bases (primary and secondary), concepts of DNA marker primers, SSR and SNP markers' primer designing and their *in silico* validation; implications in plant breeding.

Block III: Breeding by design

Unit I: Concepts of recombinant DNA technology, physical and vector-mediated gene transfer, selectable and scorable markers; transgenes, transformation, and clean transformation techniques, Examples of production of transgenic plants in various field crops; cotton, wheat, maize, rice, soybean, oilseeds, sugarcane, etc., and their commercial releases; molecular farming; application of tissue culture in developing transgenic crop cultivars; concepts of gene editing and its application in plant breeding. International and national (Indian) bio-safety ethical, legal and social issues/ regulations and intellectual property rights related to research on transgenic and gene edited crop cultivar development and their and commercial release.

Practical

- Estimation of linkage between pairs of markers; Linkage map construction
- Hands on experience on locus ordering protocols using numerical examples
- Conversion of non-additive recombination fractions to additive map distances using Haldane and Kosambi mapping functions with numerical examples
- Familiarity with the use of BLAST and Clustal W tools for DNA sequence analysis
- Hands on experience on SSR and SNP marker primer designing and their *in silico* vrediction of genes and their function.

References

- HACKETT PB, FUCHS JA AND MESSING JW. 1988. *An Introduction to Recombinant DNA Technology - Basic Experiments in Gene Manipulation*. 2nd Ed. Benjamin Publ. Co.

- CHOPRA VL AND NASIM A. 1990. *Genetic Engineering and Biotechnology: Concepts, Methods and Applications*. Oxford & IBH.
- BROWN TA. 1991. *Essential Molecular Biology: a practical Approach*. Oxford university press, 2002, 2nd edition
- GUPTA PK. 1997. *Elements of Biotechnology*. Rastogi Publishers.
- CHAWALA HS. 2000. *Introduction to Plant Biotechnology*. Oxford & IBH Publishing Co. Pvt. Ltd.
- SAMBROOK J AND RUSSEL D. 2001. *Molecular Cloning - a Laboratory Manual*. 3rd Ed. Cold Spring Harbor Lab. Press.
- SINGH BD. 2005. *Biotechnology, Expanding Horizons*. Kalyani Publishers, New Delhi.
- AZUAJE F AND DOPAZO J. 2005. *Data Analysis and Visualization in Genomics and Proteomics.* John Wiley and Sons.
- WATSON J. 2006. *Recombinant DNA*. Cold Spring harbor laboratory press.
- ROBERT NT AND DENNIS JG. 2010. *Plant Tissue Culture, Development, and Biotechnology.* CRC Press.
- REX BERNARDO. 2014. *Essentials of Plant Breeding*. Stemma Press, Woodbury, Minnesota, USA
- GEORGE ACCQUAAH. 2020. *Principles of Plant Genetics and Breeding*. Third Edition, Wiley-Blackwell, USA

GPB 507 BREEDING FOR QUALITY AND SPECIAL TRAITS 3 (2+1)

Objective of the Course

To provide insight into recent advances in improvement of quality traits in cereals, millets, legumes, oilseeds, forage and industrial crops using conventional and modern biotechnological approaches.

Theory

Block 1: Importance of nutrition in human beings

Unit I: Developmental biochemistry and genetics of carbohydrates, proteins, fats, vitamins, amino acids and anti-nutritional factors; Nutritional improvement

Block 2: Breeding for Nutritional Quality Improvements in Field Crops

Unit I: Breeding for grain quality parameters in rice and its analysis; Golden rice and aromatic rice: Breeding strategies, achievements and application in Indian context; Molecular basis of quality traits and their manipulation in rice; Post harvest manipulation for quality improvement; Breeding for baking qualities in wheat, characters to be considered and breeding strategies, molecular and cytogenetic manipulation for quality improvement in wheat.

Unit II: Breeding for quality improvement in Sorghum, pearl millet, barley and oats; Quality protein maize, specialty corns, concept and breeding strategies; Breeding for quality improvement in important forage crops for stay green traits, brown midrib trait; Genetic resource management for sustaining nutritive quality in crops.

Block 3: Breeding for nutritional quality improvements in pulses, oilseeds and commercial crops

Unit I: Breeding for quality improvement in pulses – Chickpea, Pigeonpea, green gram and black gram cooking quality; Breeding for quality in oilseeds - groundnut, mustard, soybean, sesame, sunflower and minor oilseeds; Molecular basis of fat formation and manipulation to achieve more PUFA in oil crops; Genetic manipulation for quality

improvement in cotton. Breeding for quality improvement in Sugarcane, potato.

Block 4: Genomics assisted breeding for nutritional quality

Genetic engineering protocols for quality improvement: Achievements made; Biofortification in crops; Nutritional genomics. Concept and use of gene editing in quality improvement

Practical

- Grain quality evaluation in rice;
- Quality analysis in millets;
- Estimation of anti-nutritional factors in different varieties/ hybrids: A comparison;
- Quality parameters evaluation in wheat, pulses and oilseeds;
- Evaluation of quality parameters in cotton, sugarcane and potato;
- Evaluating the available populations like RIL, NIL, etc. for quality improvement using MAS procedures;
- Successful example of application of MAS for quality trait in rice, mustard, maize, etc.

References

- CHAHAL GS AND SS GHOSAL. 2002. Principles and procedures of plant breeding - Biotechnological and Conventional approaches, Narosa Publications
- CHOPRA VL.1997. Plant Breeding. Oxford & IBH. 2018.
- FAO 2001. Speciality Rices of the World - Breeding, Production and Marketing. Oxford & IBH,1 Nov 2001.
- GHOSH P. 2004. Fibre Science and Technology. Tata McGraw Hill.
- GUPTA SK. 2007. Advances in Botanical Research Vol. 45 Academic Press USA. Hay RK. 2006.
- Physiology of Crop Yield. 2nd Ed. Blackwell.
- NIGAM J. 1996. Genetic Improvement of Oilseed Crops. Oxford & IBH.

- SINGH BD. 1997. Plant Breeding. Kalyani Publishers, New Delhi.
- SINGH RK, SINGH UK AND KHUSH GS. 2000. Aromatic Rices. Oxford & IBH.

GPB 508 MUTAGENESIS AND MUTATION BREEDING 3 (2+1)

Objective of the course

i. To impart the knowledge about general principles of mutagenesis for crop improvement and various tests/ methods for detection of mutations.

ii. To learn about mutation, various methods of inducing mutations and their utilization in plant breeding.

Theory

Block : 1 Mutation Classification and functionality

Unit I: Mutation and its history, nature and classification of mutations: spontaneous and induced mutations, micro and macro mutations, pre and post adaptive mutations; Detection of mutations. Paramutations in crops plants.

Unit II: Mutagenic agents: physical – radiation types and sources: Ionizing and non-ionizing radiations. Effect of mutations on DNA – repair mechanisms operating at DNA, chromosome, cell and organism level to counteract the mutation effects; Factors influencing mutation: dose rate, acute vs chronic irradiation, recurrent irradiation, Radiation sensitivity and modifying factors: External and internal sources – Oxygen, water content, temperature and nuclear volume.

Unit III: Chemical mutagens: Classification – base analogues, antibiotics, alkylating agents, acridine dyes and other mutagens: their properties and mode of action; Dose determination and factors influencing chemical mutagenesis; Treatment methods using physical and chemical mutagens, Combination treatments; other causes of mutation – direct and indirect action, comparative evaluation of physical and chemical mutagens.

Block: 2 : Application of Mutation in Crop Improvement

Unit I: Observing mutagen effects in M_1 generation: plant injury, lethality, sterility, chimeras, etc.; Observing mutagen effects in M_2 generation; Estimation of mutagenic efficiency and effectiveness – spectrum of chlorophyll and viable mutations; Mutations in traits with continuous variation; Factors influencing the mutant spectrum: genotype, type of mutagen and dose, pleiotropy and linkage, etc.; Individual plant based mutation analysis and working out effectiveness and efficiency in M_3 generation; Comparative evaluation of physical and chemical mutagens for creation of variability in the some species- Case studies.

Unit II: Use of mutagens in creating oligogenic and polygenic variations – Case studies; *In-vitro* mutagenesis – Callus and pollen irradiation; Handling of segregating M_2 generations and selection procedures; Validation of mutants; Mutation breeding for various traits (disease resistance, insect resistance, quality improvement, etc.) in different crops; Procedures for micromutations breeding/ polygenic mutations; Achievements of mutation breeding- varieties released across the world, problems associated with mutation breeding. Use of mutagens in genomics, allele mining, TILLING.

Practical

- Precautions on handling of mutagens; Studies of different mutagenic agents:Physical mutagens and Chemical mutagens;
- Radiation hazards: Monitoring – safety regulations and safe transportation of radioisotopes, visit to radio isotope laboratory; learning on safe disposal of radioisotopes;
- Hazards due to chemical mutagens – Treating the plant propagules at different doses of physical and chemical mutagens;
- Procedures in combined mutagenic treatments;
- Raising the crop for observation; Mutagenic effectiveness and efficiency, calculating the same from earlier literature;
- Study of M_1 generation – Parameters;
- Study of M_2 generation – Parameters;

- Mutation breeding in cereals and pulses-achievements made and an analysis;
- Mutation breeding in oilseeds and cotton- achievements and opportunities;
- Mutation breeding in forage crops and vegetatively propagated crops;
- Procedure for detection of mutations for polygenic traits in M_2 and M_3 generations. parameters evaluation.

Suggested Reading

- ALPER T. 1979. *Cellular Radiobiology*. Cambridge Univ. Press, London.
- CHADWICK KH AND LEENHOUTS HP. 1981. *The Molecular Theory of Radiation Biology*. Springer- Verlag.
- COTTON R, EDKIN E AND FORREST S. 2000. *Mutation Detection: A Practical Approach*. Oxford Univ. Press.
- International Atomic Energy Agency. 1970. *Manual on Mutation Breeding*. International Atomic Energey Agency, Vienna, Italy.
- SHU QY, FORSTER BP AND NAKAGAWA N. 2012. *Plant Mutation Breeding and Biotechnology.*
- Gutecnberg Press Ltd. Rome Italy ISBN:978-925107-022-2 (FAO).
- SINGH BD. 2003. *Genetics*. Kalyani Publishers, New Delhi. Strickberger MW. 2005. *Genetics*. 3rd Ed. Prentice Hall.

GPB 509 HYBRID BREEDING 3(2+1)

Theory

Unit I: Historical aspect of heterosis, nomenclature and definitions of heterosis; Heterosis in natural population and inbred population; Genetic consequences of selfing, sibbing and crossing in self-and cross-pollinated and asexually propagated crops; Evolutionary concepts of heterosis; Genetic theories of heterosis – Physiological, Biochemical and molecular factors underlining heterosis; theories and their estimation; Biometrical and population genetic basis of heterosis.

Unit II: Prediction of heterosis from various crosses, inbreeding depression, coefficient of inbreeding and its estimation, residual heterosis in F_2 and segregating populations, importance of inbreeding in exploitation of heterosis – case studies.; Relationship between genetic distance and expression of heterosis, case studies; Divergence and genetic distance analyses, morphological and molecular genetic distance in predicting heterosis; Development of heterotic pools in germplasm/ genetic stocks and inbreeds, their improvement for increasing heterosis.

Unit III: Male sterility and use in heterosis breeding; Male sterile line creation and diversification in self-pollinated, cross pollinated and asexually propagated crops; Creation of male sterility through genetic engineering and its exploitation in heterosis; Maintenance, transfer and restoration of different types of male sterility; Use of self-incompatibility in development of hybrids.

Unit IV: Hybrid seed production system: 3-line, 2-line and 1-line system; Development of inbreeds and parental lines- A, B and R lines – functional male sterility; Commercial exploitation of heterosis, maintenance breeding of parental lines in hybrids; Fixation of heterosis in self, cross and often cross pollinated crops, asexually/ clonally propagated crops, problems and prospects; Apomixis in fixing heterosis-concept of single line hybrid; Organellar heterosis and complementation.

Unit V: Hybrid breeding in rice, cotton, maize, pearl millet, sorghum and rapeseed- mustard, sunflower, safflower and castor oilseed crops and pigeonpea.

Practical

- Characterization of male sterile lines using morphological descriptors;
- Restorer line identification and diversification of male sterile sources;
- Male sterile line creation in crop plants, problems in creation of CGMS system, ways of overcoming them;
- Diversification and restoration;

- Success stories of hybrid breeding in Maize, Rice, Pearl millet, Sorghum and Pigeon pea;
- Understanding the difficulties in breeding apomicts;
- Estimation of heterotic parameters in self, cross and asexually propagated crops;
- Estimation from the various models for heterosis parameters;
- Hybrid seed production in field crops—an account on the released hybrids, their potential, problems and ways of overcoming it;
- Hybrid breeding at National and International level, opportunities ahead.

References

- AGARWAL RL. 1998. *Fundamental of Plant Breeding and hybrid Seed Production*. SciencePublisher London.
- AKIN E. 1979. *The Geometry of Population Genetics*. Springer-Verlag.
- BEN HL. 1998. *Statistical Genomics – Linkage, Mapping and QTL Analysis*. CRC Press.
- CHAL GS AND GOSSAL SS. 2002. *Principles and procedures of Plant Breeding, Biotechnology andConvetional Approaches*. Narosa Publishing House. New Delhi.
- DE JG. 1988. *Population Genetics and Evolution*. Springer-Verlag. 30 January 2012.
- HARTL DL. 2000. *A Primer of Population Genetics*. 3rd Ed. Sinauer Assoc.
- METTLER LE AND GREGG TG. 1969. *Population Genetics and Evolution*. Prentice-Hall. 25 April 1988
- MONTGOMERY DC. 2001. *Design and Analysis of Experiments*. 5th Ed., Wiley & Sons. 2013
- MUKHERJEE BK. 1995.*The Heterosis Phenomenon*. Kalyani Publishers, New Delhi.

- Proceedings of *Genetics and Exploitation of Heterosis in Crops* – An International Symposium CIMMYT, 1998.
- RICHARDS AJ. 1986. *Plant Breeding Systems*. George Allen & Unwin. 30 May 1997
- SINGH BD. 2006. *Plant Breeding*. Kalyani Publishers, New Delhi.
- SRIVASTAVA S AND TYAGI R. 1997. *Selected Problems in Genetics*. Vols. I, II. Anmol Publ.
- VIRMANI SS. 1994. *Heterosis and Hybrid Rice Breeding. Monographs of "Theoretical and Applied Genetics*", Springer-Verlag.

GPB 510 SEED PRODUCTION AND CERTIFICATION 2(1+1)

Objectives

Seed is the essence of life. Its improvement, production and maintenance is an essential feature of any variety. Seed chain concept is highly relevant in commercial promotion of new varieties whereas process of certification is mandatory for quality assurance of seed.

Aim of the course

To impart knowledge on principles of seed production and certification. This will help the students to understand seed production practices and seed certification procedures in different crops.

Theory

Unit I: Importance of seed as basic input in agriculture; Seed quality concept and importance; Generation system of seed multiplication - Varietal replacement rate, Seed multiplication ratios, Seed replacement rate, Seed renewal period and seed demand and supply; Various factors influencing seed production –Physical and Genetic purity in seed production; Factors responsible for varietal and genetic deterioration.

Unit II: Nucleus seed production and its maintenance - Maintenance of parental lines of hybrids, Production of breeder, foundation and certified seed and their quality maintenance; Principles of seed production

in self- and cross-pollinated crops; Hybrid seed production - system and techniques involved in Seed village concept; Organic seed production and certification.

Unit III: Principles of seed production in field crops; Floral structure, pollination mechanism and seed production techniques in self- and cross-pollinated cereals and millets.

Unit IV: Floral structure, pollination mechanism and methods and techniques of seed production in major pulses and oilseed crops; Varietal and hybrid seed production techniques in Pigeon pea, Mustard, Castor and Sunflower.

Unit V: Floral structure, pollination mechanism and methods and techniques of seed production in major commercial fibres. Hybrid-seed production techniques in major vegetatively propagated crops.

Unit VI: Seed certification - history, concept, objectives;Central seed certification board Seed certification agency/ organization and staff requirement; Legal status - Phases of seed certification, formulation, revision and publication of seed certification standards; Minimum Seed Certification Standards (MSCS) for different crops - General and specific crop standards, Field and seed standards; Planning and management of seed certification programs; Eligibility of a variety for certification, area assessment, cropping history of the seed field.

Practical

- Planting design for variety- hybrid seed production techniques, planting ratio of male and female lines, synchronization of parental lines and methods to achieve synchrony;
- Identification of rogues and pollen shedders, supplementary pollination, detasseling, hand emasculation and pollination;
- Pollen collection and storage methods, pollen viability and stigma receptivity;
- Pre-harvest sanitation, maturity symptoms, harvesting techniques;
- Visits to seed production plots - visit to seed industries;

- Planning for seed production: cost benefit ratio, seed multiplication ratio and seed replacement rate;
- General procedure of seed certification, identification of weed and other crop seeds as per specific crops, field inspection at different stages of a crop and observations recorded on contaminants and reporting of results, inspection and sampling, harvesting/ threshing, processing and after processing for seed law enforcement;
- Specifications for tags and labels to be used for certification purpose.

References

- AGRAWAL PK AND DADLANI M. 1987. *Techniques in Seed Science and Technology*, South Asian Publishers, Delhi.
- AGRAWAL RL. 1997. *Seed Technology,* Oxford & IBH Publishing.
- ANON, 1965. *Field Inspection Manual and Minimum Seed Certification Standards*, NSC Publication, New Delhi.
- ANON. 1999. *Manual of Seed Certification procedures.* Directorate of Seed Certification, Coimbatore, Tamil Nadu.
- JOSHI AK AND SINGH BD. 2004. *Seed Science and Technology*, Kalyani Publishers, New Delhi.
- KELLY AF. 1988. *Seed Production of Agricultural Crops*. John Wiley, New York.
- MC DONALD MB AND COPELAND LO. 1997. *Seed Science and Technology*, Scientific Publisher, Jodhpur.
- RAMAMOORTHY K, SIVASUBRAMANIAM K AND KANNAN M. 2006. *Seed Legislation in India*. Agrobios (India), Jodhpur, Rajasthan.
- SINGHAL NC. 2003. *Hybrid Seed Production in Field Crops*, Kalyani Publications, New Delhi
- TUNWAR NS AND SINGH SV. 1988. *Indian Minimum Seed Certification Standards*. Central Seed Certification Board, Ministry of Agriculture, New Delhi.

GPB 511 CROP BREEDING I (*KHARIF* CROPS) 3 (2+1)

Objectives

Botanical features, reproductive systems, genetics involved and important breeding techniques are essential to undertake any crop improvement programme. This course is designed for important/ major *Kharif* field crops.

Aim of the course

To provide insight into recent advances in improvement of kharif cereals, legumes, oilseeds, fibre, sugarcane and vegetative propagated crops using conventional and modern biotechnological approaches.

Theory

Unit I

Rice: Origin, evolution, mode of reproduction, chromosome number; Genetics –biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding released varieties, examples of MAS used for improvement, Aerobic rice, its implications and drought resistance breeding.

Maize: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, releasedvarieties, examples of MAS used for improvement- QPM and Bt maize – strategies and implications.

Small millets: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship - breeding objectives yield, quality characters, biotic and abiotic stress resistance, etc.

Unit II

Pigeon pea: evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding

objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement - Hybrid technology; maintenance of male sterile, fertile and restorer lines, progress made at National and International institutes.

Groundnut: Origin, evolution mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship, breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

Other pulses: Urdbean, mungbean, cowpea,: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship, breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), released varieties, examples of MAS used for improvement. Interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them.

Unit III

Soybean: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement. **Castor and Sesame**: Origin, evolution mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), released varieties, examples of MAS used for improvement; Hybrid breeding in castor – opportunities, constraints and achievements.

Unit IV

Cotton: Origin, evolution, mode of reproduction, chromosome number; Genetics – biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement, Development and maintenance of male sterile lines – Hybrid development and seed production – Scenario of Bt cottons, evaluation procedures for Bt cotton.

Jute: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement.

Unit V

Sugarcane: Evolution and distribution of species and forms, wild relatives and germplasm; Cytogenetics and genome relationship – Breeding objectives- yield, quality characters, biotic and abiotic stress resistance, etc.

Forage crops: Evolution and distribution of species and forms – Wild relatives and germplasm; Cytogenetics and genome relationship; Breeding objectives- yield, quality characters and palatability studies; Biotic and abiotic stress resistance, etc. **Seed spices**: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc.; Breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance.

Practicals

Floral biology, emasculation, pollination techniques in rice, maize, pigeon pea, soybean, sesame, cotton;

- Study of range of variation for yield and yield components;

- Study of segregating populations in cereal, pulses and oilseed crops;
- Learning on the crosses between different species; attempting crosses between black gram and green gram;
- Evaluating the germplasm of cotton for yield, quality and resistance parameters, learning the procedures on development of Bt cotton;
- Visit to Cotton Technology Laboratory and Spinning Mills;
- Learning on the Standard Evaluation System (SES) and descriptors; Use of software for database management and retrieval;
- Practical learning on the cultivation of fodder crop species on sewage water, analysing them for yield components and palatability;
- Laboratory analysis of forage crops for crude protein, digestibility percent and other quality attributes;
- Visit to animal feed producing factories;
- Learning the practice of value addition; Visiting the animal husbandry unit and learning the animal experiments related with palatability and digestibility of fodder.
- Assignments, quiz
- Group tasks, student's presentations.

References

- AGARWAL RL. 1996. *Identifying Characteristics of Crop Varieties*. Oxford & IBH.
- BAHL PN AND SALIMATH PM. 1996. *Genetics, Cytogenetics and Breeding of Crop Plants*. Vol. I.
- *Pulses and Oilseeds*. Oxford & IBH.
- CHANDRARATNA MF. 1964. *Genetics and Breeding of Rice*. Longmans.
- CHOPRA VL AND PRAKASH S. 2002. *Evolution and Adaptation of Cereal Crops*. Oxford & IBH.
- GILL KS. 1991. *Pearl Millet and its Improvement*. ICAR.
- IRRI. 1964. *Rice Genetics and Cytogenetics*. Elsevier.

- IRRI. 1986. *Rice Genetics*. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.
- IRRI. 1991. *Rice Genetics II*. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.
- IRRI. 1996. *Rice Genetics III*. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.
- IRRI. 2000. *Rice Genetics IV*. Proc. International Rice Genetics Symposium. IRRI, Los Banos, Manila, Philippines.
- JENNINGS PR, COFFMAN WR AND KAUFFMAN HE. 1979. *Rice Improvement*. IRRI, Los Banos, Manila, Philippines.
- KANNAIYAN S, UTHAMASAMY S, THEODORE RK AND PALANISWAMY S. 2002. *New Dimensions and Approaches for Sustainable Agriculture*. Directorate of Extension Education, TNAU, Coimbatore.
- MURTY DS, TABO R AND AJAYI O. 1994. *Sorghum Hybrid Seed Production and Management*. ICRISAT, Patancheru, India.
- NANDA JS. 1997. *Manual on Rice Breeding*. Kalyani Publishers.
- PARTHASARATHY VA. 2017. *Spices and Plantation Crops Vol.1* (*Part A*) *Breeding of Horticultural*
- *Crops* Vol.1 (Part-B), Today and Tomorrow Printers and Publishers
- POEHLMAN, JM. 1987. *Breeding of Field Crops*. AVI Publishing Co. Inc. East Post Connecticut, USA.
- RAM HH AND SINGH HG. 1993. *Crop Breeding and Genetics*. Kalyani.
- SHARMA, AK. 2005. *Breeding Technology of Crop Plant*. Yesh Publishing House, Bikaner
- SLAFER GA. (Ed.). 1994. *Genetic Improvement of Field Crops*. Marcel Dekker.
- SINGH HG, MISHRA SN, SINGH TB, RAM HH AND SINGH DP. (Eds.). 1994. *Crop Breeding in India*.
- International Book Distributing Co.

• WALDEN DB. 1978. *Maize Breeding and Genetics*. John Wiley & Sons.Course.

GPB 512 CROP BREEDING-II (*RABI* CROPS) 3(2+1)

Objectives

Botanical features, reproductive systems, genetics involved and important breeding techniques are essential to undertake any crop improvement programme. This course is designed for important/ major Rabi field crops.

Aim of the course

To provide insight into recent advances in improvement of *Rabi* cereals, legumes, oilseeds, fibre and vegetative propagated crops using conventional and modern biotechnological approaches

Theory

Unit I

Wheat: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement.

Oats: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

Barley: Origin, evolution, center of origin, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

Unit II

Chickpea: Origin, evolution mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

Other pulses: Lentil, field pea, Rajma, Horse gram: Origin, evolution, mode of reproduction, chromosome number; Genetics. cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement. Interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them.

Unit III

Rapeseed and Mustard: Origin, evolution, mode of reproduction, chromosome number; Genetics – cytogenetics and genome relationship; Breeding objectives; yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement, Oil quality, Improvement for oil quality.

Sunflower, Safflower: Origin, mode of reproduction, chromosome number; Genetics, cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, heterosis breeding, released varieties, examples of MAS used for improvement.

Unit IV

Mesta and minor fibre crops: Origin, mode of reproduction, chromosome number;

Genetics–cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, released varieties, examples of MAS used for improvement.

Forage crops: Origin, evolution mode of reproduction, chromosome number; Genetics–cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance.

Unit V

Seed spices: Origin, evolution, mode of reproduction, chromosome number; Genetics– cytogenetics and genome relationship; Breeding objectives: yield, quality characters, biotic and abiotic stress resistance, etc., breeding approaches, introgression of alien gene(s) (if required), biotic and abiotic stress resistance, scope of heterosis breeding, released varieties, examples of MAS used for crop improvement.

Practical

- Floral biology, emasculation and pollination techniques in wheat, oats, barley, chickpea, rajma, rapeseed mustard, sunflower;
- Study of range of variation for yield and yield components;
- Study of segregating populations in cereal, pulses and oilseed crops;
- Use of descriptors for cataloguing; Learning on the crosses between different species;
- Trait based screening for stress resistance;
- Learning on the Standard Evaluation System (SES) and descriptors;
- Use of software for database management and retrieval.

References

- AGARWAL RL. 1996. *Identifying Characteristics of Crop Varieties*. Oxford & IBH.
- BAHL PN AND SALIMATH PM. 1996. *Genetics, Cytogenetics and Breeding of Crop Plants*. Vol. I.

- *Pulses and Oilseeds*. Oxford & IBH.
- GUPTA SK. 2012. *Technological Innovations in Major World Oil crops*. Vol. I. Springer, USA.
- GUPTA SK. 2012. *Technological Innovations in Major World Oil crops*. Vol. II. Springer, USA.
- GUPTA SK. 2016. *Breeding of Oilseed Crops for Sustainable Production*. Academic Press, USA.
- KANNAIYAN S, UTHAMASAMY S, THEODORE RK AND PALANISWAMY S. 2002. *New Dimensions and*
- *Approaches for Sustainable Agriculture*. Directorate of Extension Education, TNAU, Coimbatore.
- PARTHASARATHY VA. 2017. *Spices and Plantation Crops* Vol.1 (Part A) *Breeding of Breeding and Genetics*. John Wiley & Sons.

GPB 513 BREEDING VEGETABLE CROPS 3(2+1)

Objectives

This course enables the students to learn about breeding objectives, methodologies and genetics involved for the improvement of major vegetable crops.

Aim of the course

To educate about principles and practices adopted for breeding of vegetable crops.

Theory

Unit I: Breeding for Leafy vegetables: Amaranth, chenopods and lettuce.

Unit II: Breeding for Cucurbits: Gourds, melons, pumpkins and squashes.

Unit III: Breeding for Solanaceae: Potato and tomato, eggplant, hot pepper, sweet pepper

Unit IV: Breeding for Cole crops: Cabbage, cauliflower, broccoli and knolkhol. Breeding for Root vegetables: Carrot, beetroot, radish, sweet potato and tapioca.

Unit V: Breeding for other vegetable crops: Peas, beans, onion, garlic and okra.

Practical

- Selection of desirable plants from breeding population, observations and analysis of various qualitative and quantitative traits in germplasm;
- Hybridization and handling segregating generations;
- Induction of flowering, palanological studies, selfing and crossing techniques in vegetable crops;
- Hybrid seed production of vegetable crops in bulk;
- Screening techniques for insect-pests, disease and environmental stress resistance in vegetable crops;
- Demonstration of sib-mating and mixed population;
- Molecular marker techniques to identify useful traits in the vegetable crops and special breeding techniques;
- Visit to breeding blocks, MAS for incorporating traits governed by major and polygenes.

References

- ALLARD RW. 1999. *Principles of Plant Breeding*. John Wiley & Sons.
- FAGERIA MS, ARYA PS AND CHOUDHARY AK. 2000. *Vegetable Crops: Breeding and Seed Production*. Vol. I. Kalyani Publishers, New Delhi.
- KALLOO G. 1988. *Vegetable Breeding*. Vols. I-III. CRC Press.
- KALLOO G. 1998. *Vegetable Breeding*. Vols. I-III (Combined Ed.). Panima Edu. Book Agency.
- PETER KV AND PRADEEP KT. 2008. *Genetics and Breeding of Vegetables.* ICAR.
- RAI N AND RAI M. 2006. *Heterosis Breeding in Vegetable Crops*. New India Publication Agency.

- RAM HH. 2005. *Vegetable Breeding-Principles and Practices*. Kalyani Publishers
- SHARMA JP. 2010. *Principles of Vegetable Breeding*. Kalyani Publishers, New Delhi.

GPB 514 BREEDING FRUIT CROPS 3 (2+1)

Objectives

This course is aimed to educate the students about the breeding strategies and avenues in Fruit crops.

Aim of the course

To educate students about principles and practices adopted for breeding of fruit crops.

Theory

Unit I: Fruit crop breeding: History, importance of fruit breeding, centers of diversity, distribution, domestication and adaptation of commercially important fruits.

Unit II: Issues in fruit crop breeding – heterozygosity, polyploidy, polyembryony, parthenocarpy and seed lessness, incompatibility and sterility systems.

Unit III: Apomixis - merits and demerits, types, variability for economic traits, role of genetic engineering and biotechnology in improvement of fruit crops.

Unit IV: Crop improvement in Mango, Banana, Citrus, Grapes, Papaya, Sapota and Pomegranate, Pineapple and Guava, Apple and other Rosaceous crops andregion specific fruit crops.

Practical

- Germplasm documentation;
- Floral biology of mango, guava, citrus, grape, pomegranate, pollen viability in major fruit crops;
- Pollen germination to study time of anthesis and stigma receptivity;

- Hybridization technique in important fruit crops, hybrid seed collection and raising;
- Colchicine treatment for induction of polyploidy;
- Exposure to resistance breeding and screening techniques;
- Mutation breeding practices raising and evaluation of segregating populations;
- Use of mutagens to induce mutations and polyploidy;
- Visit to Biotechnology Lab and study of *in-vitro* breeding techniques.

References

- BHOJWANI SS AND RAZDAN MK. 2006. *Plant Tissue Culture - Theory and Practice*. Elsevier Publication, Amesterdam.
- CHADHA KL AND PAREEK, OP. 1996. (Eds.). *Advances in Horticulture.* Vol. I to IV. Malhotra Publ. House, New Delhi.
- CHADHA KL AND SHIKHAMANY SD. 1999. *The Grape: Improvement, Production and Post-Harvest Management*. Malhotra Publ. House, New Delhi.
- JANICK AND MOORE JN. 1996. *Advances in Fruit Breeding*, AVI Pub., USA.
- JANICK J AND MOORE JN. 1996. *Fruit Breeding*. Vols. I to III. John Wiley & Sons.
- KUMAR N. 2006. *Breeding of Horticultural Crops - Principles and Practices*. New India Publishing Agency, New Delhi.
- MOORE JN AND JANICK JULES. 1996. *Methods in Fruit Breeding*. Purdue University Press, South Campus Court D., USA.
- PARTHASARATHY VA, BOSE TK, DEKA PC, DAS P, MITRA SK. AND MOHANADAS S. 2001. *Biotechnology of Horticultural Crops.* Vols. I-III. Naya Prokash, Kolkata.
- RAY PK. 2002. *Breeding of Tropical and Sub-tropical Fruits*. Narosa Publishing House, New Delhi.
- SIMMONDS NW. 1976. *Evolution of Crop Plants*, Orient Longman, London.

GPB 515 BREEDING ORNAMENTAL CROPS 3(2+1)

Objectives

The course will impart knowledge to student about breeding of Ornamental Crops through conventional and biotechnological interventions.

Aim of the course

To educate about principles and practices adopted for breeding of ornamental crops.

Theory

Unit I: History of improvement of ornamental plants; Centre of origin of ornamental crop; Objectives and techniques in ornamental plant breeding.

Unit II: Introduction, selection, hybridization, mutation and biotechnological techniques for improvement of ornamental and flower crops, viz., Rose, Jasmine, *Chrysanthemum*, Tuberose, *Gerbera*, *Gladiolus*, *Dahlia*, *Lilium*, *Gaillardia*, *Petunia*, *Bouganvillea*, Pansy, Marigold, *Geranium*, *Antirrhinum*, China aster, Orchids, *Carnation*, *Hibiscus,* etc.

Unit III: Development of promising cultivars of important ornamental and flower crops; Role of Heterosis and its exploitation, production of F_1 hybrids and utilization of male sterility.

Unit IV: Production of open pollinated seeds, harvesting, processing and storage of seeds; Seed certification.

Practical

- Study of floral biology and pollination in important species and cultivars of ornamental crops;
- Techniques of inducing polyploidy and mutation;
- Production of pure and hybrid seed;
- Methods of breeding suited to seed propagated plants;
- Polyploidy and mutations to evolve new varieties;
- Breeding methods for biotic and abiotic stresses;

- Visit to research institutes involved in ornamental crop breeding.

References

- ALEXANDER V. 2002. *Breeding for ornamentals: Classical and Molecular Approaches*. Kluwer Academic Publishers, London.
- ALLARD RW. 1999. *Principles of Plant Breeding*. John Wiley & Sons. INC. New York.
- BHATTACHARJEE SK AND DE LC. 2003. *Advanced Commercial Floriculture* Vol. 1. Aavishkar Publishers & Distributors, Jaipur.
- BOSE TK AND YADAV LP. 2003. *Commercial Flowers*. Naya Prokash Publishers, Kolkata.
- CHADHA KL AND BHATTACHARJEE SK. *Advances in Horticulture* Vol. 12, Malhotra Publishing House, New Delhi.
- Mc Donald MB and Kwong FY. 2005. *Flower Seeds Biology and Technology*, CABI Publishing, Oxfordshire, UK.
- WATTS L.1980. *Flower and Vegetable Plant Breeding*. Grower Books

GPB 516 BREEDING FOR STRESS RESISTANCE AND CLIMATE CHANGE 3 (2+1)

Objective of the Course

To appraise about various abiotic and biotic stresses influencing crop yield, mechanisms and genetics of resistance and methods to breed stress tolerant varieties.

Theory

Block 1: Major biotic and abiotic stresses in crops

Unit I: Concept and impact of climatic change; Importance of plant breeding with special reference to biotic and abiotic stress resistance; Classification of biotic stresses – major pests and diseases of economically important crops.

Block 2: Mechanism of plant disease resistance

Unit I: Concepts of resistance to insect and pathogen resistance; Analysis and inheritance of resistance variation; Host defence responses

to pathogen invasions- Biochemical and molecular mechanisms; Acquired and induced immunity and systemic acquired resistance (SAR); Host-pathogen interaction, gene-for-gene hypothesis, molecular evidence for its operation and exceptions; Concept of signal transduction and other host-defence mechanisms against viruses and bacteria.

Block 3: Conventional breeding for resistance to biotic and abiotic stresses

Unit I: Types and genetic mechanisms of resistance to biotic stresses –Horizontal and vertical resistance in crop plants; Quantitative resistance/ adult plant resistance and slow rusting resistance; Classical and molecular breeding methods - Measuring plant resistance using plant fitness; Behavioural, physiological and insect gain studies; Phenotypic screening methods for major pests and diseases; Recording of observations; Correlating the observations using marker data – Gene pyramiding methods and their implications.

Classification of abiotic stresses - Stress inducing factors, moisture stress/ drought and water logging and submergence; Acidity, salinity/ alkalinity/ sodicity; High/ low temperature, wind, etc.; Stress due to soil factors and mineral toxicity; Physiological and Phenological responses; Emphasis of abiotic stresses in developing breeding methodologies.

Block 4: Genomics enabled breeding for resistance to biotic and abiotic stresses

Unit I: Genetics of abiotic stress resistance; Genes and genomics in breeding cultivars suitable to low water regimes and water logging and submergence, high and low/ freezing temperatures; Utilizing MAS procedures for identifying resistant types in important crops like rice, sorghum, wheat, cotton, etc.; Breeding for resistance to stresses caused by toxicity, deficiency and pollutants/ contaminants in soil, water and environment.

Unit II: Use of crop wild relatives as a source of resistance to biotic and abiotic factors in major field crops; Transgenics in management of biotic and abiotic stresses, use of toxins, protease inhibitors, lectins, chitinases and Bt for diseases and insect pest management.

Practical

- Symptoms and data recording; use of MAS procedures;
- Evaluating the available populations like RIL, NIL, etc. for pest resistance;
- Use of standard MAS procedures.
- Breeding for herbicide resistance;
- Screening crops for drought and flood resistance; factors to be considered and breeding strategies;
- Screening varieties of major crops for acidity and alkalinity- their effects and breeding strategies;
- Screening forage crops for resistance to sewage water and tannery effluents; Quality parameters evaluation.

References

- BLUM A. 1988. Plant Breeding for Stress Environments. CRC Press.
- CHRISTIANSEN MN AND LEWIS CF. 1982. Breeding Plants for Less Favourable Environments. Wiley International.
- FRITZ RS AND SIMMS EL. (Eds.). 1992. Plant Resistance to Herbivores and Pathogens: Ecology, Evolution and Genetics. The University of Chicago Press.
- LI PH AND SAKAI A. 1987. Plant Cold Hardiness. Liss, New York Springer
- LUGINPILL P. 1969. Developing Resistant Plants - The Ideal Method of Controlling Insects. USDA, ARS, Washington DC.
- MAXWELL FG AND JENNINGS PR. (Eds.). 1980. Breeding Plants Resistant to Insects. John Wiley & Sons. Wiley-Blackwell.
- ROBERTO F. 2018. Plant Breeding for Biotic and Abiotic Stress Tolerance. Springer.
- RUSSEL GE. 1978. Plant Breeding for Pest and Disease Resistance. Butterworths.

- SAKAI A AND LARCHER W. 1987. Frost Survival in Plants. Springer-Verlag.
- SINGH BD. 2006. Plant Breeding. Kalyani Publishers, New Delhi
- TURNER NC AND KRAMER PJ. 1980. Adaptation of Plants to Water and High Temperature Stress. John Wiley & Sons.
- VAN DER PLANK JE. 1982. Host-Pathogen Interactions in Plant Disease. Academic Press.

GPB 517 GERMPLASM CHARACTERIZATION AND EVALUATION 2(1+1)

Objective of the course

i. To impart the knowledge about morphological and quality agronomic traits of accessions as well as their reaction to biotic and abiotic stresses.

ii. To learn about germplasm characterization, evaluation and documentation of information. Exposure to development of web based tools for systematic description for efficient use of germplasm.

Theory

Block : 1 Structure of Genetic Diversity and Characterization

Unit I: Understanding genetic diversity in crop plants; Crop descriptors, descriptor states; germplasm characterization/ evaluation procedures; evaluation of germplasm for specific traits; evaluation of biotic and abiotic stresses, Principles and methods for formulating core and mini core collections and their validation, Web based tools for management of data.

Unit II: Principles and practices of germplasm regeneration and maintenance, breeding systems and mode of reproduction; maintaining sufficiently large populations for effective conservation of farmer landraces, evaluation and maintenance of wild relatives of crop plants. Genetic enhancement, Use of CWRs genetic resources for crop improvement.

Block : 2 Modernization in Characterization

Unit I: Evaluation for nutritional traits, resistance traits - Biochemical and molecular markers for characterization.

Practical

- Recording field data on germplasm evaluation in different agri-horticultural crops,post harvest handling;
- Evaluating quality traits, biochemical and phyto-chemical evaluation of crop germplasm, data processing;
- Documentation, analysis of diversity and cataloguing, data analysis, viability equations, sampling strategies, data documentation, cataloguing, biochemical analyses of samples.

References

- BROWN AHD, CLEGG MT, KAHLER AL, WEIR BS (eds.) 1990. *Plant Population Genetics, Breeding, and Genetic Resources*, Sinauer Associates, USA.
- FRANKEL R AND GALUN E 1977. *Pollination Mechanisms, Reproduction and Plant Breeding. Monographs on Theoretical and Applied Genetics*, Springer-Verlag, Berlin, Heidelberg.
- HAYWARD MD, BOSEMAK NO AND ROMAGOSA I. 1993. *Plant Breeding: Principles and Practices*, Chapman & Hall.
- HOLDEN JHN AND WILLIAMS JT 1984. *Crop genetic resources: conservation and evaluation*, IBPGR. Puzone, L and Th. Hazekamp 1996. *Characterization and Documentation of Genetic ResourcesUtilizing Multimedia Database*. NBPGR, New Delhi.
- RANA RS, SAPRA RL, AGRAWAL RC AND GAMBHIR R 1991. Plant Genetic Resources, *Documentation and Information Management*. NBPGR, New Delhi.
- STOSKOPF NC 1993. *Plant Breeding: Theory and Practice*, Westview Press.
- SUNDEEP KUMAR, *ET AL.* 2016. *Evaluation of 19,460 wheat accessions conserved in the Indian national genebank to identify new sources of resistance to rust and spot blotch diseases*. PloS One Vol 11, pages 0167702.

• TRIPATHI K, BHARDWAJ R, BHALLA S, KAUR V, BANSAL R, YADAV R, GANGOPADHYAY KK, KUMAR A AND CHAUDHURY R. 2018. *Plant Genetic Resources Evaluation: Principles and Procedures*, Indian Council of Agricultural Research - National Bureau of Plant Genetic Resources (ICAR-NBPGR), New Delhi. vi+50 p.

GPB 518 GENETIC ENHANCEMENT FOR PGR UTILIZATION 2(1+1)

Objective of the course

i. To teach theoretical and practical know how on CWRs reproductive behavior, acclimatization and adaptation for utilization in prebreeding programmes usig advanced tools.

ii. To understand and use classical and advanced plant breeding methods for planning and execution of prebreeding programmes so that the PGR is put into effective use for food and agriculture.

Theory

Block 1 : Relevance of Genetic Diversity in Crop Improvement

Unit I: Concepts of gene pools; Introduction, potential of pre-breeding. Role of crop wild relatives, semi exotics, creating and managing variation, basic concepts to set up a successful pre-breeding programme.

Unit II: Understanding crop adaptation, handling and maintenance of CWRs, synchronization of flowering, overcoming impediments to flowering through photoperiodic adjustments, role of other barriers to flowering, role of amphidiploids, semi exotics and other unadapted germplasm, identifying desirable traits in natural populations, screening for biotic and abiotic stress resistance traits; screening of nutritionally important traits, genetic analysis to understand the inheritance of novel traits.

Unit III: Parental selection for prebreeding, search for superior genotypes, breeding methods for trait transfer; moving the genes - unadapted to adapted, wide hybridization, Incongruity and its management, modern tools for incongruity management, cytogenetical

approaches for gene transfer such as alien addition and substitution, segregating populations and their management in wide crosses, purging the undesirable traits, testing and improving the adaptability of wide cross derivatives,

Practical

- Characterization of CWRs by visiting the fields;
- Screening methods for special traits-biotic and abiotic resistance;
- Screening for nutritional traits;
- Crossability studies in CWRs of cereals, Rice Maize, legumes : Redgram, oilseeds : Sunflower Groundnut, vegetables Tomato. Assessment of pre and post-zygotic barriers in wide hybridization crosses;
- Pollen storage studies; Suggested Reading
- Andey Pereira. 2006. *Plant Reverse Genetics*, Methods and Protocols, Humana Press
- Bisht *et al*. 2004. Broadening the genetic base of sesame (*Sesamum indicum* L.) through genetic enhancement. *Plant Genetic Resources* **2**(3): 143–151.
- Dale JW and von Schantz M. 2007. *From genes to genomes. Concepts and applications of DNA technology*. John Wiley & Sons Ltd., Chichester, England.
- Duvick DN. 1990. Genetic enhancement and plant breeding. p. 90–96. In: J. Janick and J.E. Simon (eds.), Advances in new crops. Timber Press, Portland.
- Goodman, RM. 2004. *Encyclopedia of plant and crop science*. Marcel Dekker Inc., Switzerland. Kimber, G and Feldman, M. 1987. *Wild Wheat: An introduction*. Special report 353, College of Agriculture, University of Missouri-Columbia.
- Lynch M. and Walsh B. 1998. *Genetics and analysis of quantitative traits*. Sinauer Associates Inc., MA, USA.
- Murphy D. 2007. *Plant breeding and biotechnology: Societal context and the future of agriculture*.

- Cambridge University Press, Cambridge, UK. Ram JS. 2010. *Plant Cytogenetics*. CRC Press.
- Ramanatha Rao V, Brown AHD, Jackson M. 2001. *Managing Plant Genetic Diversity*. CABI publication.
- Sharma S, Upadhyaya HD, Varshney RK, *et al*. 2013. Pre-breeding for diversification of primary gene pool and genetic enhancement of grain legumes. *Front. Plant Sci*. **4**: 309.
- Yunbi Xu. 2010. Molecular plant breeding, CABI publishers

e-Resources

https://www.integrated breed Planing. net/pre-breeding-effective-use-plant-genetic-resources http://www.croptrust.org/ http://www.bioversityinternational.org/training/training_materials/pre_breeding.htm http://www.grdc.com.au/director/research/prebreeding.

M.Sc. (Agri.) in Horticulture

Course Code	Course Title	Credit Hours
HRT 501	Major Tropical and Subtropical Fruits	3 (2+1)
HRT 502	Commercial Vegetable Crops	3 (2+1)
HRT 503	Production Technology of Major Commercial Flowers	3 (2+1)
HRT504	Major Spices and Plantation Crops	3 (2+1)
HRT505	Post - harvest Technology of Horticulture Produce	3 (2+1)
HRT 506	Protected Cultivation of Horticulture Crops	2 (1+1)
HRT 507	Growth and Development of Horticulture Crops	3 (2+1)
HRT 508	Principles and Practices of Dryland Horticulture	2 (1+1)
HRT 509	Organic Horticulture	2 (1+1)
HRT 510	Plant Tissue - culture and its Application in Commercial Production of Horticulture Crops	2 (1+1)
HRT 511	Propagation and Nursery Management of Fruit Crops	3 (2+1)
HRT 512	Minor Tropical and Subtropical Fruits	2 (1+1)
HRT 513	Breeding of Fruit Crops	3 (2+1)
HRT 514	Canopy Management in Fruit Crops	2 (1+1)
HRT 515	Minor Vegetable Crops	2 (1+1)
HRT 516	Breeding of Vegetables Crops	3 (2+1)
HRT 517	Seed Production Technology of Vegetable Crops	2 (1+1)
HRT 518	Production Technology of Medicinal and Aromatic Crops	3 (2+1)
HRT 519	Landscaping and Ornamental Gardening	3 (2+1)
HRT 520	Production Technology of Minor Commercial Flowers	2 (1+1)
HRT 521	Breeding of Flower Crops and Ornamental Plants	3 (2+1)
HRT 522	Fundamentals of Processing of Fruits and Vegetables	2 (1+1)
	Total	**56 (34+22)**
HRT 580	Qualifying Examination	2 (0+2)
HRT 581	Seminar - I	1 (0+1)
HRT 582	Seminar - II	1 (0+1)
HRT 591	Research - I	13 (0+13)
HRT 592	Research - II	14 (0+14)

HRT 501 MAJOR TROPICAL AND SUBTROPICAL FRUITS (2+1)

Objective

To impart basic knowledge about the importance and production technology of major tropical and subtropical fruits grown in India.

Theory

Block 1: Introduction, Fruit industry and institution on major tropical and sub tropical fruit crops

Unit I: Fruit industry, National and International scenario, export and import status.

Unit II: Classification based on climatic requirement, photo periodic response, tolerance to shade, photo thermal requirement, drought tolerance, salt tolerance, according to soil reaction, soil topography.

Unit III: Horticulture classification based on bearing habit, longevity, rate of respiration during ripening, size of the fruits, nutritional aspects, stem morphology, fruit morphology.

Unit IV: Botanical classification, based on morphological, cytological characters, floral biology, place of origin etc.

Block 2: Orchard planning, layout and management

Unit I: Site selection, climate, soil, irrigation facilities, fencing , wind breaks, roads and building.

Unit II: Layout

Unit III: Popular system of planting, adopted in orchards like square system, rectangular system, triangular / alternate system, quincunx / diagonal system, hexagonal system, contour system.

Unit IV: Planting distance, high density planting, selection of planting material and planting.

Unit V: Orchard management – soil management, mulching, intercropping, nutritional management, irrigation, fertigation.

Unit VI: Training and pruning, different training methods adopted

like central leader system, open center system, modified leader system, bower system etc. Pruning, thinning, weeding.

Block 3 : Production technology of major tropical fruit crops

Unit I: Importance, history, origin, area, distribution, production, propagation, harvesting of Mango, Banana, Papaya, Guava, Sapota and Jackfruit

Unit II: Special problems – Mango-irregular bearing and malformation, physiological disorders, post harvest technology, pest and diseases and their management.

Block 4 : Production technology of major sub-tropical fruit crops

Unit I: Importance, history, origin, area, distribution, production, Propagation, harvesting of Citrus, Grape and Pineapple

Unit II: Physiological disorders, post harvest technology, pest and diseases and their management.

Practicals

- Study of varieties and species.
- Propagation methods, Planting and after care.
- Study of flowering and fruit set.
- Identification of pests, diseases and their management.
- Hybridization techniques.
- Visit to progressive orchards and research centers may be arranged.

References

- EDMOND, J. B., SEN, T. L., ANDREWS, F. S. AND HALFACRE, R. G., 1981, *Fundamentals of Horticulture*, Tata McGraw Hill Publishing Co. Ltd., New Delhi
- JITENDRA SINGH, 2006, *Basic Horticulture, Kalyani Publishers, Ludhiana*
- JULES JANIK, 1999, *Basic Horticulture*
- BOSE, T. K., 2009, *Fruits of India: Tropical and Sub-tropical*, Noya Prokash Publishing Co., Kolkata

- NAIK, K. C., *South Indian Fruits and their culture*
- CHADHA, K. L., 2001, *Hand book of Horticulture*, IARI, New Delhi
- PRASAD AND KUMAR, 2010, *Principles of Horticulture 2nd Edition*, Agribos India Publication
- SAINI, G. S., 2010, *Plant Propagation and Nursery Management Husbandry,* Aman Publication.
- HARTMANN, H. T. AND KESTER, D. E., 1986, *Plant Propagation-Principles and Practices*, 4th Edition, Prentice-Hall, Inc., N.J., USA PP 727.

HRT 502 COMMERCIAL VEGETABLE CROPS (2+1)

Objective

To teach production technology of commercial vegetables

Theory

Block 1: Production technology of tomato, potato, eggplant, hot and sweet peppers

Unit I: National and International scenario, export and import status, importance, history, origin, area, distribution, taxonomy, improved varieties / hybrids production and culture of commercial vegetable crops.

Unit II: Climatic and soil requirements, sowing/planting, after care, water and nutrient requirements, fertigation and mulching, interculture, plant protection, inter-cropping and use of growth regulators.

Unit III: Harvesting and post-harvest technology, seed production, specific problems associated with different crops and prospects of improvement through breeding.

Block 2 : Production technology of carrot, radish, beetroot and sweet potato

Unit I: National and International scenario, export and import status, importance, history, origin, area, distribution, taxonomy, improved varieties / hybrids production and culture of commercial vegetable crops.

Unit II: Climatic and soil requirements, sowing/planting, after care, water and nutrient requirements, fertigation and mulching, interculture, plant protection, inter-cropping and use of growth regulators.

Unit III: Harvesting and post-harvest technology, seed production, specific problems associated with different crops and prospects of improvement through breeding.

Block 3: Production technology of cabbage, cauliflower, knol-khol, okra

Unit I: National and International scenario, export and import status, importance, history, origin, area, distribution, taxonomy, improved varieties / hybrids production and culture of commercial vegetable crops.

Unit II: Climatic and soil requirements, sowing/planting, after care, water and nutrient requirements, fertigation and mulching, interculture, plant protection, inter-cropping and use of growth regulators.

Unit III: Harvesting and post-harvest technology, seed production, specific problems associated with different crops and prospects of improvement through breeding.

Block 4 : Production technology of beans, cowpea, onion, garlic, leafy vegetables, amaranthus & palak

Unit I: National and International scenario, export and import status, importance, history, origin, area, distribution, taxonomy, improved varieties / hybrids production and culture of commercial vegetable crops.

Unit II: Climatic and soil requirements, sowing/planting, after care, water and nutrient requirements, fertigation and mulching, interculture, plant protection, inter-cropping and use of growth regulators.

Unit III: Harvesting and post-harvest technology, seed production, specific problems associated with different crops and prospects of improvement through breeding.

Block 5: Production technology of major cucurbitaceous vegetables, cucumber, gherkin, watermelon, muskmelon, bitter gourd, ash

gourd and pumpkin

Unit I : National and International scenario, export and import status, importance, history, origin, area, distribution, taxonomy, improved varieties / hybrids production and culture of commercial vegetable crops.

Unit II : Climatic and soil requirements, sowing/planting, after care, water and nutrient requirements, fertigation and mulching, interculture, plant protection, inter-cropping and use of growth regulators.

Unit III : Harvesting and post-harvest technology, seed production, specific problems associated with different crops and prospects of improvement through breeding.

Practicals

- Cropping systems
- Study of varieties/ hybrids
- Study of nursery techniques
- Seed treatment
- Role of growth substances in vegetable production
- *Rhizobium* inoculation
- Hardening of seedlings sowing/planting and after care
- Environmental factors limiting vegetable production
- Identification of pests and diseases and physiological disorders and their management
- Harvest and post-harvest technology
- Visit to progressive farms and research centers

Reference

- BOSE, T. K. AND SOM, M. G., Vegetable crops in India
- CHADHA, K. L. AND KALLOO, G. Advances in Horticutlure (Vol-V)
- CHAUHAN, D. V. S., Vegetables production in India.
- CHOUDHURY, B., Vegetables

- HAZRA, P. AND SOM, M., Technology for vegetable production and improvement
- SINGH, R.S., Diseases of vegetable crops.
- THAMBURAJ, S. AND SINGH, N., Text book of vegetable, tuber crops and spices.
- THOMPSON, H. C. AND KELLY, W. C., Vegetable crops.
- T. R. GOPALKRISHNAN. Vegetable crops

HRT 503 PRODUCTION TECHNOLOGY OF MAJOR COMMERCIAL FLOWERS (2+1)

Objective

To impart basic knowledge about the importance and production technology of commercial flowers grown in India

Theory

Block 1: Scenario of Floriculture industry

Unit I: Importance, scope and history of commercial flower crops

Unit II: Protected cultivation of commercial flower crops

Block 2: Production technology of Rose and Chrysanthemum

Unit I: Importance, history, origin, area, distribution, botany, taxonomy, varieties, classification and crop improvement.

Unit II: Climatic and soil requirements, propagation, rootstocks and problems of multiplication.

Unit III: Planting and after care, nutrition, training, pruning, pinching, disbudding, irrigation, intercropping, use of growth regulators and harvesting.

Unit IV: Physiological disorders, pests and diseases and their management.

Unit V: Protected cultivation of rose -climate, varieties, propagation, media, planting method, fertigation, pruning, defoliation,

disbudding, bending, use of growth regulators, harvesting, physiological disorders, pests and diseases and their management.

Block 3: Production technology of Carnation, Gerbera, Anthurium and Orchids

Unit I: Importance, history, origin, area, distribution, botany, taxonomy, varieties, classification and crop improvement.

Unit II: Protected cultivation of Carnation and Gerbera -climate, varieties, propagation, media, planting method, fertigation, special horticultural practices (wire netting, pinching, disbudding, leaf pruning, de-suckering) use of growth regulators, harvesting, physiological disorders, pests and diseases and their management.

Unit III: Protected cultivation of Anthurium and Orchids -climate, varieties, propagation, media, planting method, fertigation, de-suckering, use of growth regulators, harvesting, physiological disorders, pests and diseases and their management.

Block 4: Production technology of Gladiolus, Tuberose, Alstromeria and Lilliums

Unit I: Importance, history, origin, area, distribution, botany, taxonomy, varieties, classification and crop improvement.

Unit II: Climatic and soil requirements, propagation and problems of multiplication.

Unit III: Planting and after care, nutrition, staking, disbudding, irrigation, intercropping, use of growth regulators and harvesting.

Unit IV: Physiological disorders, pests and diseases and their management.

Block 5: Production technology of Jasmine, Crossandra, China aster and Marigold, Bird of Paradise and Heliconia

Unit I: Importance, history, origin, area, distribution, botany, taxonomy, varieties, classification and crop improvement.

Unit II: Climatic and soil requirements, propagation and problems of multiplication.

Unit III: Planting and after care, nutrition, irrigation, intercropping, use of growth regulators and harvesting.

Unit IV: Physiological disorders, pests and diseases and their management.

Practicals

- Identification, classification and description of commercial species and varieties of major commercial flower crops
- Propagation of commercial crops
- Pruning, pinching, disbudding and staking of commercial flower.
- Use of growth regulators.
- Harvesting, sorting, grading, storing and packing of flowers.
- Survey of different cut flower markets.
- Visit to commercial flower units and research centers

Reference

- S. K. BHATACHARJEE & L. C. DE., Advanced Commercial Floriculture
- S. PRASAD AND U. KUMAR., Commercial Floriculture
- Prof. M. M. SYAMAL., Commercial Floriculture
- T. K. BOSE, L. P. YADAV, P. PAL, P. DAS. AND V. A. Parthasarathy. Commercial Flowers Vol.1& Vol.2– Edited
- GOPALASWAMI IYENGAR, Complete Gardening in India
- J. PRAKASH AND K. R. BHANDALY, Floriculture – Technology, Trades and Trends
- T. K. BOSE, R. G. MAITI, R. S. DHUA AND P. DAS Floriculture and Landscaping

- DESH RAJ Floriculture -At Glance
- Dr. G. S. RANDHAWA AND A. MUKHOPADHYAY, Floriculture in India
- S. SARASWATHI, T. L. PRRETHI, BALASUBRAMANYAM, J. SURESH, N. REVATHY, S. NATARAJAN, Post harvest Technology of Horticultural Crops-
- Dr. T. VENKATESH REDDY AND Dr. C. G. NAGARAJA, Protected cultivation of Roses
- AMITABHA MUCHOPADHYAY, Roses
- B. P. PAL., The Rose in India

HRT 504 MAJOR SPICES AND PLANTATION CROPS (2+1)

Objective

To impart basic knowledge about the importance and production technology of spices and plantation crops grown in India.

Theory

Block 1: Major spices and plantation crops

Unit I: Role of spices and plantation crops in national economy, export potential, IPR issues, classification and varietal wealth..

Unit II: Plant multiplication including *in vitro* multiplication, systems of cultivation, multitier cropping, photosynthetic efficiencies of crops at different tiers, rainfall, humidity, temperature, light and soil pH on crop growth and productivity.

Block 2 : Production technology of Coffee, Cocoa and Tea

Unit I: Nutritional requirements, physiological disorders, role of growth regulators and macro and micro nutrients, water requirements, fertigation, moisture conservation, shade regulation, weed management,

training and pruning, crop regulation, maturity indices, harvesting .

Unit II: Cost benefit analysis.

Block 3 : Production technology of Cashew, rubber, oil palm, Coconut and arecanut

Unit I: Nutritional requirements, physiological disorders, role of growth regulators and macro and micro nutrients, water requirements, fertigation, moisture conservation, shade regulation, weed management, training and pruning, crop regulation, maturity indices, harvesting.

Unit II: Cost benefit analysis.

Block 4: Production technology of Black pepper, cardamom, turmeric and ginger

Unit I: Nutritional requirements, physiological disorders, role of growth regulators and macro and micro nutrients, water requirements, fertigation, moisture conservation, shade regulation, weed management, training and pruning, crop regulation, maturity indices, harvesting .

Unit II : Cost benefit analysis.

Block 5: Production technology of Clove, Cinnamon, nutmeg and seed spices

Unit I: Nutritional requirements, physiological disorders, role of growth regulators and macro and micro nutrients, water requirements, fertigation, moisture conservation, weed management, training and pruning, crop regulation, maturity indices, harvesting.

Unit II: Organic farming of major spices and plantation crops. Organic certification and quality analysis.

Unit III: Management of drought and precision farming.

Unit IV: Cost benefit analysis.

Practicals

- Study of varieties and species
- Propagation and nursery techniques

- Layout and planting
- Sex behavior
- Pollination and fruit set
- Breeding techniques
- Growth analysis and quality evaluation
- Identification of pests / diseases and their management
- Processing of plant products
- Visit to progressive plantation and research centers may be arranged.

Reference

- A. A. FAROOQI AND B. S. SREERAMU, Cultivation of Medicinal and Aromatic Crops (2006), Ed.:
- A. A. FAROOQI, B. S. SREERAMU AND K. N. SRINIVASAPPA, Cultivation of spice crops (2005), Ed.: Publishers: Universities Press, Hyderabad
- K. L. CHADHA, Hand Book of Horticulture (2003), Ed.: Published by ICAR
- V. A. PARTHASARATHY, P. K. CHATTOPADHYAY & T. K. BOSE, Plantation Crops Vol. 1 & Vol. 2 (2006), Ed.: Publishers: NayaUdyog, Kolkata
- Publishers: Universities Press, Hyderabad
- T. K. BOSE, S. K. MITRA, A. A. FAROOQI AND M. K. SADHU, Tropical Horticulture (1999), Vol. 1, Ed.: Publishers: NayaProkash, Kolkata.

HRT 505 POST-HARVEST TECHNOLOGY OF HORTICULTURE PRODUCE (2+1)

Objective

To facilitate deeper understanding on the principles and practices of post-harvest management of horticultural crops.

Theory

Block 1: Scope, Importance and of post harvest management of horticultural crops.

Unit I: Importance of post-harvest handling and management of horticultural produce, present status and future scope pre and post-harvest losses and their causes. Maturity standards/ Indices for harvesting. Physico chemical changes during development, ripening and storage. Impact of physiological processes associated with ripening and senescence. Bio-synthesis and sources of ethylene for ripening, Climacteric and non-climacteric fruits. Harvesting, handling, grading, packing and transportation of fresh produce like fruits and vegetables. Pre-cooling methods and storage requirements for fruits, vegetables and flowers.

Unit II: Harvesting, harvesting tools and their design aspects; curing, washing, sorting, grading of fruits, flowers and vegetables for local markets and export packaging of fresh and processed fruit and vegetable products, preservation by use of additives and chemical preservatives.

Block 2: Pre and Post-harvest treatments for extending storage life

Unit I: Use of protective coats, fungicides and chemicals. Control of ripening and senescence by growth regulators control of dormancy, sprouting and discoloration in vegetables.

Block 3: Post harvest physiology of horticulture produce

Unit I: Spoilage of fresh and processed horticultural produce; biochemical changes and enzymes associated with spoilage of horticultural produce; principal spoilage organisms, food poisoning and their control measures. Role of microorganisms, enzymes and water activity in food preservation.

Unit II: Cold storage, controlled atmosphere storage and hypobaric storage – equipments used. Preservation by freezing and irradiation.

Block 4: Post harvest handling of horticulture produce

Unit I: Principles of transport and commercial transport operations. Modes of transportation, types of vehicles, transit requirements for different horticultural produce. Marketing- factors influencing marketing of perishable crops, marketing systems and organizations.

Practicals

- Studies on morphological features of some selected fruits and vegetables.
- Study of maturity indices for harvest of fruits, vegetables, spices and plantation crops.
- Determination of physiological loss in weight and respiration rate in fruits and vegetables.
- Determination of RQ. Determination of chemical constituents like sugar, starch, pigments, vitamin C, carotenes, acidity during maturation and ripening in fruits/ vegetables.
- Estimation of ethylene evolved from ripening fruits. Hastening of ripening by ethereal treatments.
- Protective skin coating with wax emulsion and pre and post-harvest treatment with fungicides, chemicals and growth regulators to extend the shelf life of fruits and vegetables. Prepackaging, and VHT. Extension of vase life of cut flowers by use of chemicals and growth regulators. Control of sprouting of potato and onion by using growth regulators.
- Study of modern harvesting, sorting and grading equipments.
- Study of effect of pre-cooling on shelf-life and quality of fresh fruits, vegetables and flowers.
- Study of packages – bulk and consumer packs for different fruits, vegetables, flowers and spices.
- Visit to packaging centres.
- Visit to local markets, co-operative organisations like HOPCOMS, SAFAL, super markets dealing with marketing of perishables. Visit to CFTRI, Mysore.

References

- GIRIDHARI LAL, SIDDAPPA, G. S. AND TANDON, G. L., 2009, Preservation of fruits and vegetables, Popular Prakashan, Mumbai
- GULERIA, S. P. S. AND ANIL KUMAR VERMA, 2010, Question Bank on Post Harvest Technology, New India Publishing Agency, New Delhi.
- JACOB JOHN, P., 2012, A Hand book on Post Harvest Management of Fruits and Vegetables, Astral International Private Ltd., New Delhi
- RANGANNA, S., 2017, Handbook of analysis and quality control for fruit and vegetable products. II Edn., McGraw Hill Education (India) Pvt. Ltd., Bengaluru
- SATISH KUMAR SHARMA AND NAUTIYAL, M. C., 2009, Post harvest technology of horticultural crops: Practical manual Series - 2, New India Publishing Agency, New Delhi.
- SATISH KUMAR SHARMA, 2009, Post harvest management and processing of fruits and vegetables – Instant Notes, New India Publishing Agency, New Delhi.
- SRIVASTAVA, R. P. AND SANJEEV KUMAR, 2003, Fruits and Vegetable preservation - Principles and Practices, III Edn., International Book Distributing Co., Lucknow.
- SUDHEER, K. P. AND INDIRA, V., 2007, Post harvest technology of Horticultural Crops, New India Publishing Agency, New Delhi.
- SWATI BARCHE AND KAMAL SINGH KIRAD, 2014, Post Harvesting Handling of Fruits, Vegetables and Flowers, Jain Brothers, New Delhi
- VERMA, L. R. AND JOSHI, V. K., 2002, Post harvest technology of fruits and vegetables: Handling, processing, fermentation and waste management, Vol. 1 & 2, Indus Publishing Company, New Delhi.

HRT 506 PROTECTED CULTIVATION OF HORTICULTURAL CROPS (1+1)

Objective

Understanding the principles, theoretical aspects and developing skills in protected cultivation of horticultural crops.

Theory

Block 1: Scope and importance of Protected Cultivation of Horticultural Crops

Unit I: Introduction, history, present status, importance, problems and prospects of protected cultivation. Types and designs of protected structures and their management.

Unit II: Environment control in protected structures.

Unit III: Growing media and sterilization. Soilless cultivation, hydroponics and aeroponics. **Unit IV :**Irrigation, Fertigation and water management of green house crops.

Block 2: Hi-tech nursery - Vegetable seedlings production

Unit I: Protected structures, media, pro-trays, and environmental condition for commercial vegetable seedlings production under protection.

Block 3: Protected cultivation of horticulture crops

Unit I: Protected cultivation of flower crops : Rose, Carnation, Gerbera, Orchids, Anthurium. Lilium, Chrysanthemum, New ornamentals, growing filler materials like Limonium (statice), Ligianthus, Gypsophila, Fern, Asparagus, etc. ((media, bed preparation, varieties, planting, irrigation and fertigation, harvesting, specific operation for different crops and economics)

Unit II: Protected cultivation of vegetable crops: Capsicum, Tomatoes, Cucumber and other Exotic Vegetables. (media, bed preparation, varieties, planting, irrigation and fertigation, harvesting, specific operation for different crops and economics)

Block 4: Post harvest management of flowers and vegetables grown under protected cultivation

Unit I: Sorting, grading, packing, storage, transportation and marketing. Integrated insect pest and disease management.

Practicalsx

- Study of different protected structures, cladding materials used, installation and their management.
- Study of environment control devices used in protected structures and measurement of temperature, RH, light and CO2. Study of growing media and sterilization.
- Study of irrigation and fertigation system and their management.
- Soilless cultivation. Hydroponics and aeroponics.
- Vegetable seedlings production under protection.
- Cultivation of Crops under protected environment: Rose, Carnation. Gerbera, Orchid and Anthurium, Lilium and chrysanthemum, Capsicum, Tomatoes, Exotic vegetables.
- Study of filler materials like limonium(statice), ligianthus, gypsophila, fern, asparagus.
- Post harvest management of flowers and vegetable. Study of insect pests and diseases and their control.
- Visit to commercial green house projects

References

- D. K. SINGH AND K. V. PETER, Protected Cultivation of Horticultural Crops,
- Balraj Singh, Protected Cultivation of Vegetable Crops
- S. TYAGI AND S. SAHAY, Protected Cultivation of Flowers,
- M. K. JHA, S. S. PAIKRA AND M. R. SAHOO Protected Cultivation of Horticulture Crops,
- H. P. SINGH, G. SINGH, J. C. SAMUEL AND R. K. PATHAK, Precision farming in horticulture,
- BRAHMA SINGH, Precision Farming and Protected Cultivation,

HRT 507 GROWTH AND DEVELOPMENT OF HORTICULTURAL CROPS (2+1)

Objective

To develop understanding of growth and development of Horticultural crops which have implications in their management.

Theory

Block 1 : Growth and development of Horticultural crops

Unit I: Definition, parameters of growth and development, growth dynamics, morphogenesis.

Unit II: Annual, semi-perennial and perennial horticultural crops, environmental impact on growth and development, effect of light, photosynthesis and photoperiodism, vernalisation, effect of temperature, heat units, thermoperiodism.

Unit III: Assimilate partitioning during growth and development, influence of water and mineral nutrition during growth and development, biosynthesis of auxins, gibberellins, cytokinins, abscissic acid, ethylene, brasssinosteroids, growth inhibitors, morphactins, role of plant growth promoters and inhibitors.

Block 2: Physiology and biochemistry of Horticultural crops

Unit I: Developmental physiology and biochemistry during dormancy, bud break, juvenility, vegetative to reproductive interphase, flowering, pollination, fertilization and fruit set, fruit drop, fruit growth, ripening and seed development.

Unit II: Growth and developmental process during stress - manipulation of growth and development, impact of pruning and training, chemical manipulations in horticultural crops, molecular and genetic approaches in plant growth development.

Practicals

- Understanding dormancy mechanisms in seeds
- Tubers and bulbs and stratification of seeds, tubers and bulbs, visit

to arid, subtropical and temperate horticultural zones to identify growth and development patterns,

- Techniques of growth analysis, evaluation of photosynthetic efficiency under different environments
- Study of growth regulator functions, hormone assays, understanding ripening phenomenon in fruits and vegetables
- Study of impact of physical manipulations on growth and development
- Study of chemical manipulations on growth and development
- Understanding stress impact on growth and development.

References

- V. KUMAR, SATHYA PRAKASH, ARVINDA KUMAR AND R. K. NARESH, Growth and Development of Horticultural crops by
- K. L. CHADA, Hand Book of Horticulture
- P. BHATNAGAR., Physiology of Growth and Development of Horticultural crops

HRT 508 PRINCIPLES AND PRACTICES OF DRY-LAND HORTICULTURE (1+1)

Objective

Understanding the principles and practices of dry land horticulture.

Theory

Block 1: Introduction and importance of dry land horticulture

Unit I: Definition, importance and limitations of dry land horticulture, present status and future scope. Constraints encountered in dry lands. Agro-climatic features in rain shadow areas, scarce water resources, high temperature, soil erosion, run-off losses etc.

Block 2: Dry land water shed management in horticulture crops

Unit I: Techniques of development and management of dry land horticulture. Watershed development. Soil and water conservation

methods - terraces, contour bunds etc; methods of control and impounding of run off water - farm ponds, trenches, macro catch pits etc; in-situ water harvesting methods - micro catchments, different types of tree basins etc.

Block 3: Water stress manangement in dry land horticulture crops

Unit I: Methods of reducing evapo-transpiration - use of shelter belts, mulches, anti-transpirants, growth regulators etc. Water use efficiency - need-based, economic and conjunctive use of water, micro systems of irrigation etc.

Unit II: Selection of plants/crops having drought resistance/ tolerance characteristics.

Unit III: Special techniques of planting and after care - use of seedling races, root stocks, in situ grafting, deep pitting/planting, canopy reduction etc.

Practicals

- Water shed management practices in dry land horticulture: Contour bunding/trenching, microcatchments, soil erosion and its control.
- Study of evapo-transpiration, mulches and micro irrigation systems.
- Special techniques of planting and after care in dry lands.
- Study of morphological and anatomical features of drought tolerant horticulture crops.

References

- M. K. JATAV, P. L. SAROJ AND B. D. SHARMA Dry Land Horticulture
- A. SOLAIMALAI AND A. PALANISAMY., Dry Land Horticulture
- B. S. CHUNDAWAT., Textbook of dryland horticulture

HRT 509 ORGANIC HORTICULTURE (1+1)

Objective

To develop understanding of organic horticulture production system including GAP (Good Agricultural Practices).

Theory

Block 1: Introduction to organic horticulture

Unit I: definition, synonyms and misnomers, principles, methods, merits and demerits.

Block 2: Organic farming systems in horticulture.

Unit I: Organic farming systems, components of organic horticultural systems, different organic inputs, their role in organic horticulture, role of biofertilizers, biodynamics and the recent developments.

BLOCK 3: EM (Effective microorganism) technology

Unit I: EM (Effective microorganism) technology and its impact in organic horticulture, indigenous practices of organic farming, sustainable soil fertility management, weed management practices in organic farming, biological/natural control of pests and diseases, organic horticulture in quality improvement.

Block 4: Organic certification in horticulture crops

Unit I: GAP - Principles and management, HACCP (Hazard Analysis and Critical Control points) exercise, certification of organic products and systems, agencies involved at national and international levels, standards evolved by different agencies.

Unit II: Constraints in certification, organic horticulture and export, IFOAM (International Federation of Organic Agricultural Movement) and global scenario of organic movement, post-harvest management of organic produce.

Practicals

- Features of organic orchards, working out conversion plan
- Input analysis manures, nutrient status assessment of manures, bio-composting, bio-fertilizers and their application
- Preparation of panchagavya and other organic nutrients application
- Methods of preparation of compost, vermicompost, green manuring, preparation of neem products and application, BD (Bio dynamic) preparations and their role
- EM technology and products, biological/natural control of pests and diseases
- Good Agricultural /horticultural practices : Soil solarization, frame work for GAP (Good Agricultural Practices), case studies, HACCP analysis, residue analysis in organic products, documentation for certification,
- Visit to fields cultivated under organic practices.

References

- MAMTA BANSAL, Basics of organic farming
- S. P. PALANIAPPAN AND K. ANNADURAI, Organic farming, Theory and Practic
- S. R. REDDY, Principles of Organic Farming

HRT 510 PLANT TISSUE CULTURE AND ITS APPLICATION IN COMMERCIAL PRODUCTION OF HORTICULTURE CROPS (1+1)

Objective

Understanding the principles and practices in Tissue Culture and developing skills for commercial production of horticultural crops.

Theory

Block 1: Plant Tissue Culture - Principles and Practices

Unit I: Introduction, Significance, brief history, terminologies in plant tissue culture

Unit II: Regeneration pathways in tissue culture

Unit III: Techniques in tissue culture: Seed culture, Shoot - tip culture, Meristem culture, callus culture, cell culture, organ culture, Embryo culture, Anther culture, Pollen culture, Ovule culture etc.,

Block 2: Plant tissue culture media

Unit I: Components of Plant Tissue Culture Media - Macronutrients, Micronutrients, Organic supplements, sugars, pH of the media, Gelling agents.

Unit II: Plant Growth Regulators: Auxins, Cytokinins, Gibberellins, Ethylene, Abscisic Acid. Role of growth regulators in tissue culture.

Block 3: Micropropagation

Unit I: Definition stages of micropropagation, Advantages and disadvantages of micropropagation, Factors influencing in vitro cultures

Unit II : Methods in Micro propagation-Seed culture, Shoot - tip culture, Meristem culture, Node culture, direct organogenesis, indirect organogenesis, Direct embryogenesis, Indirect embryogenesis, Storage organ formation, Micrografting.

Block 4: Commercial micropropagation in Horticulture

Unit I: Commercial micropropagation techniques in selected Fruit crops, plantation and spice crops.

Unit II: Commercial micropropagation techniques in selected vegetable crops, flower crops, Medicinal and aromatic plants

Unit III : Problems and prospects of micropropagation with reference to high value Horticultural crops.

Practicals

- Layout of Plant Tissue Culture laboratory
- Designing laboratory for commercial production, Laboratory equipments and instruments, laboratory practices
- Media preparation, sterilization techniques, initiation and establishment of aseptic cultures and subculturing,
- Hardening, marketing, upkeeping of laboratory and hardening area
- Development of protocol for large scale production of horticultural crops.

References

- S. S. BHOJWANI AND P. K. DANTU, Plant Tissue Culture: An Introductory Text
- S. NAGAR AND MADHAVI ADHAV, Practical Book of Biotechnology and Plant Tissue Culture
- S. S. BHOJWANI AND M.K. RAZDAN Plant Tissue Culture: Theory and Practice

HRT 511 PROPAGATION AND NURSERY MANAGEMENT OF FRUIT CROPS (2+1)

Objective

Familiarization with principles and practices of propagation and nursery management for fruit crops.

Theory

Block 1: Principles of propagation for fruit crops

Unit I: Introduction, life cycles in plants, cellular basis for propagation, sexual propagation, apomixis, polyembryony, chimeras. Principles factors influencing seed germination of horticultural crops, dormancy, hormonal regulation of germination and seedling growth.

Unit II: Seed quality, treatment, packing, storage, certification,

testing. Asexual propagation – rooting of cuttings, factors affecting-Nutritional, physiological, anatomical and biochemical aspects of root induction in cuttings.

Block 2: Methods of propagation for fruit crops

Unit I: Layering – principles and methods, Budding and grafting – selection of elite mother plants, methods. Establishment of bud wood bank, stock, scion and inter stock, relationship – Incompatibility. Rejuvenation through top working – Progeny orchard and scion bank.

Unit II: Micro-propagation – principles and concepts, commercial exploitation in horticultural crops. Techniques - in vitro clonal propagation, organogenesis, meristem culture, somatic embryogenesis,. Hardening, packing and transport of micro-propagules.

Block 3: Nursery management for fruit crops

Unit I: Nursery – types, structures, components, planning and layout. Nursery management practices for healthy propagule production.

Practicals

- Study of seed germination and breaking dormancy
- Study of vegetative propagation methods
- Anatomical studies in rooting of cutting and graft union
- Construction of propagation structures
- Study of media and PGR. Hardening – case studies, micro propagation, explant preparation, media preparation, culturing – in vitro clonal propagation, meristem culture, shoot tip culture, axillary bud 15 culture, direct organogenesis, direct and indirect embryogenesis, hardening.
- Visit to TC labs and nurseries.

References

- H. T. HARTMANN, D. E. KESTER, F. T. DAVIES AND JR. R. L. GENEVE, Plant Propagation, Principles and Practices,

- R. R. SHARMA Propagation of Horticultural Crops, Principles and Practices,
- S. RAJAN AND B. L. MARKOSE, Propagation of Horticultural crops,
- J. S. BAL, S. S. GILL AND A. S. SANDHU, Raising Fruit Nursery
- R. R. SHARMA, Text book of plant propagation and nursery management

HRT 512 MINOR TROPICAL AND SUB TROPICAL FRUITS (1+1)

Objective

To impart basic knowledge about the importance and management of minor tropical and subtropical fruits grown in India.

Theory

Block 1: Production technology of minor tropical and sub-tropical fruit crops

Unit I: Importance, history, origin, area, distribution, area production and culture of pomegranate, fig, ber, annonanceous fruits, jamun, rose apple, jack fruit, bread fruit, passion fruit, West Indian cherry, karonda, wood-apple, bael fruit, Avocado, litchi, loquat, strawberry, carambola, rambutan, durian, mangosteen, langsat, bilimbi, tamarind, etc.

Block 2: Botany, taxonomy and propagation of minor tropical and sub-tropical fruit crops.

Unit I: Botany and taxonomy. Climatic and soil requirements. Propagation, root stocks and problem of large scale multiplication. Planting and after care. Training, pruning and nutrition.

Unit II: Pests - diseases and their management.

Unit III: Vegetative and reproductive phases, fruit set and fruiting. Developments in crop improvement.

Practicals

- Study of varieties and species.
- Propagation methods. Planting and after care.
- Study of flowering and fruit set.
- Identification of pests - diseases and their management.
- Visit to progressive orchards and research centre may be arranged.

References

- B. C. MAZUMDAR, Minor Fruit Crops in India: Tropical and Subtropical
- S. N. GHOSH, Minor Fruits : Nutraceutical Importance and Cultivation
- K. K. MISRA, A. KHOLIA. AND K. SATKAR, Minor Fruits

HRT 513 BREEDING OF FRUIT CROPS (2+1)

Objective

To impart comprehensive knowledge about the principles and practices of breeding of fruit crops.

Theory

Block 1: Taxonomical origin and distribution of fruit crops

Unit I: Origin and distribution, taxonomical status - species and cultivars, cytogenetics, genetic resources, blossom biology.

Unit II: Breeding systems, breeding objectives, ideotypes.

Unit III: Aapproaches for crop improvement - introduction, selection, hybridization, mutation breeding, polyploidy breeding, rootstock breeding, improvement of quality traits, resistance breeding for biotic and abiotic stresses, biotechnological interventions, achievements and future thrust in the following selected fruit crops.

Unit IV: Mango, banana and pineapple,

Unit V: Citrus, grapes, guava and sapota,

Unit VI: Jackfruit, papaya, custard apple, aonla, avocado and ber

Unit VII: Mangosteen, litchi, jamun, phalsa, raspberry and nuts

Unit VII: Apple, pear, plums, peach, apricot, cherries and strawberry.

Practicals

- Characterization of germplasm
- Study of floral biology, study of flower anthesis, estimating fertility status
- Practices in hybridization, ploidy breeding, mutation breeding, evaluation of biometrical traits and quality traits, screening for resistance, developing breeding programme for specific traits
- Visit to research stations working on tropical, subtropical and temperate fruit improvement.

References

- DHILLON, B. S., R. K. TYAGI., S. SAXENA. AND G. J. RANDHAWA., 2005, Plant Genetic Resources: Horticultural Crops. Narosa Publ. House., New Delhi.
- GUPTA, S. K., 2000, Plant Breeding. Theory and Techniques. Vedam Publishers, Solan.Harihar. Ram. 2001. Kumar, N. 2006. Breeding of Horticultural crops: Principles and Pracitices. New India Publishing Agency, Pitam Pura, NewDelhi.
- KUMAR, U. AND M. J. ASIJA., 2004, Biodiversity: Principles and Conservation Agrobios, Jodhpur.
- D. ROY, Breeding of fruit crops,
- B. NAIK AND R. K. TARA, Breeding of fruits and plantation crops
- R. K. RAMACHANDRA, V. NACHEGOWDA AND M. K. HONNABYRAIAH, Breeding of fruit crops
- N. KUMAR, Breeding of Horticultural Crops- Principles and Practices

HRT 514 CANOPY MANAGEMENT IN FRUIT CROPS (1+1)

Objective

To impart knowledge about the principles and practices in canopy management of fruit crops.

Theory

Block 1: Canopy management in fruit crops

Unit I: Canopy management - Importance and advantages; factors affecting canopy development.

Unit II: Canopy types and structures with special emphasis on geometry of planting, canopy manipulation for optimum utilization of light. Light interception and distribution in different types of tree canopies.

Unit III: Spacing and utilization of land area - Canopy classification; canopy management through rootstock and scion.

Unit IV: Canopy management through plant growth inhibitors, training and pruning and management practices.

Unit V: Canopy development and management in relation to growth, flowering, fruiting and fruit quality in temperate fruits, grapes, passion fruits, mango, sapota, guava, citrus and ber.

Practicals

- Study of different types of canopies
- Training of plants for different canopy types
- Canopy development through pruning
- Use of plant growth inhibitors
- Geometry of planting
- Study on effect of different canopy types on production and quality of fruits.

References

- T. K. CHATTOPADHYAY, A Text book on Pomology- Tropical Fruits Volume 2
- K. K. SRIVATAVA, Canopy Management in Fruit Crops,
- S. DIENGNGAN AND M. A. HASAN, Introductory Fruits and Orchard Management,
- MAYNARD SAMUEL TAYLOR, Orchard Management; Cover Crops in Orchards; Pruning of Orchards
- B. C. MAZUMDAR, Principles and Methods of orchrd establishment
- AKASH KUMAR AND H. S BAWEJA, Text book on orchard and estate management.

HRT 515 MINOR VEGETABLE CROPS (1+1)

Objective

To teach production technology of minor vegetables.

Theory

Block 1: Production technology of leguminous (Cluster bean, Winged bean, Dolichos, bean and Cowpea) and leafy vegetables (Lettuce, Methi, Coriander etc)

Unit I: Importance, history, origin, area, distribution, production. Taxonomy and varieties.

Unit II: Climatic and soil requirements, sowing/planting. after care, water and nutrient requirements, interculture, intercropping and use of growth regulators.

Unit III: Harvesting and post harvest technology and plant protection.

Unit IV: Seed production, specific problems and management of each crops and prospects of improvements through breeding.

Block 2: Production technology of Cassava, Colocasia, Amorphophallus, Dioscoria

Unit I: Importance, history, origin, area, distribution, production. Taxonomy and varieties.

Unit II: Climatic and soil requirements, sowing/planting. after care, water and nutrient requirements, interculture, intercropping and use of growth regulators.

Unit III: Harvesting and post harvest technology and plant protection.

Unit IV: Seed production, specific problems and management of each crops and prospects of improvements through breeding.

Block 3: Production technology of Tinda, Chow-chow, Little gourd, Snake gourd, Ridge gourd, Sponge ground and Oriental pickling melon

Unit I: Importance, history, origin, area, distribution, production. Taxonomy and varieties.

Unit II: Climatic and soil requirements, sowing/planting. after care, water and, nutrient requirements, interculture, intercropping and use of growth regulators.

Unit III: Harvesting and post harvest technology and plant protection.

Unit IV: Seed production, specific problems and management of each crops and prospects of improvements through breeding.

Block 4: Production technology of Broccoli, Brussel sprout, Perennial Vegetables (Drum Stick, Chow Chow, Coccinia, Curry Leaf etc)

Unit I: Importance, history, origin, area, distribution, production. Taxonomy and varieties.

Unit II: Climatic and soil requirements, sowing/planting. after care, water and, nutrient requirements, interculture, intercropping and use of growth regulators.

Unit III: Harvesting and post harvest technology and plant protection.

Unit IV: Seed production, specific problems and management of each crops and prospects of improvements through breeding.

Practicals

- Preparation of cropping scheme
- Study of varieties
- Study of nursery techniques sowing/planting and after care
- Identification of pests, diseases, physiological disorders and their management
- Harvesting and Post-harvest technology
- Visit to progressive farms and research centres

References

- GHOSH, S. P. RMANUJAM, T. JOS, J. S. MOORTHY, S. N. AND NAIR, R. G. Tuber Crops
- K. L. BHAT, Minor Vegetables Un tapped Potential
- JAMES M. STEPHENS, Manual of Minor Vegetables
- M. TOPWAL AND S. AGARWAL, Production technology of minor vegetables,
- M. K. RANA, Vegetable crop science
- INDIRA, P. AND K. V. PEETER, Uexploited tropical vegetables.

HRT 516 BREEDING OF VEGETABLE CROPS (2+1)

Objective

To educate principles and practices adopted for breeding of vegetable crops.

Theory

Block 1: Breeding of Potato and Tomato, Eggplant, Hot Pepper, Sweet Pepper

Unit I: Origin, botany, taxonomy, cytogenetics, male sterility and self-compatibility in plants-causes and implication in breeding

Unit II: Genetic basis of plant breeding, vegetables breeding objectives & breeding methods, issue of patenting, PPVFR act.

Unit III: Heterosis and hybrid breeding, resistance breeding for biotic and abiotic stress

Unit IV: Concept of bio-technology and its application in vegetable breeding.

Block 2: Breeding of Peas, Beans, Amaranth and Lettuce

Unit I: Origin, botany, taxonomy, cytogenetics, male sterility and self-compatibility in plants-causes and implication in breeding

Unit II: Genetic basis of plant breeding, vegetables breeding objectives & breeding methods, issue of patenting, PPVFR act.

Unit III: Heterosis and hybrid breeding, resistance breeding for biotic and abiotic stress

Unit IV: Concept of bio-technology and its application in vegetable breeding.

Block 3: Breeding of Cucumber, Melons, Gourds, Pumpkins and Squashes

Unit I: Origin, botany, taxonomy, cytogenetics, male sterility and self-compatibility in plants-causes and implication in breeding.

Unit II: Genetic basis of plant breeding, vegetables breeding objectives & breeding methods, issue of patenting, PPVFR act.

Unit III: Heterosis and hybrid breeding, resistance breeding for biotic and abiotic stress.

Unit IV: Concept of bio-technology and its application in vegetable breeding.

Block 4: Breeding of Cabbage, Cauliflower and Okra

Unit I: Origin, botany, taxonomy, cytogenetics, male sterility and self-compatibility in plants-causes and implication in breeding

Unit II: Genetic basis of plant breeding, vegetables breeding objectives & breeding methods, issue of patenting, PPVFR act.

Unit III: Heterosis and hybrid breeding, resistance breeding for biotic and abiotic stress.

Unit IV: Concept of bio-technology and its application in vegetable breeding.

Block 5: Breeding of Carrot, Beetroot, Radish, Sweet Potato

Unit I: Origin, botany, taxonomy, cytogenetics, male sterility and self-compatibility in plants-causes and implication in breeding.

Unit II: Genetic basis of plant breeding, vegetables breeding objectives & breeding methods, issue of patenting, PPVFR act.

Unit III: Heterosis and hybrid breeding, resistance breeding for biotic and abiotic stress.

Unit IV: Concept of bio-technology and its application in vegetable breeding.

Practicals

- Selection of desirable plants from breeding population
- Observations and analysis of various qualitative and quantitative traits in germplasm, hybrids and segregating generations
- Induction of flowering, palanological studies, selfing and crossing techniques
- Hybrid seed production of vegetable crops in bulk.
- Screening techniques for insectpests, disease and environmental stress resistance.

- Demonstration of sib-mating and mixed population
- Molecular marker techniques to identify useful traits in the vegetable crops
- Special breeding techniques.
- Visit to breeding blocks.

Reference

- DHILLON, B. S., R. K. TYAGI., S. SAXENA. NAD G. J. RANDHAWA., 2005, Plant Genetic Resources: Horticultural Crops. Narosa Publ. House., New Delhi.
- FAGERIA, M. S., P. S. ARYA. AND A. K. CHOUDHARY., 2000, Vegetable Crops: Breeding and Seed Production. Vol. I. Kalyani Publ.,New Delhi.
- GUPTA, S. K., 2000, Plant Breeding. Theory and Techniques. Vedam Publishers, Solan.Harihar. Ram. 2001. Vegetable Breeding. Kalyani Publishers, Ludhiana.
- Rana, M. K., 2011, Heterosis Breeding in Vegetable Crops. New India Publ. Agency, New Delhi. Breeding and Protection of Vegetables. New India Publishing Agency. New Delhi.
- KALLOO, G., 1994, Vegetable Breeding – Combined Edition – Panima Book Publishers, New Delhi.
- KALLOO, G. AND B. O. BERGH., 1993, Genetic improvement of vegetable crops. Elsevier Ltd 3. Peter, K.V. and T. Pradeepkumar. 2008. Genetics and Breeding of Vegetables, Revised, ICAR, New Delhi.
- KUMAR, N., 2006, Breeding of Horticultural crops: Principles and Pracitices. New India Publishing Agency, Pitam Pura, NewDelhi.
- KUMAR, U. AND M. J. ASIJA., 2004, Biodiversity: Principles and Conservation Agrobios, Jodhpur.
- PETER, K. V. AND T. PRADEEPKUMAR., 2008, Genetics and

Breeding of Vegetables, Revised, ICAR, New Delhi. Rai, N. and M. Rai. 2006.

- SINGH, P. K., S. K. DASGUPTA. AND S. K. TRIPATHI., 2004, Hybrid Vegetable Development. International Book Distributing Co., New Delhi.

HRT 517 SEED PRODUCTION TECHNOLOGY OF VEGETABLE CROPS (1+1)

Objective

To educate principles and methods of quality seed and planting material production in vegetable crops.

Theory

Block 1: Scope of vegetable seed industry in India

Unit I: Definition of seed and its quality, new seed policies; DUS test

Unit II: Categories of seed; maintenance of nucleus, foundation and certified seed; seed certification, seed standards; seed act and law enforcement, plant quarantine and quality control.

Block 2: Principles and methods of vegetable seed production

Unit I: Genetical and agronomical principles of seed production; methods of seed production; use of growth regulators and chemicals in vegetable seed production; floral biology, pollination, breeding behavior, seed development and maturation; methods of hybrid seed production.

UNIT II: Categories of seed; maintenance of nucleus, foundation and certified seed; seed certification, seed standards; seed act and law enforcement, plant quarantine and quality control.

UNIT III : Physiological maturity, seed harvesting, extraction, curing, drying, grading, seed processing, seed coating and pelleting, packaging (containers/packets), storage and cryopreservation of seeds, synthetic seed technology.

Block 3: Techniques for seed production in annual and biennial vegetables

Unit I: Solanaceous vegetables

Unit II: Cucurbits, okra, leafy vegetables

Unit III: Leguminous vegetables and root vegetables

Unit IV: Cole crops, bulb crops

Unit V: Root vegetables, and vegetatively propagated vegetables

Practicals

- Seed sampling, seed testing (genetic purity, seed viability, seedling vigour, physical purity) and seed health testing
- Testing, releasing and notification procedures of varieties
- Floral biology; rouging of off-type
- Methods of hybrid seed production in important vegetable crops
- Seed extraction techniques
- Handling of seed processing and seed testing equipments
- Seed sampling
- Testing of vegetable seeds for seed purity, germination, vigour and health
- Visit to seed processing units, seed testing laboratory and seed production farms.

Reference

- MORE T. A., KALE P. B. AND KHULE, B., Vegetable Seed production Technology
- AGRAWAL, R.L., Seed Technology
- HARIHAR RAM, RUPAUPADHYAY, R.K. DUBEY, B.C. MANDAL, Vegetable seed production -Principles and practices,
- Harihar Ram Vegetable Breeding -Principles and practices
- PHUNDAN SINGH, Principles of Seed Technology

HRT 518 PRODUCTION TECHNOLOGY OF MEDICINAL AND AROMATIC CROPS (2+1)

Objective

To impart comprehensive knowledge about the production technology of medicinal and aromatic crops.

Theory

Block 1: Introduction, herbal industry and institutions on medicinal plants

Unit I: Herbal industry, WTO scenario, Export and import status

Unit II: Indian system of medicine, Indigenous Traditional Knowledge, IPR issues, Classification of medicinal crops, Systems of cultivation, Organic production.

Unit III: Role of institutions and NGO's in production, GAP in medicinal crop production.

Block 2: Production technology of medicinal plants

Unit I: Propagation, production, harvesting of Senna, Periwinkle, Coleus, Aswagandha, Glory lily, Sarpagandha, Aloe vera, kalmegh. Isabgol, Poppy, Stevia, *Ocimum* sp.

Unit II: Post harvest handling – Drying, Processing, Grading, Packing and Storage, processing and value addition; GMP and Quality standards in herbal products.

Unit III: Influence of biotic and abiotic factors on the production of secondary metabolites, Regulations for herbal raw materials, Phytochemical extraction techniques.

Block 3: Introduction, aromatic industry and institutional support

Unit I: Aromatic industry, WTO scenario, Export and import status

Unit II: Indian perfumery industry, History, Advancements in perfume industry.

Unit III: Institutional support and international promotion of

essential oil and perfumery products.

Block 4: Production technology of aromatic crops

Unit I: Propagation, production, harvesting of palmarosa, lemongrass, citronella, vettiver, geranium, davana, mentha, ocimum, eucalyptus, rosemary, patchouli.

Unit II: Post-harvest handling, Distillation methods, advanced methods, Solvent extraction process, steam distillation, Perfumes from non-traditional plants, Quality analysis, Value addition, Aroma chemicals, quality standards and regulations.

Practicals

- Botanical description, propagation techniques and maturity standards of medicinal and aromatic plants
- Digital documentation of important medicinal and aromatic plants
- Project preparation for commercially important medicinal crops,
- Visit to medicinal crop fields,
- Visit to herbal extraction units. Extraction of Essential oils,
- Project preparation for commercially important Aromatic crops,
- Visit to distillation and value addition units – Visit to CIMAP.

References

- T. K. BOSE, S. K. MITRA, A. A. FAROOQI AND M. K. SADHU, Tropical Horticulture (1999), Vol. 1, Ed.: Publishers: NayaProkash, Kolkata
- K. L. CHADHA, Hand Book of Horticulture (2003), Ed.: Published by ICAR
- A. A. FAROOQI AND B. S. SREERAMU, Cultivation of Medicinal and Aromatic Crops (2006), Ed.: Publishers: Universities Press, Hyderabad.
- N. DEEPA DEVI, A Text Book of Medicinal and Aromatic Crops
- M. K. MOHIDEEN, Production Technology Of Medicinal And Aromatic Crops

HRT 519 LANDSCAPING AND ORNAMENTAL GARDENING (2+1)

Objective

Familiarization with principles and practices of landscaping and ornamental gardening.

Theory

Block 1: Types and styles of gardens

Unit I: Landscape designs & principles of gardening, types and styles of gardens, English, Mughal, Japanese, Persian, Italian.

Block 2: Landscaping for residential and public places

Unit I: Urban landscaping, Landscaping for specific situations, institutions, industries, residents, hospitals, roadsides, traffic islands, dam, sites, IT parks, corporates.

Block 3: Features of garden

Unit I: Features of garden, arboretum, shrubbery, fernery, palmatum, arches and pergolas, edges and hedges, climbers and creepers, cacti and succulents, herbs, annuals, flower borders and beds, ground covers, carpet beds, bamboo groves.

Block 4: Lawns

Unit I: Establishment and maintenance.

Block 5: Special types of garden

Unit I: Vertical garden, roof garden, bog garden, sunken garden, rock garden, Zen garden. Bio-aesthetic planning, eco-tourism, theme parks, indoor gardening, therapeutic gardening, non-plant components, water scaping, xeriscaping, hardscaping.

Practicals

- Selection of ornamental plants
- Practices in preparing designs for home gardens, institutional gardens, corporates, avenue planting
- Practices in planning and planting of special types of gardens

- Lawn making
- Planting herbaceous and shrubbery borders
- Visit to parks, botanical gardens, and commercial landscape gardens.

Reference

- ARORA, J. S., 2006, Introductory Ornamental horticulture. KalyaniPublishers
- BHATTACHARJEE, S. K., 2006, Advances in Ornamental Horticulture. Vols. I-VI. 2. Pointer Publ.
- BOSE, T. K., MAITI, R. G., DHUA, R. S, AND DAS, P., 1999, Floriculture and Landscaping. NayaProkashPublishers
- CHADHA, K. L. AND CHAUDHURY, B., 1992, Ornamental Horticulture in India. ICAR.
- CHADHA, K. L., 1995, Advances in Horticulture. Vol. XII. Malhotra Publ. House.
- LAURIA, A. AND RIES, V. H., 2001, Floriculture – Fundamentals and Practices. AgrobiosPublishers
- RANDHAWA, G. S. AND MUKHOPADHYAY, A., 1986, Floriculture in India. Allied Publ.
- REDDY, S., JANAKIRAM, B., BALAJI, T., KULKARNI, S. AND MISRA, R. L., 2007, Hightech Floriculture. Indian Society of Ornamental Horticulture, New Delhi.

HRT 520 PRODUCTION TECHNOLOGY OF MINOR COMMERCIAL FLOWERS (1+1)

Objective

To impart basic knowledge about the importance and management of minor commercial flowers grown in India.

Theory

Block 1: Production technology of Lotus, Amaryllis, Dahlia, Bird of paradise and Zantedeschia

Unit I: Importance, history, origin, distribution, area and production of minor commercial flowers

Unit II: Botany, taxonomy, varieties and their classification and crop improvement.

Unit III: soil and climatic requirements. propagation, planting and aftercare. Nutrition, irrigation, inter culture, weed control, use of growth regulators and harvesting.

Unit IV: Pests and diseases and their management.

Block 2: Production technology of Champka, Nerium and Helichrysum

Unit I: Importance, history, origin, distribution, area and production of minor commercial flowers

Unit II: Botany, taxonomy, varieties and their classification and crop improvement.

Unit III: soil and climatic requirements. propagation, planting and aftercare. Nutrition, irrigation, interculture, weed control, use of growth regulators and harvesting

Unit IV: Pests and diseases and their management.

Block3: Production technology of Gaillardia, Berlaria, Gomphrena and Antirrhinum

Unit I: Importance, history, origin, distribution, area and production of minor commercial flowers

Unit II: Botany, taxonomy, varieties and their classification and

crop improvement.

Unit III: soil and climatic requirements. Propagation, planting and aftercare. Nutrition, irrigation, interculture, weed control, use of growth regulators and harvesting.

Unit IV: Pests and diseases and their management.

Block 4: Production technology of Gypsophylla, Statice, Solidago, Michaelmus daisy

Unit I: Importance, history, origin, distribution, area and production of minor commercial flowers

Unit II: Botany, taxonomy, varieties and their classification and crop improvement.

Unit III: soil and climatic requirements. Propagation, planting and aftercare. Nutrition, irrigation, interculture, weed control, use of growth regulators and harvesting.

Unit IV: Pests and diseases and their management.

Practicals

- Identification, classification and description of commercial species and varieties.
- Studies on propagation.
- Use of growth regulators. Survey of cut flower markets.
- Harvesting, post harvest handling practice, and packing of flowers.
- Visit to commercial flower market and research centres may be arranged.

Reference

- ARORA, J. S., 2006, Introductory Ornamental horticulture. Kalyani Publishers.

- BHATTACHARJEE, S. K., 2006, Advances in Ornamental Horticulture. Vols. I-VI. 2. Pointer Publ.
- BOSE, T. K. AND YADAV, L. P., 1989, Commercial Flowers. Naya Prokash Publishers.
- BOSE, T. K., MAITI, R. G., DHUA, R. S. AND DAS, P., 1999, Floriculture and Landscaping. NayaProkashPublishers
- CHADHA, K. L AND CHAUDHURY, B., 1992, Ornamental Horticulture in India. ICAR.
- CHADHA, K. L., 1995, Advances in Horticulture. Vol. XII. Malhotra Publ. House.
- LAURIA, A. AND RIES, V. H., 2001, Floriculture – Fundamentals and Practices. AgrobiosPublishers
- PRASAD, S. AND KUMAR, U., 2003, Commercial Floriculture. AgrobiosPublishers
- RANDHAWA, G. S. AND MUKHOPADHYAY, A., 1986, Floriculture in India. Allied Publ.
- REDDY, S., JANAKIRAM, B., BALAJI, T., KULKARNI, S. AND MISRA, R. L. 2007, Hightech Floriculture. Indian Society of Ornamental Horticulture, New Delhi.

HRT 521 BREEDING OF FLOWER CROPS AND ORNAMENTAL PLANTS (2+1)

Objective

To impart comprehensive knowledge about the principles and practices of breeding of flower crops and ornamental plants.

Theory

Block 1: Introduction to breeding of flower crops

Unit I: Principles - Evolution of varieties, origin, distribution, genetic resources, genetic divergence-Patents and Plant Variety Protection in India.

Unit II: Genetic inheritance of flower colour, doubleness, flower size, fragrance, post harvest life.

Block 2: Breeding methods

Unit I: Breeding methods suitable for sexually and asexually propagated flower crops and ornamental plants - introduction, selection, domestication, polyploidy and mutation breeding for varietal development, role of heterosis, production of hybrids, male sterility, incompatibility problems, seed production of flower crops.

Block 3: Breeding constraints and achievements

Unit I: Breeding constraints and achievements made in commercial flowers - rose, chrysanthemum, carnation, gerbera, orchids, gladiolus, anthurium, jasmine, crossandra, china aster, marigold, tuberose, dahlia, liliums, alstroemeria.

Practicals

- Description of botanical features
- Cataloguing of cultivars, varieties and species in flowers, floral biology, selfing and crossing, evaluation of hybrid progenies, seed production
- Induction of mutants through physical and chemical mutagens, induction of polyploidy, screening of plants for biotic, abiotic stresses
- Environmental pollution, *in vitro* breeding in flower crops and ornamental plants.

References

- KUMAR, N., 2006, Breeding of Horticultural crops: Principles and Pracitices. New India Publishing Agency, Pitam Pura, NewDelhi.
- BHATTACHARJEE, S. K., 2006, Advances in Ornamental Horticulture. Vols. I-VI. Pointer Publ.
- DARBESHWAR, ROY., Breeding of OrnamentalCrops, 2019, Published by Narosa Publishing House,
- DE L. C., BHATTACHARJEE, S. K., 2011, 'Ornamental Crop Breeding', Published by Aavishkar Publishers & Distributors,
- KUMAR, U. AND M. J. ASIJA., 2004, Biodiversity: Principles and Conservation Agrobios, Jodhpur.

HRT 522 FUNDAMENTALS OF PROCESSING OF FRUITS AND VEGETABLES (1+1)

Objective

To educate about the principles and practices of processing of fruits and vegetables.

Theory

Block 1: Importance of processing of fruits and vegetables

Unit I: Importance of processing of fruits and vegetables. Indian and global scenario on production and processing of fruits and vegetables. History of food preservation, present status and future prospects of fruit and vegetable preservation industry in India.

Block 2: Raw materials for processing

Unit I: Quality requirements of raw materials for processing; sourcing and receiving at processing plants, primary and minimal processing, nutritive value of processed fruits and vegetables. Processing equipments, layout and establishment of processing industry, FPO license. Importance of hygiene; Plant sanitation.

Block 3: Principles and methods of preservation

Unit I: Principles and methods of preservation by heat, drying, chemicals, radiation, freezing, fermentation, etc., Important fruit and vegetable products. Preservation of fruit juices, beverages, pulp, puree and concentrates. Methods of preparation of confectionery and tomato products. Technology for fruit and vegetable based snacks; chips, wafers; processing of fruits for candies, bars, toffees, jams and jellies from locally available fruits. Major value added products from fruits and vegetables. management and utilization of horticulture waste and byproducts of fruit and vegetable processing industry.

Block 4: Food safety standards in processing

Unit I: Food safety – Hazard analysis and critical control points (HACCP), labeling, labeling act and nutrition labeling. Quality assurance and quality control, TQM, GMP, food standards – FPO, PFA, etc. food laws and regulations. Study of food standards – National, international, CODEX Alimentarius;

Unit II: Principles and methods of sensory evaluation of fresh and processed fruits and vegetables.

Unit III: GAP - Principles and management.

Unit IV: Investment analysis.

Practicals

- Study of machinery and equipments used in processing of horticultural produce
- Chemical analysis for nutritive value of fresh and processed fruits and vegetables.
- Preparation and preservation of fruit based beverages and blended products from fruits and vegetables.
- Evaluation of pectin grade; preparation and quality evaluation of fruit jam.
- Preparation of papain.
- Preparation of dehydrated vegetables.

- Study of different types of spoilages in fresh as well as processed horticultural produce; Classification and identification of spoilage organisms
- Study of biochemical changes and enzymes associated with spoilage
- Laboratory examination of fruit and vegetable products
- Sensory evaluation of fresh and processed fruits and vegetables
- Visit to processing units to study the layout, equipments, hygiene, sanitation and residual / waste management.

Reference

- R. P. SRIVASTAVA AND SANJEEV KUMAR, Fruits and vegetable preservation –Principles and practices
- F. YILDIZ AND R. C.WIILEY, Minimally processed refrigerated fruits and vegetables
- N. S. RATHORE, G. K. MATHUR AND S. S. CHASTA, Post harvest management and processing of fruits and vegetables

M.Sc. (Agri.) in Microbiology

Course Code	Course Title	Credit Hours
MIC 501	Techniques in Microbiology	2 (0+2)
MIC 502	Principles of Microbiology	4 (3+1)
MIC 503	Microbial Physiology and Metabolism	4 (3+1)
MIC 504	Microbial Genetics	3 (2+1)
MIC 505	Soil Microbiology	3 (2+1)
MIC 506	Microbial Biotechnology	3 (2+1)
MIC 507	Food Microbiology	3 (2+1)
MIC 508	Bacteriophages	2 (1+1)
MIC 509	Environmental Microbiology	3 (2+1)
MIC 510	Industrial Microbiology	3 (2+1)
MIC 511	Bio fertilizer Technology	3 (2+1)
MIC 512	Cyanobacteria and Algal Biotechnology	2 (2+0)
	Total	**35 (23+12)**
MIC 580	Qualifying Examination	2 (0+2)
MIC 581	Seminar - I	1 (0+1)
MIC 582	Seminar - II	1 (0+1)
MIC 591	Research - I	13 (0+13)
MIC 592	Research - II	14 (0+14)

MIC 501 TECHNIQUES IN MICROBIOLOGY (0+2)

Objectives

1. To introduce various techniques and methods required for the study of microorganisms.
2. To provide hands on training on techniques and methods used in the microbiological laboratory such as preparation of different culture media, isolation, purification, culturing and characterization of microorganisms of microorganisms isolated from different environmental samples.

3. To hone skills in the use of microscopes, spectrophotometers, chromatography and electrophoresis.

Theory

Principles of light and electron microscopy. Study of different types of light and electron microscopes. Enumeration microorganisms from water, soil, air, *etc*. Operation and care of microscopes. Preparation of bacterial smears, fungal slides and their morphological observations using a microscope. Micrometry. staining techniques. Study of Biochemical characteristics, culture media *etc*, Laboratory culturing of microorganisms. Water potability tests.

Practicals

Awareness about lab safety measures. Study of general microbiological equipments, cleaning of glassware and apparatus for laboratory use. Methods of sterilization used in Microbiology laboratory

Use of simple techniques in the laboratory (Colorimetry, Centrifugation, electrophoresis and chromatography). Types of culture media. Isolation techniques and direct microscopic count. Staining techniques - simple staining, negative staining, Gram stain, and acid-fast staining, flagella, capsule, staining and inclusion bodies.

Environmental factors affecting bacterial growth: physical, chemical, temperature, pH, osmotic pressure, light (UV), and bacteriostatic agents. Bacteriology of air, water and soil. Characteristics of important types of micro-organisms: major functional groups of bacteria, lactic acid, spore-forming, and coliforms bacteria, yeasts, and molds.

Assessment of microbial quality of potable water. Handling of microscopes.

Differential, selective media for bacteria fungi and algae. Enrichment culture technique. Isolation and enumeration of microorganisms using pour plate streak plate and spread plate techniques. Culturing of anaerobic bacteria, Pure culture techniques. Preservation of microbial cultures

References

- BROCK, T.D. 2008. *Biology of Microorganisms* (Ed.) Madigan MT, Martinko J M, Dunlap PV, Clark D.P., 12th ed. Pearson, New Jersey.
- PELCZAR, M.J. JR., CHAN, E.C.S. AND KREIG, N.R. 1997. *Microbiology, Concepts and Application*, 5th edition, Tata McGraw Hill, NewYork.
- PRESCOTT, L.M.,HARLEYANDKLEIN.2002.*Microbiology*5th Edition, Tata Mc GrawHill, NewYork.
- MADIGAN, M.T., KELLY, S. B., DANIEL, H. B., SATTLEY, W. M., STAHL, D. A., 2021. *Brock Biology of Microorganisms* 16th Ed. Pearson Education lnc,USA.
- TORTORA, G.J., B.J. FUNKE AND C.L. CASE. 2010. *Microbiology: An Introduction*.10th Ed. Benjamin Cummings., NewYork.

MIC 502 PRINCIPLES OF MICROBIOLOGY (3+1)

Objectives

1. To understand the history and scope of microbiology and contributions of different scientists to the development of microbiology.
2. To understand the working principles and provide practical skills in the use of different types of microscopes.
3. To understand evolutionary link of prokaryotes including phylogenetic classification and use of DNA and RNA sequencing in bacterial classification
4. To provide an insight into microbial growth, characterization and regulation.

Theory

Block 1: Scope and History of Microbiology and Microscopy.

Unit 1: Scope of Microbiology

Scope of Microbiology, microbes and microbiologist. Emergence of special fields of Microbiology.

Unit 2: History routes the Germ Theory of Disease, Early studies: Pasteur's further contributions, Koch's contributions, work toward controlling infections, spontaneous generation theory.

Unit 3: Staining and Microscopy

Microscopy; Bright field, Dark field, Phase contrast, Confocal, Fluorescence, TEM, SEM - Working principles and applications; Properties of light; Simple staining, differential and special staining.

Block 2: Evolutionary Link of Prokaryotes

Unit1: Phylogenetic classification

Evolutionary relationship among prokaryotes. Prokaryotes and Eukaryotes, Phylogenetic and numerical taxonomy. Species concept.

Unit 2: Methods of sequencing

Use of DNA and r-RNA sequencing in classifications.

Block 3:Microbial Growth, Characterization and Regulation

Unit1: Microbial Growth and Reproduction

Microbial growth and reproduction-communication, bacteria, yeast and virus growth, replication, cultivation methods, Normal microbiome of Human body; Immune response- specific and non-specific host resistance.

Unit 2: Sterilization techniques

Physical and chemical methods of sterilization.

Unit 3: Nutritional requirements for microbial growth

Classification of microbes: electron, energy and carbon sources.

Practicals

Working principles and handling of different types of microscopes - Bright and Dark field microscopy

Working principles and handling of different types of microscopes- SEM and TEM.

Methods of isolation from different environments soil, water, milk and food.

Use of selective media for isolation of bacteria, fungi and algae

Purification techniques of bacteria and fungi

Enumeration and quantification techniques

Maintenance and preservation of cultures

Assessment of microbial quality of potable water

Morphological characterization of bacteria

Morphological characterization of fungi

Biochemical characterization of bacteria and fungi

References

- BROCK, T. D. 2008. *Biology of Microorganisms* (Ed.) Madigan MT, Martinko J M, Dunlap P V, Clark DP, 12th ed. Pearson, NewJersey.
- PELCZAR, M. J. J. R., CHAN, E. C. S. AND KREIG, N. R. 1997. *Microbiology, Concepts and Application*, 5th edition, Tata McGraw Hill, New York.
- MADIGAN, M. T., J. M. MARTINKO, P.V. DUNLAP AND D.P. CLARK.2001. *Brock biology of Microorganism* 10th Ed. Pearson Education lnc, USA.
- TORTORA, G. J., B.J. FUNKE AND C.L. CASE. 2010. *Microbiology: an introduction*.10th Ed. Benjamin Cummings., NewYork
- ALEXOPOULUS, C. J. AND C. W. MIMS. 1993. *Introductory Mycology* (3rd edition). Wiley Eastern Ltd, NewDelhi.
- WEBSTER, J. 1993. Introduction to Fungi. (2ndedition). Cambridge University press, Cambridge.
- PELCZAR, JR, M. J. CHAN, E. C. S. AND KREIG, N. R. 1993. *Microbiology*, Mc. Graw Hill. Inc, New York.
- MADIGAN, M. T, BENDER, K. S, BUCKLEY, H. D, SATTLEY, W. M, STAHL, D. A. 2017. *Brock Biology of Microorganisms* - 15th edition. Pearson Education, USA.

MIC 503 MICROBIAL PHYSIOLOGY AND METABOLISM (3+1)

Objectives

1. To understand the scope of microbial physiology and growth, different metabolic pathways in microbes and their significance.
2. To provide insights in to bioenergetics of carbohydrate utilization and different metabolic patterns in microorganisms with suitable examples.
3. To study enzyme kinetics and microbial metabolism including biosynthesis of ATP.

Theory

Block 1: Scope of Microbial Growth and Physiology

Unit 1: Structure, function and biosynthesis of cellular components - Microbial nutrition

Chemical composition of microbial cell – Structure, function and assembly of cell membrane in prokaryotes, archaea and fungi – Macro and Micro- nutrients and their physiological functions – Transport of solutes across the membrane.

Block 2: Pathways and their Significance; Growth Kinetics and Nutritional Classifications

Unit 1: Growth Kinetics, cell cycle, cell division, pathways and fermentation metabolism.

Microbial growth. Cell cycle and cell division. Bioenergetics - carbohydrate utilization via EMP, HMP, ED, TCA pathways, Aerobic and anaerobic respiration. Fermentative metabolism. Assimilation of nitrogen and Sulphur - Oxygenic and anoxygenic photosynthesis Mechanisms of carbon-dioxide fixation in prokaryotes. Ethanol, lactic acid, butanol, acetone and mixed acid fermentation. Fermentation of nitrogenous organic compounds. Regulation of microbial metabolism

Unit 2: Growth and factors affecting growth and culture systems

Effects of physical, chemical and other environmental factors on bacterial growth, Continuous culture, Diauxic growth and Synchronous

culture. Methods of growth measurement. Morphogenesis and cellular differentiation.

Unit 3: Nutritional classification and spore formation and germination

Metabolic diversity in photoautotrophs, photo heterotrophs, chemoautotrophs and chemoheterotrophs. Nutritional grouping/ classification of microorganisms. Bacterial endospore-types, morphology, biochemistry and regulation of formation and germination.

Block 3: Enzymes and Microbial Metabolism

Unit 1: Kinetics and mechanism of enzymes

Enzyme kinetics: Michaelis Menten kinetics - mechanisms of inhibition of enzyme activity - coenzymes and prosthetic groups.

Unit 2: Microbial metabolism

Methods to determine free energy of biochemical reactions - high energy compounds. Microbial metabolism: generation of ATP, reducing power, development of proton gradient and biosynthesis of ATP.

Block 4: Synthesis of Macromolecules

Unit 1: Biosynthesis of macromolecules - Synthesis and assembly of cell wall components Methods of studying biosynthesis - regulation of MBL Metabolism.

Practicals

Use of simple techniques in laboratory (Colorimetry, Centrifugation, electrophoresis & GLC) etc.,

Determination of viable and total number of cells

Measurement of cell size

Gross cellular composition of microbial cell

Growth – Factors affecting growth

Study of bacterial spores and factors affecting germination

Enzyme activity and kinetics – calculating Km and Vmxx of an enzyme

Demonstration of growth of thermos-, meso-, and psychrophilic microorganisms

Production and testing of inducible enzymes in bacteria

Sporulation and spore germination in bacteria

Protoplasts formation and regeneration

Determination of generation time and specific growth rate for bacteria and yeast

Diauxic growth curve

Production of synchronous cells

Effect of chemicals and environmental factors on bacterial growth

Isolation and Identification of reserve food material (Glycogen / polyphosphates, PHB) from bacteria (*Azotobacter*, *Bacillus megaterium*)

Growth of microorganisms on various carbon and nitrogen sources

References

- MOAT, A.G.AND J.W. FOSTER.2002. *Microbial Physiology*. John Wiley& Sons, New York, USA. 11th ed. Prentice-Hall, Inc. Englewood Cliffs, New Jersey.
- MADIGAN, M.T, J.M. MARTINKO AND J. PARKER. 2006. *Brock: Biology of Microorganisms*, 11th ed. Prentice-Hall, Inc. Englewood Cliffs, New Jersey.
- WHITE, D. 2007. *The Physiology and Biochemistry of Prokaryotes*, 3rd Edition. Oxford University Press.
- DOWNS, D. M. 2006. *Understanding microbial metabolism*. Annual Review of Microbiology 60,533–559.
- DOELLE, H. W. 1969. *Bacterial Metabolism*. Academic Press.
- GOTTSCHALK, G.. 1979. *Bacterial Metabolism.* Springer Verlag.
- VOET, D. AND VOET, J. G. 2002. *Fundamentals of Biochemistry*, Upgrade Edition, Wiley.

MIC 504 MICROBIAL GENETICS (2+1)

Objectives

1. To provide an understanding of fundamental concepts in microbial genetics
2. To Identify and distinguish genetic regulatory mechanisms at different levels of gene expression.
3. To familiarize the students on how microbial genetics has advanced science and society.
4. To give an overview of how bacteria regulate gene expression - providing detailed examples of important regulatory systems.

Theory

Block 1: Introduction to Microbial Genetics

Unit 1: Historical perspectives of microbial genetics

Introduction to microbial genetics; historically important events and major contributions of scientists in the field of microbial genetics; terminologies employed in microbial genetics and definitions; Nucleic acid – overview of DNA, RNA.

Unit 2: Genome of prokaryote, eukaryote (fungi) and virus

Bacterial genome eukaryotic genome; viral genome; differences between prokaryotic and eukaryotic genome; mechanisms and role of prokaryotic genome- an overview.

Unit 3: Genetic elements

chemical structure and property, enzymes associated and replication Structure of DNA - A form, B form, Z form; RNA- t RNA, m RNA, r RNA; Role and Replication of DNA and RNA; Enzymes involved in replication and its role.

Unit 4: Extra-chromosomal DNA in bacteria and eukaryotic cells: Plasmids, Mitochondrial DNA, Chloroplast DNA – structure and function.

Block 2: Gene Expression and Regulation

Unit 1: Introduction to gene structure and expression

Gene structure and expression, principles of operon, gene expression in prokaryote and eukaryotes, intron and exons, post-transcriptional modifications.

Unit 2: Regulation of gene expression

Regulation of gene expression, negative regulation (*lac* operon and *trp* operon), positive regulation (c AMP).

Block 3: Mutation, Genetic Recombination and Sequencing

Unit 1: Mutation and types

Spontaneous and induced mutation, different types of mutations, selection principles of mutants.

Unit 2: Mutagens and their mode of action

Mutagens and their mode of action, transposable genetic elements: IS elements and transposons, transposition models.

Unit 3: DNA damage

DNA repair mechanisms DNA damage, DNA repair mechanisms in bacteria.

Unit 4: Genetic recombination in bacteria

Genetic recombination in bacteria, mechanisms of recombination, transformation, conjugation, transduction.

Unit 5: Gene sequencing

Gene cloning and gene sequencing. Impact of gene cloning in agriculture and human welfare, polymerase chain reaction, DNA sequencing, recombinant DNA technology.

Practicals

Isolation of genomic DNA from pure cultures of bacteria and fungi.

Isolation of bacterial plasmids and Plasmid curing.

Qualitative and quantitative assay of DNA by spectrometry and gel-electrophoresis.

Inducing mutation by chemicals, physical and biological agents, Replica plating technique and isolation of auxotrophic mutants.

Transformation and selection of transformants.

Replica plating technique and isolation of auxotrophic mutants

Amplification of gene of interest by PCR- cloning and expression.

Isolation of metagenomic DNA from environmental samples.

References

- BROWN, T. A. 2001. *Gene Cloning and DNA Analysis: AnIntroduction*. Fourth Edition. Black well Science Inc., Oxford, UK.
- LEVIN, B. 2002. *Gene VIII*. Oxford Univ. Press, New York.p.990.
- MALOY, S. R, CRONAN, J. E., FREIFELDER, D. 2008. *Microbial Genetics* - second edition. Narosa Publising house, New Delhi. p.525.
- SAMBROOK, J, FRITSCH, E. F, MANIATIS, T. 2000. *Molecular Cloning: A laboratory Manuel*. Third Edition. Cold Spring Harbor Press, NewYork.
- Streips, U. N, Yasbin, R. E. 2006. *Modern Microbial Genetics*. Wiley – Liss. John Wiley & sons, Inc. Publication, NY.
- BIRGE, E. A. 1981. *Bacterial and Bacterio phage Genetics*. Springer Verlag.
- GARDNER, J. E, Simmons M J and Snustad D P. 1991. *Principles of Genetics*. John Wiley & Sons.
- LEWIN, B.1999. *Gene*. Vols. VI-IX. John Wiley &Sons.

MIC 505 SOIL MICROBIOLOGY (2+1)

Objectives

1. To provide an insight in to historical perspectives of soil microbiology, Ecology and factors affecting soil microorganisms.
2. To study the role of micro organisms in the ecosystem functioning, nutrient cycling and biogeochemical processes including soil enzymes, through their metabolic activity and interactions.

Theory

Block 1: Developments in Soil Microbiology and Soil Parameters

Unit 1: Historical prospective of soil microbiology. Factors affecting soil microorganisms.

Landmarks in the history of soil microbiology. Abiotic factors (physical and chemical) affecting soil microorganisms such pH, chemicals, moisture, air, temperature *etc*.

Unit 2: Ecology of soil microorganisms

Soil biota, Soil microbial ecology, types of organisms in different soils; Soil microbial biomass; Microbial interactions: un culturable soil biota.

Block 2: Microbiology and Biochemistry of Plant Parts

Unit 1: Plant parts and soil interface interactions, Microbiology and biochemistry of root-soil interface; phyllosphere, plant growth promoting rhizo bacteria, soil enzyme activities and their importance.

Block 3: Role of Microorganisms in Nutrient cycles

Unit 1: Microbial transformation of various nutrients

Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil. Siderophores and antimicrobials.

Unit 2: Microbial degradation of organic matter

Biochemical composition and biodegradation of soil organic matter and crop residues.

Unit 3: Microbial diversity

Endophytic microorganisms Mycorrhizae, types and role in phosphate mobilization. Potassium releasing bacterium. Microbes in biotic and abiotic stress management.

Unit 4: Role of microorganisms in biodegradation of xenobiotics and pesticides

Biodegradation of pesticides and organic wastes, and their use for the production of biogas and manures.

Practicals

Enumeration of microbial population in rhizosphere, phyllosphere Determination of soil microbial biomass.

Decomposition studies in soil, Soil enzymes and their roles nutrient mineralization pesticide degradation by soil microorganisms

Measurement of important soil microbial processes such as ammonification, nitrification, N_2 fixation, S - oxidation, Phosphate solubilization and mineralization of other micro nutrients such as Fe and Mn

Study of rhizosphere effect diversity of endophytic microorganisms

Mycorrhizae types and role in phosphate mobilization Potassium

releasing bacterium Microbes in biotic and abiotic stress management

References

- PAUL EA. 2015. *Soil Microbiology, Ecology and Bio chemistry*. Elsevier
- JAN DIRK VAN ELSAS, TREVORS JT AND ELIZABETH M.H. WELLINGTON, 1997. *Modern Soil Microbiology*. Marcel Dekker,Inc.
- PAUL EA. 2007. *Soil Microbiology and Biochemistry* 3rd Edition. AcademicPress.

MIC 506 MICOBIAL BIOTECHNOLOGY (2+1)

Objectives

1. To provide insights into scope of microbial biotechnology including fermentation, fermentor designs, operations and fermentation systems.
2. To update the current development in the production of recombinant products and recent advances in microbial biotechnology including concept of probiotics and applications of new tools of biotechnology for quality feed/food production.

Theory

Block 1: Scope of Microbial Technology and Fermentation Metabolism.

Unit1: Microbial Biotechnology

Introduction, Scopes, historical development, application and challenges.

Unit 2: Fermentation metabolism

Fermentation metabolism, isolation, preservation screening and genetic improvement of industrially important microbes; Microbial growth kinetics.

Unit 3: Fermentor /bioreactor design and operation

Fermentors - types of fermentors, stirred tank reactor, bubble column reactor, airlift reactor, packed bed reactor, fluidized bed reactor and trickle bed reactor, agitation and aeration in a reactor, mass transfer. Foam formation and control.

Unit 4: Fermentation System

Types, batch, fed batch and continuous fermentation - multistage system. Solid state fermentation, Overproduction of primary and secondary metabolites *e.g*., amino acids, organic acids, alcohols, enzymes, organic solvents, antibiotics, *etc*. Immobilization of enzymes and cells; scale-up principles; down-stream processing *etc*.

Block 2: Recombinant Products

Unit 1: Production of recombinant Products

Current advances in production of antibiotics, vaccines, and biocides; Steroid transformation; Bioprocess engineering; Production of recombinant DNA products, Immobilization techniques.

Block 3: Microbial Conversion and their Product Formation

Unit 1: Industrial production of beverages, acids, antibiotics and solvent

Production of alcohol (ethanol, wine and beer) and improvement by genetic engineering. Microbial production of acids (citric, acetic and gluconic acid) solvents(glycerol, acetone, and butanol) aminoacids (lysine and glutamic acid). Industrial production of antibiotics.

Unit 2: New tools and recent advances in microbial biotechnology

Concept of probiotics and applications of new tools of biotechnology for quality feed/food production; Microorganisms and proteins used in probiotics; Lactic acid bacteria as live vaccines; Bioconversion of substrates, anti-nutritional factors present in feeds;

Microbial detoxification of aflatoxins; Microbial polysaccharides: fermentative production of xanthan gums. Bacterial bio-plastics, genetic engineering of microorganisms for the production of poly-3 hydroxy alkanoates. Single cell protein, bio-insecticides; Bio-fertilizers; waste as source of energy /food microbiologically- produced food, colours, and flavours. retting of flax. Silage making, Recent advances in microbial biotechnology.

Practicals

Isolation and maintenance of industrially important microbes

Production of alcohol

Production of beer

Production of citric acid

Production of lactic acid

Standardization of physical factors for the higher production of citric acid

Production and assay of antibiotics

Production of dextran and pullulan

SCP production

Study of bioreactors and their operation

Genetic improvement of industrially important micro-organisms

Visit to antibiotic industries / wineries / breweries *etc*.

References

- CRUGER, W. AND CRUGER A. 2004. *Biotechnology - A Textbook of Industrial Microbiology*. 2nd Ed. Panima.
- WARD, O. P. 1989. *Fermentation Biotechnology*. Prentice Hall.
- WISEMAN, A. 1983. *Principles of Biotechnology.* Chapman &Hall

MIC 507 FOOD MICROBIOLOGY (2+1)

Objectives

1. To provide knowledge of microorganisms associated with foods and their origin and role; Knowledge of the factors that determine the presence, growth and survival of micro organisms in food.
2. To impart knowledge about fermentation techniques used in dairy industry, role of micro organisms in fermentation and to gain skills to control fermentation process.
3. To familiarize the students with recent advances in food microbiology including fermented foods, dairy, food preservation, detection of food- borne diseases, their control measures.

Theory

Block 1: Historical Perspective and Scope of Microbiology in Relation to Food

Unit 1: Importance and significance of microorganisms in food

Introduction and scope of Food Microbiology, Important microorganisms in food and their sources. Importance and significance of micro-organisms in food.

Unit 2: Factors of special significance in food microbiology

Intrinsic and extrinsic factors influencing microbial growth in foods; Spores and their significance; Indicator organisms and Microbiological criteria and standards.

Unit 3: Microbial spoilage of different types of foods

Microbial spoilage of meat, milk, fruits, vegetables and their products. Food-borne pathogens (bacteria, fungi and viruses) and intoxication.

Block 2: Fermentation and Food Preservation Methods

Unit 1: Food fermentation

Fermented dairy, vegetable, fruits, cereals, meat products.

Unit 2: Preservatives and preservation methods

Principles of food preservation: Physical methods, and chemical

preservatives; Preservatives and natural antimicrobial compounds. Bio-preservation. Foods for Safe Health Use (FOSHU), Probiotic bacteria; Bifidus factor. Bacteriocins and their applications; pre-, probiotics and synbiotics. Microbes as source of Human food: mushrooms, single cell protein.

Block 3: Food Safety and Quality Management Systems

Unit 1: Advanced techniques in detecting food-borne pathogens and toxins Food safety and Quality Management Systems

General principles of food safety risk management, Recent concerns on food safety- Safe food alternatives (Organic foods), Good agricultural Practices (GAP), Food Indicators of water and food safety and quality Advanced techniques in detecting food-borne pathogens and toxins. HACCP (Hazard analysis and Critical Control Point) CODEX, FSSAI (Food Safety and Standard Authority of India) systems in controlling microbiological hazards in foods. Food safety regulations.

Practicals

Statutory, recommended and supplementary tests for microbiological analysis of various foods

Infant foods, canned foods, milk and dairy products, eggs, meat, vegetables, fruits, cereals, surfaces, containers, normal, spoiled, processed, fermented food and water

Testing of anti microbial agents

Microbiological analysis of water

HACCP Plan

Visit to food processing industries

References

- BIBEK, RAY. 1996. *Fundamentals of Food Microbiology*. CRC Press.
- FRAZIER, W. C. AND WESTH OFF D. C. 1991. *Food Microbiology*. 3rd Ed. Tata Mc Graw Hill.
- BANWART, G. J., 1989. Basic Food Microbiology. AVI.
- JAMES M JAY. 1987. Modern Food Microbiology. CBS.

- ADAM, M. R. AND MOSS, M. O., 1985, Food Microbiology, IV Edition, Publ: RSC, Cambridge
- ADAMS, M.R., AND M. O. MOSS 1996. *Food Microbiology*, New Age International (Rt) Ltd., New Delhi.
- FRAZIER, W.C. AND D.C. WESTH OFF, 1988. *Food Microbiology* (Reprint1995), Tata Mc Graw Hill Publishing Ltd., New Delhi.
- JAMES M. JAY., LOESSNER, M.J. AND GOLDEN D.A. 2005. *Modern Food Microbiology*, Seventh edition.
- DOYLE, M.P. AND BEUCHAT, L.R.2007. *Food Microbiology - Fundamentals and Frontiers*, ASM Press.
- GARBUTT, J., 1997. *Essentials of Food Microbiology*, Armold – International Student sedition, London.
- MARRIOTT, N.G. AND GRAVANI R. B. 2006. *Principles of Food Sanitation, Food Science text Series*, Springer International, New York,USA.

MIC 508 BACTERIOPHAGES (1+1)

Objectives

1. To familiarize the students about phages and biological processes of phage – bacterial interactions.
2. To demonstrate the complete sequence of host parasite reactions and provide a model by which virus - host cell reactions can be postulated for infection in higher plants and animals.

Theory

Block 1: Bacteriophages

Unit 1: Historical prospective of bacteriophages

Historical developments and classification of bacteriophages.

Unit 2: Biological processes of phage bacterial interaction

Physiology, biochemistry, enzymology and molecular biology of phage- bacterial interactions.

Unit 3: Life cycle of bacteriophages

Structure, functions and life cycles of P_2 phage, Lambda phage, M13 phage, ÕX174 phage.

Unit 4: Biotechnological genetic manipulation

Phages in the development of molecular biology and genetic engineering.

Practicals

Titration of phages and bacteria

Absorption of phages

Preparation of phage stocks

Isolation of new phages and phage resistant bacteria

One step growth curve, phage burst

Induction of lambda

Complementation of T_4*rH* mutants *etc*

References

- BIRGE E A. 2000. *Bacterial and Bacteriophage Genetics.* Springer-Verlag. Mathew C K. 1972. *Bacteriophage Biochemistry*. Am. Chemical Soc.
- MATHEW C K, KUTTER E M, MOSIG G &BERGET P. 1988. *Bacteriophage T 4*. Plenum Press.
- NANCY T AND TREMPY J. 2004. *Fundamental Bacterial Genetics*. Blackwell. Stent SG. 1963. *Molecular Biology of Bacterial Viruses*. WH Freeman and Co.
- WINKLER J, RUGER W AND WACKERNAGEL W. 1979. *Bacterial, Phage and Molecular Genetics - An Experimental Course.* Narosa.
- WINKLER U AND RUGR W. 1984. *Bacteria, Phage and Molecular Genetics*. ALA.

MIC 509 ENVIRONMENTAL MICROBIOLOGY (2+1)

Objectives

1. To familiarize the students about different microbial communities and understand their role in biochemical processes in different ecosystems - air, soil, water and sediments.
2. To understand the interactions of microorganisms with higher plants and animals.
3. To understand the geochemically and environmentally significant processes mediated by microorganisms.
4. To familiarize the students about the basic microbiological principles, the methods in microbial ecology and their theoretical and practical use.

Theory

Block 1: Microbial Ecology

Unit 1: Scope of environmental microbiology and ecological niche Scope of environmental microbiology, Microbial ecology: Microbial evolution and biodiversity – Ecological niches – Definitions, biotic and abiotic environment. Environmental segments. Composition and structure of environment. Concept of biosphere, communities and ecosystems. Ecosystem characteristics, structure and function. Food chains, food webs and trophic structures. Ecological pyramids.

Unit 2: Microorganisms and their natural habitats

Microorganisms and their natural habitats: Aero microbiology, astrobiology, methane and chlorates on Mars, terrestrial analogues. Biofilms and microbial mats, Aquatic ecosystems - Public health microbiology.

Unit 3: Extremophiles. Extremophiles

Definition and ecological aspects. Thermophiles, Xerophiles, Psychrophiles, Piezophiles, Alkaliphiles, Acidophiles - Halophiles and Barophiles. Environmental distribution and taxonomic diversity, physiology, adaptive mechanisms, enzymes, applications.

Block 2: Microbial interaction

Unit 1: Biogeochemical cycles

Biogeochemical cycling and its consequences. Global environmental problems.

Unit 2: Waste water and solid waste treatment

Microbiology of wastewater and solid waste treatment: - Waste-types- solid and liquid waste characterization, physical, chemical, biological, aerobic, anaerobic, primary, secondary and tertiary treatments. Anaerobic processes-Bio-remediation of nuclear wastes. Bio-conversion of Solid waste and utilization as fertilizer. Bio-accumulation of heavy metal ions from industrial effluents. Bio-mining. Microbiology of degradation of xenobiotics in the environment, ecological considerations, decay behavior.

Unit 3: Microbial up gradation in fossil fuels and interaction in the rumen and gastrointestinal tract

Microbial upgradation of fossil fuels and coal gas. Microbial interactions in the rumen and gastrointestinal tract.

Practicals

- Microbiological examination of samples from soil, sewage and fresh water ecosystems.
- Analysis of natural waters.
- Determination of indices of pollution by measuring
- BOD/COD of different effluents.
- Quality control tests, waste treatment and anaerobic digestion; Demonstration of waste water treatment processes such as activated sludge processes, bio-filter and fluidized bed process.
- Bacterial reduction of nitrate from ground waters.
- Isolation and purification of degradative plasmid of microbes growing in polluted environments.
- Recovery of toxic metal ions of an industrial effluent by immobilized cells.
- Utilization of microbial consortium for the treatment of solid waste [Municipal Solid Waste].
- Bio - transformation of toxic metal ions into non-toxic metals ions.

- Microbial dye decolorization /adsorption.
- Bio - trap based isolation of selective functional microbes.
- Thermophlic enzyme in biomass deconstructions.
- Halophilic microbes from Salt Lake-Pesticide degradation by microbes.
- Field trips to study microbial diversity in different ecosystems. / Visit to municipality waste water treatment plants.

References

- CAMPBELL, R. 1983. *Microbial Ecology*. Blackwell.
- HAWKER, L. E & LINTON, A. H. 1989. *Microorganisms Function, Form and Environment*. 2nd Ed. Edward Arnold.
- ATLAS, R. M. AND BARTHA, R., 2009, Microbial Ecology: Fundamentals and Applictaions. IV edition, Publ: Pearson Education
- MITCHELL R. 1992. *Environmental Microbiology*. John Wiley &Sons.
- BAKER, K. H. AND HERSON, D.S. 1994. *Bioremediation.* McGraw Hill Inc., N.Y.
- MITCHELLR AND GUJI-DONG.2010. *Environmental Microbiology*. John V, Wiley Sons. Inc.
- BITTON, G. 2010. *Waste Water Microbiology* 2nd Edition.
- FORSTER, C. F AND JOHN WASE, D. A. *Environmental Biotechnology*. Ellis Horwood Ltd. Publication.
- HURST, C. J. 2001. *A Manual of Environmental Microbiology*. 2nd Edition. ASM Publications.

MIC 510 INDUSTRIAL MICROBIOLOGY (2+1)

Objectives

1. To familiarize the students with basics of industrial microbiology with a focus on historical account and fermented microbial products.
2. To provide exposure to the students on the commercial exploitation of microorganisms for the production of useful industrial products

such as bioagents, biopesticides, biopolymers and enhanced production of valuable products.

Theory

Block 1: Basics of Industrial Microbiology

Unit 1: Historical account of microbes in industrial microbiology

Introduction to Industrial Microbiology. Sources and characteristics of industrially important microbes; their isolation, purification and maintenance. Types of fermentation and fermentors. Microbial growth kinetics in batch, continuous and fed-batch fermentation process.

Unit 2: Fermented microbial products

Bioreactors Types and configuration. Microbiology and production of alcoholic beverages; malt beverages, distilled beverages, wine and champagne; Commercial production of organic acids like acetic, lactic, citric, and gluconic acids Commercial production of important amino acids (glutamic acid, lysine and tryptophan), vitamins (riboflavin and vitamin A), enzymes, antibiotics and single cellproteins.

Block 2: Bio-plastics, Bio-polymers and Bio-fuels

Unit 1: Bio-control agents and Bio pesticides

Bio-control agents and Bio-pesticides: Bio-control agents and their scope in control of plant diseases, nematodes and insect pests. Role of bio-agents in sustainable agriculture.

Unit 2: Industrial production of bio-plastics and biopolymers. Introduction and industrial production of bio-plastics: microorganisms involved in synthesis of biodegradable plastics and microbial pigments and biopolymers. Biosensors: Development of biosensors to detect food contamination and environment pollution. Biofuels: Production of ethanol, biogas and hydrogen from organic residues, fuels from algae; Mushroom cultivation.

Unit 3: Production of valuable products

Genetic engineering of microbes, Role of recombinant microbes in industrial sectors for enhanced production of valuable products. Mechanisms of pesticide degradation by microbes. Bio-mining: Coal,

mineral and gas formation, prospecting for deposits of crude, oil and gas, recovery of minerals from low- grade ores.

Practicals

Isolation and purification of industrially important microbes (Bacteria, fungi and algae)

Production of industrial compounds such as alcohol, beer, citric acid, lactic acid acetic acids gluconic acid and their recovery

Demonstration of biogas production

Production and assay of enzymes, organic acids and pigments

Mass production of bio-control agents

Visit to biotechnology industries

References

- CRUEGER, W., CRUEGER, A. ANDBROCK, T. D., 1989, Biotechnology: A Textbook of Industrial Microbiology, II edn, Publ: Sunderland Sinauer.
- WAITES, M. J., MORGAN, N. L., ROCKEY, J. S. AND HIGTON, G., 2002. *Industrial Microbiology: An Introduction.* Blackwell Science Publishers.
- REED, G., 1999. *Prescott and Dunn's Industrial Microbiology*. CBS Publishers.
- DEMAIN, A. L., 2001. *Industrial Microbiology and Biotechnology* II Edition. ASM Press, Washington.
- STANBURY, P. F., WHITAKER, W. AND HALL, S. J., 1997. *Principles of Fermentation Technology* Aditya Books (P) Ltd., New Delhi.
- BALTZ, R. H, DAVIES, J. E. AND DEMAIN, A. L., 2010. *Manual of Industrial Microbiology and Biotechnology*. 3rd Edition, ASMPress.
- OKAFER, N., 2007. *Modern Industrial Microbiology and Biotechnology,* Scientific Publishers, Enfield, USA.
- NDUKA, O. and BENEDICT, O. C., 2018. *Modern Industrial Microbiology and Biotechnology*, Taylor and Francis 465p.

- STANBURY, A. F. AND WHITAKER, A., 1984. Principles of Fermentation Technology–Oxford Pergamon press New York.
- Casida, L. E. Jr. 1989. *Industrial Microbiology* Wiley Eastern Ltd., N.Delhi.

MIC 511 BIO-FERTILIZER TECHNOLOGY (2+1)

Objectives

1. To provide an overview of different agriculturally important microorganisms such as N_2 fixers, PO_4- solubilizes, PGPRs, biocontrol inoculants.
2. To provide practical skills on mass production of different formulations of microbial inoculants.
3. To familiarize the students with BIS standards in existence for different bio-fertilizers and FCO norms for quality bio-fertilizers.
4. To provide the students with entrepreneurship skills to start a biofertilizer production unit and economics of bio-fertilizer production.

Theory

Block 1: Agriculturally Important Microorganisms

Unit1: Important beneficial nitrogen fixing microorganisms

Different agriculturally important beneficial microorganisms: Chemical Vs Bio-fertilizers: Current scenario in bio-fertilizer technology in world-In India-List of bio-fertilizers-their applications in agriculture. Brief introduction about agriculturally beneficial microorganisms (free living, symbiotic (rhizobial, actinorhizal), associative and endophytic nitrogen fixers including phosphobacteria, cyanobacteria, their types and importance taxonomic classification, nitrogen fixing bio-fertilizers: nodule formation, competitiveness and quantification of N_2 fixed and their use. BIS standards of bio-fertilizers.

Unit 2: Agriculturally important beneficial microorganisms related to phosphorus, potassium, sulphur and zinc nutrition

Different agriculturally important beneficial microorganisms: phosphate solubilizing bacteria and fungi, including mycorrhiza;

Mechanisms of phosphate solubilization. Bacteria for potassium, sulphur and zinc nutrition.

Unit 3: Agriculturally important beneficial microorganisms having plant growth promoting rhizobacteria

Different agriculturally important beneficial microorganisms: plant growth promoting rhizobacteria. Bio-fertilizer production and usage at national and international levels.

Unit 4: Agriculturally important bio-control microbial inoculants

Different agriculturally important beneficial microorganisms: Bio-control microbial inoculants. Requirements for establishing bio-inoculants production unit Economics of bio-fertilizers production Constraints in bio-fertilizers production and usage.

Unit 5: Economics of bio-fertilizer production

Different agriculturally important beneficial microorganisms for recycling of organic waste and compositing, bio-remediators and other related microbes.

Block 2: Production of Bio-fertilizer

Unit 1: Production and quality control of bio-fertilizer

Different agriculturally important beneficial microorganisms - selection, establishment, competitiveness, crop productivity, soil and plant health, mass scale production and quality control of bio inoculants. Bio-fertilizer inoculation and microbial communities in the soil. Different formulations of bio-fertilizers - Carrier based and liquid formulations. Advantages and limitations of liquid formulation.

Practicals

Isolation of nitrogen fixing, phosphate solubilizing microorganisms.

Determination of beneficial properties in important bacteria to be used as bio-fertilizer, Nitrogen fixing activity, indole acetic acid (IAA), siderophore production etc,

Bio-inoculant production and quality control.

Population dynamics in broth and carrier materials during storage.

Development of cultures from starter.

Preparation of broth for large scale cultivation in fermentor / large containers. Inoculation and development of culture.

Mass production of carrier based and liquid bio-fertilizers. Mass production of important bio-control agents (*Trichoderma viride, Pseudomonas fluorescens and Metarhizium anisopliae*).

Formulation, dose and method of application.

Mass production of AM fungi in pot and root organ culture.

Determination of quality of microbial inoculants and BIS standards in existence.

Mass production of *Azolla* and BGA.

Methods of application.

Visit to bio-fertilizer production plants

References

- ALEXANDER, M., 1977. *Soil Microbiology*. John Wiley.
- BERGERSON, F. J., 1980. *Methods for Evaluating Biological Nitrogen Fixation.* John Wiley & Sons.
- SYLVIA, D. M, FUHRMANN, J. J., HARTLLY, P. T. AND ZUBERER, D., 2005. *Principles and Applications of Soil Microbiology.* 2nd Ed. Pearson Prentice Hall Edu.
- VAN ELSAS, J. D., TREVORS, J. T. AND WELLING TON, E. M. H., 1997. *Modern Soil Microbiology*. C R C Press.
- Gaur AC. 2010. *Bio fertilizers in Sustainable Agriculture*, ICAR, New Delhi.
- CHANDA, P. AND SRIVATHSA, R. S. H., 2005. *Liquid Biofertilizers*. Ministry of Agriculture Department of Agriculture & Cooperation, GOI.
- SOMANI, L. L, SHILKAR, P. AND SHILPKAR, D., 2011. *Biofertilizers Commercial Production Technology & Quality Control*. Agro Publishing Acadamy, Udaipur.

- KANNAIYAN, S. AND KUMAR, K., 2005. *Azolla biofertiliser for sustainable Rice Production*. Daya Publishing House, Delhi.
- KANNAIYAN, S., KUMAR, K. AND GOVINDARAJAN, K., 2010. *Biofertilizer Technology*.Scientific Publishers (India), Jodhpur.

MIC 512 CYANOBACTERIAL & ALGAL BIOTECHNOLOGY (2+0)

Objectives

1. To provide an overview of importance, physiology and culturing of cyano bacteria and algae.
2. To impart knowledge on algal mass production techniques and their valuable products of commercial importance.
3. To provide exposure on the potential applications of cyano bacteria and algae in agriculture, industry and environment
4. To introduce the R&D and entrepreneurial opportunities.

Theory

Block 1: Importance of Cyano bacteria and Algae

Unit 1: Ecology and evolution of algae and cyano bacteria

Introduction to cyano bacteria and algae. Definition, occurrence and distribution, thallus structure, reproduction, life cycles, origin and evolution of cyano bacteria, molecular evolution; role of algae in evolution of land plants and horizontal transfer of genes. Brief classification of algae: different classes, occurrence and distribution.

Block 2: Physiology and Culturing of Cyano bacteria and Algae

Unit 1: Algal pigments, storage products

Algal pigments structures products physiology and metabolism including photosynthesis.

Unit 2: Metabolism of carbon and nitrogen

Ecology of algae - primary colonizers and cycling in soil and water. Cellular differentiation and nitrogen fixation, nitrogen metabolism carbon metabolism.

Unit 3: Culturing methods

Algal culturing and cultivation. Culture types, culture conditions, culture vessels, culture media, sterilization, culture methods, synchronous cultures, photo bioreactors, algal density and growth, seaweed cultivation.

Block 3: Role of Cyano bacteria and Algae in Agriculture and their Products of Industrial Importance

Unit 1: Importance as fuels, nutraceuticals and industrial importance

Cyano bacterial and algal fuels, Fine chemicals (restriction enzymes etc.) and nutraceuticals from algae; UV absorbing pigments Industrial products from macro algae – sea weed biotechnology, sustainable aquaculture. Ecology of algae- distribution in soil and water; primary colonizers, carbon sequestration and cycling in soil and water. Cellular differentiation and nitrogen fixation, nitrogen metabolism.

Unit 2: Role of algae related to environment

Algae in pollution control - as pollution indicators, eutrophication agents and role in bio-remediation and reclamation of problem soils. Cyanobacterial and algal toxins, allelopathic interactions, Algae in global warming and environmental sustainability. Cyanobacteria and selected microalgae in agriculture – bio-fertilizers and algalization; soil conditioners; reclamation of problem soils.

References

- AHLUWALIA, A. S., 2003. *Phycology: Principles, Processes and Applications*. Daya Publ.
- BARSANTI, L. AND GUALTIERI, P., 2006. *Algae: Anatomy, Biochemistry and Biotechnology*. Taylor & Francis, C R C Press.
- CARR, N. G. AND WHITTON, B. A., 1982. *The Biology of Cyano bacteria*. Blackwell.
- HERRERO, A. AND FLORES, E., 2008. *The Cyano bacteria Molecular Biology, Genomics and Evolutin*. Calster Academic Press

- KUMAR, H. D. 2005. *Introductory Phycology.* East West Press. Linda E Graham & Lee W Wilcox. 2000. *Algae*. PrenticeHall.
- ANDERSEN, R. A. 2005. *Algal Culturing Techniques.* Academic Press.
- VENKATARAMAN, L. V. AND BECKER, E. W. 1985. *Biotechnology and Utilization of Algae: The Indian Experience*.DST.
- DAS, M. K., 2010. *Algal Biotechnology*. Daya Publishing House.
- TIWARI., 2014. *Cyanobacteria: Nature, Potentials and Applications*. Daya Publishing House.
- KHATTAR, J. I. S, SINGH AND D. P, KAUR, G. 2009. *Algal Biology and Biotechnology*. I.K. International Publishing House Pvt. Ltd.
- BHATNAGAR, S. K., SAXENA, A., KRAAN, S., 2011.*Alga Bio fuels*. Stadium Press (India) Pvt. Ltd.
- SAHOO, D. AND KAUSHIK, B. D. 2012. *Algal Biotechnology and Environment*. I. K. International Publishing House Pvt. Ltd.

M.Sc. (Agri.) in Molecular Biology and Biotechnology

Course Code	Course Title	Credit Hours
MBB 501	Principles of Biotechnology	3 (2+1)
MBB 502	Fundamentals of Molecular Biology	3 (3+0)
MBB 503	Molecular Cell Biology	3 (3+0)
MBB 504	Techniques in Molecular Biology I	3 (1+2)
MBB 505	Omics and Systems Biology	3 (2+1)
MBB 506	Plant Genetic Engineering	3 (3+0)
MBB 507	Techniques in Molecular Biology II	3 (1+2)
MBB 508	Introduction to Bioinformatics	3 (2+1)
MBB 509	Plant Tissue Culture	3 (2+1)
MBB 510	Microbial and Industrial Biotechnology	3 (2+1)
MBB 511	Molecular Plant Breeding	3 (2+1)
MBB 512	IPR, Bio-safety and Bioethics	2 (2+0)
MBB 513	Immunology and Molecular Diagnostics	3 (3+0)
MBB 514	Nano Biotechnology	3 (2+1)
MBB 515	Environmental Biotechnology	3 (3+0)
MBB 516	Bio-entrepreneurship	1 (1+0)
MBB 517	Stress Biology and Genomics	2 (2+0)
MBB 518	Gene Regulation	2 (2+0)
	Total	**52 (40+12)**
MBB 580	Qualifying Examination	2 (0+2)
MBB 581	Seminar - I	1 (0+1)
MBB 582	Seminar - II	1 (0+1)
MBB 591	Research - I	13 (0+13)
MBB 592	Research - II	14 (0+14)

MBB 501 PRINCIPLES OF BIOTECHNOLOGY (2+1)

Objective

- To understand the basics of Molecular biology, plant and microbial Biotechnology
- Importance and applications in agriculture, case studies and success stories
- Public education, perception, IPR and related issues

Theory

Block 1: Overview of Biotechnology

Unit I: Branches of Biotechnology

History, scope and importance of Biotechnology; Specializations in Agricultural Biotechnology: Genomics, Genetic engineering, Tissue Culture, Bio-fuel, Microbial Biotechnology, Food Biotechnology *etc.* Basics of Biotechnology, Primary metabolic pathways, Enzymes and its activities.

Unit II: Genetic material, rDNA technology and application

Structure of DNA, RNA and protein, their physical and chemical properties. DNA function: Expression, exchange of genetic material, mutation. DNA modifying enzymes and vectors; Methods of recombinant DNA technology; Nucleic acid hybridization; DNA/RNA libraries; Applications of gene cloning in basic and applied research.

Block 2: Biotechnology in crop improvement

Unit I: Molecular markers and omic technologies

Molecular analysis of nucleic acids - PCR and its application in agriculture and industry, Introduction to Molecular markers: RFLP, RAPD, SSR, SNP *etc,* and their applications; DNA sequencing, different methods; Introduction to genomics, transcriptomics, ionomics, metabolomics and proteomics.

Unit II: Plant tissue culture and genetic engineering

Plant cell and tissue culture techniques and their applications, Plant transformation: Gene transfer methods and applications of GM crops. Genome editing, gene silencing

Block 3: Bioethics, biosafety and IPR

Unit I: Bioethics, biosafety and IPR

Introduction to Emerging topics: Plant microbial interactions, Success stories in Biotechnology, Careers and employment in biotechnology. Public perception of biotechnology; Bio-safety and bioethics issues; Intellectual property rights in biotechnology.

References

- WATSON, J. D., BAKER, T. A., BELL, S. P., GANN, A., LEVINE, M. AND LOSICK, R., 2014, Molecular Biology of the Gene, 7th edition, Cold Spring Harbor Laboratory Press, New York
- BROWN, T. A., 2010, Gene Cloning and DNA analysis an Introduction 6th edition, Wiley Blackwell
- PRIMROSE, S. B. AND TWYMAN, R., 2006, Principles of gene Manipulation 7th edition, Wiley Blackwell
- SINGH, B. D., 2012, Biotechnology: Expanding Horizons 4th edition, Kalyani publisher, New Delhi, India

MBB 502 FUNDAMENTALS OF MOLECULAR BIOLOGY (3+0)

Objective

- To understand the basics of DNA, RNA, structure, types and chromatin assembly.
- To get insights into the Central Dogma, basic cellular processes, role of mutation and recombination.
- To understand different levels of gene regulation and the pathways involved.

Theory

Block 1: Nucleic acid structure, types and function

Unit I: History and chemistry of nucleic acid

Historical developments of molecular biology, Nucleic acids as genetic material, Chemistry and Nomenclature of nucleic acids; Structure

of DNA: primary structure; secondary structure, Forms of DNA: A,B, Z and their function; Structure and Types of RNA Genome organization in prokaryotes and eukaryotes; DNA Topology; DNA re-association kinetics, Types of repeat sequences.

Unit II: Central dogma and DNA replication and repair

Central dogma of Molecular Biology; DNA replication- Classical experiments, Models of DNA replication; DNA replication, Origin and Steps in DNA replication – initiation, elongation and termination; Enzymes and accessory proteins and its mechanisms; Eukaryotic DNA replication in brief. Types of DNA damages and mutations; DNA repair mechanisms, Recombination: Homologous and non-homologous, Genetic consequences.

Block 2: Gene expression

Unit I: Prokaryotic and eukaryotic transcription

Prokaryotic transcription, initiation, elongation and termination, promoters, Structure and function of eukaryotic RNAs and ribosomal proteins. Eukaryotic transcription – RNA polymerase I, II and III, Elongation and Termination, Eukaryotic promoters and enhancers, Transcription factors,Post transcriptional processing, Splicing, Catalytic RNAs, RNA stability and transport, RNA editing.

Unit II: Genetic code and translation

Genetic code and its characteristics, Universal and modified genetic code and its characteristics, Wobble hypothesis; Translational machinery; Ribosomes in prokaryotes and Eukaryotes. Initiation complex formation, Cap dependent and Cap independent initiation in eukaryotes, Elongation: translocation, transpeptidation and termination of translation; Co- and Post-translational modifications of proteins; Translational control; Protein stability -Protein turnover and degradation.

Block 3: Gene regulation

Unit I: Prokaryotic gene regulation

Gene regulation in prokaryotes, Constitutive and Inducible expression, small molecule regulators; Operon concept: lac and trp operons, attenuation, anti-termination, stringent control.

Unit II: Eukaryotic gene regulation

Gene regulation in eukaryotes– regulatory RNA and RNA interference mechanisms, silencers, insulators, enhancers, mechanism of silencing and activation; Families of DNA binding transcription factors: Helix-turn-helix, helix-loop-helix etc. Epigenetic regulations.

References

- NELSON, D. L. AND COX, M. M., 2017, Lehinger's Principles of Biochemistry, 7th edition, W H Freeman Publication New York.
- KREBS, J. E., GOLDSTEIN, E. S., KILPATRICK, S. T., 2017, Lewin's Genes XII 12th edition, Jones & Bartlett Learning publisher, Inc.
- WATSON, J. D., BAKER, T. A., BELL, S. P., GANN, A., LEVINE, M. AND LOSICK, R., 2014, Molecular Biology of the Gene, 7th edition, Cold Spring Harbor Laboratory Press, New York.
- ALBERTS, B., 2017, Molecular Biology of the Cell 5th edition, WW Norton & Co, Inc.
- ALLISON, L. A., 2011, Fundamentals of Molecular Biology. 2nd Edition, John Wiley and Sons.

MBB 503 MOLECULAR CELL BIOLOGY (3+0)

Objective

- To understand the basics structure and function of plant and animal cell
- To get insights into the basic cellular processes, transport, signalling, cell movement, cell division and general regulation mechanisms.

Theory

Block 1: Introduction and scope of cell biology

Unit I: Cell theories and cell structure

Origin of life, History of cell biology, Evolution of the cell: endo-symbiotic theory, tree of life, General structure and differences between prokaryotic and eukaryotic cell; Similarities and distinction between plant and animal cells; different kinds of cells in plant and animal tissues.

Unit II: Cell and its organelles

Cell wall, cell membrane, structure and composition of bio-membranes, Structure and function of major organelles: Endoplasmic reticulum Ribosomes, Golgi apparatus, Mitochondria, Chloroplasts, Lysosomes, Peroxisomes, Micro-bodies, Vacuoles, Nucleus, Cyto-skeletal elements.

Block 2: Cell division and communication

Unit I: Cell division and apoptosis

Chromatin structure, Cell division and regulation of cell cycle; Mechanisms of cell division, Molecular events at M phase, mitosis and cytokinesis, Ribosomes in relation to cell growth and division, Extracellular and intracellular Control of Cell Division; abnormal cell division: cancer- hall marks of cancer and role of oncogenes and tumor suppressor genes in cancer development - Programmed cell death (Apoptosis).

Unit II: Cell-cell communication and intercellular processes

Membrane transport; Diffusion, osmosis, ion channels, active transport, mechanism of protein sorting and regulation of intracellular transport, transmembrane and vesicular transport - endocytosis and exocytosis; General principles of cell communication: hormones and their receptors, signaling through G-protein coupled receptors, enzyme linked receptors; signal transduction mechanisms and regulation, Cell junctions, Cell adhesion, Cell movement; Extracellular matrix.

Block 3: Differentiation and morphogenesis

Unit I: Cell differentiation and animal models

Morphogenetic movements and the shaping of the body plan, Cell diversification, cell memory, cell determination, and the concept of positional values; Differentiated cells and the maintenance of tissues and organ development; Stem cells: types and applications; Basics of Animal development in model organisms (C. elegans; Drosophila); Plant development.

References

- Alberts, B., 2017, Molecular Biology of the Cell 5th edition, WW Norton & Co, Inc.
- LODISH, H., BERK, A., KAISER, C. A., KRIEGER, M., BRETSCHER, A., PLOEGH, H., AMON, A., MARTIN, K. C., 2016, Molecular Cell Biology 8th Edition. W.H. Freeman & Co. New York.
- ALBERTS, B., BRAY, D., LEWIS, J., RAFF, M., ROBERTS, K., HOPKIN, K., JOHNSON, A., WALTER, P., 2013, Essential of Cell Biology, WW Norton & Co, Inc.
- COOPER, G. M. AND HAUSMAN, R. E., 2013, The cell: A Molecular Approach 6th edition, Sinauer Associates, Inc.

MBB 504 TECHNIQUES IN MOLECULAR BIOLOGY I (1+2)

Objective

- ❖ To get a basic overview of molecular biology techniques, good lab practices and recombinant DNA technology.
- ❖ To get a hands on training in chromatography, protein analysis, nucleic acid analysis, bacterial and phage genetics.

Credit Hours: Practicals

- Good lab practices, preparation of buffers and reagents.
- Principle of centrifugation and spectrophotometry.
- Growth of bacterial culture and preparation of growth curve,
- Isolation of Genomic DNA from bacteria.
- Isolation of plasmid DNA from bacteria.
- Growth of lambda phage and isolation of phage DNA.
- Isolation and restriction of plant DNA (e.g. Rice / Moong / Mango / Merigold).
- Quantification of DNA by (a) Agarose Gel electrophoresis and (b) Spectrophotometry
- PCR using isolated DNA.

- PAGE Gel electrophoresis.
- Restriction digestion of plasmid and phage DNA, ligation, Recombinant DNA construction.
- Transformation of E. coli and selection of transformants
- Chromatographic techniques
  - ❖ TLC
  - ❖ Gel Filtration Chromatography,
  - ❖ Ion exchange Chromatography,
  - ❖ Affinity Chromatography
- Dot blot analysis, Southern hybridization, Northern hybridization, Western blotting and ELISA.
- Radiation safety and non-radio isotopic procedure.

References

- SAMBROOK, J. AND RUSSELL, R. W., 2001, Molecular Cloning: A Laboratory Manual 3rd Edition, Cold spring harbor laboratory press, New York.
- WILSON, K. AND WALKER, J., 2018, Principles and Techniques of Biochemistry and Molecular Biology 8th edition, Cambridge University Press.
- AUSUBEL, F. M., BRENT, R., KINGSTON, R. E., MOORE, D. D., SEIDMAN, J. G., SMITH, J. A. AND STRUHL, K., 2002, Short Protocols in Molecular Biology 5th edition, Current Protocols publication.

MBB 505 OMICS AND SYSTEMS BIOLOGY (2+1)

Objective

- To get a basic overview of genomics, proteomics, ionomics and metabolomics.
- To get a primary information on the application of omics science across the industry.

Theory

Block 1: Omics technologies

Unit I: Genomics and ionomics

Different methods of genome sequencing, principles of various sequencing chemistries, physical and genetic maps, Comparative and evolutionary genomics, Organelle genomics, applications in phylogenetics, case studies of completed genomes, preliminary genome data analysis, basics of ionomics analysis, different methods.

Unit II: Proteomics

Protein-basics: primary-, secondary- and tertiary structure, Basics of X-ray crystallography and NMR, Principal and Applications of mass spectrometry, Proteomics: Gel based and gel free, Basics of software used in proteomics, MASCOT, PD-Quest, *etc.,* Study of protein interactions, Prokaryotic and yeast-based expression system and purification.

Unit III: Metabolomics and integrated omics

Metabolomics and its applications, Use of 1D/2D NMR and MS in metabolome analysis, Multivariate analysis and identification of metabolite as biomarkers, Study of ionome using inductively coupled plasma – mass spectroscopy (ICP-MS), X-Ray Fluorescence (XRF), Neutron activation analysis (NAA), Data integration using genome, transcriptome, proteome, metabolome and ionome with phenome.

Block 2: Systems Biology

Unit I: Introduction to systems biology and regulatory networks

Introductory systems Biology - The biochemical models, genetic models and systems model, Molecules to Pathway, equilibrium binding and cooperatively - Michaelis - Menten kinetics, Biological oscillators, genetic oscillators, quorum sensing, cell-cell communication, Drosophila development, pathways to network, gene regulation at a single cell level, transcription network, Regulatory Circuits, Negative and positive auto-regulation, alternative stable States, bimodal switches, network building and analysis.

Practical

- Isolation of HMW DNA and brief overview of sequencing, Primary information on genome data analysis.

- BSA Standard curve preparation, Extraction of protein and estimation methods.
- Quantification of proteins from different plant tissues using spectrophotometry.
- 2-D Gel Electrophoresis, 2-D Image analysis.
- Experiments on protein-protein interaction (Yeast 2-hybrid, Split Ubiquitin system).
- Demonstration on MALDI-TOF.
- Demonstration on ICP-MS, AAS, Nitrogen estimation using various methods.

References

- PRIMROSE, S. B. AND TWYMAN, R., 2006, Principles of Gene Manipulation 7th edition, Wiley Blackwell
- WILSON, K. AND WALKER, J., 2018, Principles and Techniques of Biochemistry and Molecular Biology 8th Edition, Cambridge University Press.

MBB 506 PLANT GENETIC ENGINEERING (3+0)

Objective

1. To get a basic overview of molecular cloning, vectors and genomic library construction.
2. To get an overview of PCR and its applications, sequencing, gene knockouts, transgenics etc.

Theory

Block 1: Tools for genetic engineering

Unit I: Requirement for genetic engineering including Enzymes, Probes and Vectors

Historical Requirement background, Restriction Enzymes; DNA Modifying enzymes, ligase, T_4 DNA polymerase, Polynucleotide kinase *etc,* Cohesive and blunt end ligation; Labeling of DNA: Nick translation, Random priming, Radioactive and non-radioactive probes, Plasmids; Bacteriophages; M13, Phagemids; Lambda vectors; Insertion and

Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Animal Virus derived vectors-SV-40; Expression vectors; pMal, pET-based vectors; Baculovirus vectors system, Plant based vectors, Ti and Ri plasmids as vectors, Yeast vectors, Shuttle vectors.

Unit II: Gene cloning, transformation and Transfection methods

Transformation; Construction of libraries; Isolation of mRNA and total RNA; cDNA and genomic libraries; cDNA and genomic cloning, Jumping and hopping libraries, Protein-protein interactive cloning and Yeast two hybrid system; Phage display; Principles in maximizing gene expression; Codon optimization for heterologous expression. Introduction of DNA into mammalian cells; Transfection techniques.

Block 2: Detection of transgene integration and expression

Unit I: PCR and its variants

Principles of PCR, Primer design, DNA polymerases, Types of PCR – multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, cloning of PCR products; T- vectors; Applications of PCR in gene recombination, Protein purification; His-tag; GST-tag; MBP-tag, *etc.*;

Unit II: Mutagenesis and detection of mutations

Site specific mutagenesis, molecular diagnostics; Viral and bacterial detection; Mutation detection: SSCP, DGGE, RFLP, Oligo Ligation Assay.

Unit III: DNA and Protein based Hybridization detection methods

Hybridization techniques: Northern, Southern and Colony hybridization, Fluorescence *in situ* hybridization; Chromatin Immunoprecipitation; DNA-Protein Interactions: Electromobility shift assay

Block 3: Plant genetic transformation
Unit I: Requirements and methods of plant transformation

Genetic transformation of plants: Vectors and transgene design - Promoters and Marker genes. Indirect DNA delivery – *Agrobacterium* mediated method. Direct DNA delivery – Chemical mediated

Electroporation and Particle bombardment (Gene gun) method. Chloroplast mediated transformation.

Unit II: Analysis of transgenic plants and advanced methods in plant genetic engineering

Development of marker-free plants. Analysis of transgenic plants – molecular and Biochemical assays, genetic analysis - Identification of gene integration site - Advance methods – cis genesis, Intragenesis and targeted genome modification – ZFN, TALENS and CRISPR. Application of transgenic technology.

References

- BROWN, T. A., 2010, Gene Cloning and DNA Analysis an Introduction. 6th edition, Wiley Blackwel.
- PRIMROSE, S. B. AND TWYMAN, R., 2006, Principles of Gene Manipulation 7th edition, Wiley Blackwell.
- SAMBROOK, J. AND RUSSELL, R. W., 2001, Molecular cloning: A laboratory manual 3rd Edition, Cold spring harbor laboratory press, New York.
- WILSON, K. AND WALKER, J., 2018, Principles and Techniques of Biochemistry and Molecular Biology 8th Edition, Cambridge University Press.

MBB 507 TECHNIQUES IN MOLECULAR BIOLOGY II (1+2)

Objectives

- To get a basic overview of molecular biology techniques, good lab practices and molecular markers.
- To get a hands on training in RNAi, microarrays, yeast2 hybrid and immunological techniques.

Practicals

- Construction of gene libraries (cDNA and Genomics).

- Synthesis and cloning of cDNA.
- Real time PCR and interpretation of data.
- Molecular markers

  i. RAPD.

  ii. SSR.

  iii. AFLP / ISSR and their analysis.
- Case study of SSR markers - construction of linkage map.
- QTL analysis using genotypic data based on SSR.
- SNP identification and analysis.
- Microarray studies and use of relevant software.
- Proteomics

  i. 2D gels,

  ii. Mass spectrometry
- RNAi - designing of construct, phenotyping of the plant.
- Yeast 1 and 2-hybrid interaction.
- Generation and screening of mutants.
- Transposon mediated mutagenesis.
- Immunology and molecular diagnostics: Ouchterlony double diffusion, Immuno precipitation, Radiation Immuno diffusion, Immuno electrophoresis, Rocket Immuno electrophoresis, Counter Current Immuno electrophoresis, ELISA, Latex Agglutination, Immunohistochemistry.

References

- WILSON, K. AND WALKER, J., 2018, Principles and Techniques of Biochemistry and Molecular Biology 8th Edition, Cambridge University Press
- BONIFACINO, J. S., DASSO, M., HARFORD, J. B., LIIPINCOTT-SCHWARTZ, J. AND YAMADA, K. M., 2004, ShortProtocols in Cell Biology. John Wiley & Sons, New Jersey
- HAWES, C. AND SATIAT-JEUNEMAITRE, B., 2001, Plant Cell Biology: Practical Approach. Oxford University Press, Oxford

• SAWHNEY, S. K., SINGH, R., 2014, Introductory Practical Biochemistry, Alpha science international limited.

MBB 508 INTRODUCTION TO BIOINFORMATICS (2+1)

Objectives

- To get a basic overview of computational techniques related to DNA, RNA and protein analysis.
- To get a hands on training in software's and programs used to analyse, assemble or annotate genomes, phylogenetics, proteomics *etc.*

Theory

Block 1: Overview, scope and importance of Bioinformatics

Unit I: Biological databases

Bioinformatics basics, scope and importance of bioinformatics; Biological databases for DNA and Protein sequences -PIR, SWISSPROT, GenBank, DDBJ, secondary database, structural databases –PDB,SCOP and CATH, Specialized genomic resources, Microarray database.

Unit II: Gene sequence and structure analysis

Bioinformatics Tools Facilitate the Genome-Wide Identification of Protein-Coding Genes, Sequence analysis, Sequence submission and retrieval system-SEQUIN, BANKit, SAKURA, Webin, Sequence alignment, pair wise alignment techniques, multiple sequence alignment; Tools for Sequence alignment- BLAST and its variants; Phylogenetic analysis- CLUSTAL X, CLUSTAL W, Phylip, Tcoffee.

Block 2: Proteomics and drug discovery

Unit I: Protein structure and function prediction

Sequencing of protein; Protein secondary structure prediction- Chousfasman, GOR Method, Protein 3DStructure Prediction: Evaluation of models- Structure validation and refinement - Ramachandran plot, Force field calculations, SAVES. Protein function prediction- sequence and domain based, Primer designing- principles and methods.

Unit II: Drug discovery

Drug discovery, structure based drug design - rationale for computer aided drug designing, basic principles, docking, QSAR.

Practical

- Usage of NCBI resources, retrieval of sequence/structure from databases and submission.
- Different Databases, BLAST exercises.
- Assembly of DNA and RNA Seq data, annotation of assembled sequences.
- Phylogenetics and alignment.
- Visualization of structures, docking of ligand receptors, protein structure analysis and modeling.

References

- ATTWOOD, T. K. AND PARRY-SMITH, D. J., 2004, Introduction to Bioinformatics, Pearson Education (Singapore) Pvt. Ltd.
- DAVID EDWARDS (Ed.), 2007, Plant Bioinformatics: Methods and Protocols. Humana Press, New Jersey, USA.
- MOUNT, D. W., 2004, Bioinformatics: Sequence and Genome Analysis. 2nd Revised edition Cold Spring Harbor Laboratory Press, U.S.
- PEVSNER. J., 2009, Bioinformatics and Functional Genomics, 2nd edition, Wiley-Blackwell.

MBB 509 PLANT TISSUE CULTURE (2+1)

Objective

- To provide insight into principles of plant cell culture and genetic transformation.
- To get a hands on training in basic plant tissue culture techniques, callusing, micro propagation and analysis.

Theory

Block 1: Plant tissue culture techniques and applications

Unit I: History, concepts and scope of tissue culture

History of plant tissue culture, principle of Totipotency; Tissue culture media; Plant hormones and morphogenesis; Direct and indirect organogenesis; Direct and indirect somatic embryogenesis; Applications of plant tissue culture;

Unit II: Methods of plant tissue culture

Micropropagation of field and ornamental crops; Virus elimination by meristem culture, meristem tip culture and micrografting; Androgenesis and gynogenesis -production of androgenic and gynogenic haploids - diploidization; protoplast culture - isolation and purification; Protoplast culture; protoplast fusion; Somatic hybridization - Production of somatic hybrids and cybrids, Somatic embryogenesis and artificial seeds, Wide hybridization - embryo culture and embryo rescue techniques; Ovule, ovary culture and endosperm culture.

Block 2: Callus and cell suspension culture

Unit I: Cell suspension culture for secondary metabolite production

Large-scale cell suspension culture - Production of alkaloids and other secondary metabolites- techniques to enhance secondary metabolite production

Unit II: Somaclonal variations

Somaclonal and gametoclonal variations – causes and applications; Callus culture and in vitro screening for stress tolerance;

Unit III: Germplasm conservation

In vitro germplasm storage and cryo-preservation.

Block 3: Commercial plant tissue culture

Unit I: Case studies/success stories

Commercial Tissue Culture: Case studies and success stories.

Unit II: Genetic purity testing and virus indexing

National certification and Quality management of TC plants; Genetic Fidelity testing and Virus indexing methods – PCR, ELISA, Market assessment; project planning and preparation, economics, government policies.

Practical

- Preparation of stocks - macronutrients, micronutrients, vitamins and hormones, filter sterilization of hormones and antibiotics. Preparation of Murashige and Skoog medium.
- Micro-propagation of plants by nodal and shoot tip culture.

- Embryo culture to overcome incompatibility, Anther culture for haploid production.
- Callus induction in tobacco leaf discs, regeneration of shoots, root induction, role of hormones in morphogenesis.
- Acclimatization of tissue culture plants and establishment in greenhouse.
- Virus indexing in tissue culture plants. (Using PCR and ELISA).
- Plan of a commercial tissue culture unit.

References

- RAZDAN, M. K., 2003, Introduction to plant tissue culture, 2nd edition, Oxford publications group
- BUTENKO, R. G., 2000, Plant Cell Culture University Press of Pacific
- HERMAN, E. B., 2008, Media and Techniques for Growth, Regeneration and Storage, Agritech Publications, New York, USA.
- BHOJWANI, S. S. AND DANTU, P., 2013, Plant Tissue Culture – An Introductory Text. Springer Publications. Gamborg, O. L and G. C. Philips (eds.).

MBB 510 MICROBIAL AND INDUSTRIAL BIOTECHNOLOGY (2+1)

Objective

To familiarize about the various microbial processes/systems/ activities, which have been used for the development of industrially important products/processes.

Theory

Block 1: Scope and applications of Industrial Biotechnology

Unit I: Industrially important microbes, screening and improvement

Introduction, scope and historical developments; Isolation, screening and genetic improvement (involving classical approaches) of industrially important organisms. Strategies for development of industrial microbial strains with scale up production capacities; Metabolic pathway engineering of microbes for production of novel product for industry.

Unit II: Production of industrially important metabolites

Primary metabolites, production of industrial ethanol as a case study; Secondary metabolites, bacterial antibiotics and non-ribosomal peptide antibiotics as case study; Recombinant DNA technologies for microbial processes.

Unit III: Microbial enzymes and immobilization

Microbial enzymes, role in various industrial processes, production of fine chemicals for pharmaceutical industries; Bio- augmentation with production of vitamin C as a case study; Bioreactors, their design and types; Immobilized enzymes-based bioreactors; Microencapsulation technologies for immobilization of microbial enzymes.

Block 2: Environmental Biotechnology

Unit I: Biotreatment, Bioremediation and waste management

Environmental Biotechnology, biotreatment for pollution control, treatment of industrial and other wastes, biomass production involving single cell protein; Bio-transformations, Bioremediation of soil; Production of eco-friendly agricultural chemicals, bio- pesticides, bio-herbicides, bio-fertilizers, bio-fuels, *etc.*

Practical

- Isolation of industrially important microorganisms, their maintenance and improvement.
- Lab scale production of industrial compounds such as alcohol, beer, citric acid, lactic acid and their recovery.
- Study of bio-reactors and their operations.
- Production of bio-fertilizers.
- Experiments on microbial fermentation process of antibiotics, bio-pigments, dairy product harvesting purification and recovery of end products. Immobilization of cells and enzymes, studies on its kinetic behavior, growth analysis and biomass estimation. Determination of mass transfer coefficient.

References

- WAITES, M. J., MORGAN, N. L., ROCKEY, J. S., HIGTON, G., 2001, Industrial Microbiology: An Introduction, Wiley-Blackwell.

- SLATER, A., SCOTT, N. W. & FOWLER, M. R., 2003, The Genetic Manipulation of Plants. Plant Biotechnology Oxford, England: Oxford University Press.
- KUN, L. Y., (Ed.), 2003, Microbial biotechnology: principles and applications. World Scientific Publishing Company.

MBB 511 MOLECULAR PLANT BREEDING (2+1)

Objective

- To familiarize the students about the use of molecular biology tools in plant breeding.
- To provide a hands on training in data analysis, diversity analysis and mapping of genes and QTLs.

Theory

Block 1: Mapping population and Molecular markers

Unit I: Inheritance of traits, heritability and development of mapping population

Inheritance of qualitative and quantitative traits. Heritability – its estimation, Population structure of self- and cross-pollinated species, Factors affecting selection efficiency. Development of different kinds of segregating populations – F2, F3, BC1F1, BC1F2, BC4F2, RIL (Recombinant Inbred Lines), AIL (Advanced Intercrossed Lines), DH (Di-haploid population), NIL (Near Isogenic lines), NAM (Nested Association Mapping), MAGIC (Multi-parent Advanced Generation Intercross population).

Unit II; Molecular markers and linkage map construction

Causes of sequence variation and its types, Types of molecular markers and development of sequence based molecular markers – RFLP, AFLP, SCARs, CAPS, SSRs, STMS, SNPsInDel and DARTseq; Inheritance of markers, Linkage analysis using test cross, F2, F3, BC1F1, RIL. Construction of genetic map, Mapping genes for qualitative traits; Genotyping by sequencing and high-density chip arrays.

Block 2: QTL mapping

Unit I: QTL mapping and GWAS

QTL mapping using structured populations; Association mapping using unstructured populations; Genome Wide Association Studies (GWAS),Principle of Association mapping– GWAS-SNP genotyping methods, Fine mapping of genes/QTL; Development of gene based markers; Allele mining by TILLING and Eco-TILLING.

Unit II: Genotying by sequensing

DART array sequencing, Illumina's Golden Gate Technology, Genotyping by sequencing methods- Fluidigm; GBS, Illumina Hi seq-Nano pore sequencing, Principles and methods of Genomic Selection.

Block 3: Applications of molecular markers in crop improvement

Unit I: Marker-Assisted selection and gene introgression

Tagging and mapping of genes. Bulk segregant and co-segregation analysis, Marker assisted selection (MAS); Linked, unlinked, recombinant, flanking, peak markers. Foreground and background selection; MAS for gene introgression and pyramiding: MAS for specific traits with examples. Haplotype concept and Haplotype-based breeding; Genetic variability and DNA fingerprinting. Molecular markers in Plant variety protection, IPR issues, hybrid purity testing, clonal fidelity testing and transgenic testing.

Practical

- Construction of linkage map.
- QTL analysis using the QTL cartographer and other software.
- SNP data analysis using TASEEL.
- Detection of haplotype block using SNP data - pLinksoftware.
- Genotyping by sequencing methods –Illumina genotyping platform.
- Marker assisted breeding – MABB case studies quality traits in rice/maize.
- Genome Assisted Breeding in model crops, Genomic Selection models using the morphological and SNP data.

References

- ACQUAAH, G., 2007, Principles of Plant Genetics and Breeding, Blackwell Publishing Ltd. USA.
- WEISING, K., NYBOM, H., WOLFF, K. AND KAHL, G., 2005, DNA Fingerprinting in Plants: Principles, Methods and Applications, 2nd ed. Taylor and Francis Group, Boca Raton, FL.
- HALFORD, N., 2006, Plant Biotechnology-Current and future applications of genetically modified crops, John Wiley and Sons, England.
- SINGH, B. D. AND SINGH, A. K., 2015, Marker-Assisted Plant Breeding: Principles and Practices Springer (India) Pvt. Ltd.
- Boopathi, NM. 2013. Genetic Mapping and Marker Assisted Selection: Basics, Practice and Benefits. Springer India. p293.

MBB 512 IPR, BIO-SAFETY & BIOETHICS (2+0)

Objective

- To familiarize the students about ethical and biosafety issues in plant biotechnology.

Theory

Block 1: Intellectual property rights

Unit I: IPR, types of IPR and patents in biotechnology

IPR: historical background in India; trade secret; patent, trademark, design& licensing; procedure for patent application in India; Patent Cooperation Treaty (PCT); Examples of patents in biotechnology-Case studies in India and abroad; copyright and PVP.

Unit II: Implications of IPR for commercialization and trade agreements

Implications of IPR on the commercialization of biotechnology products, ecological implications; Trade agreements- The WTO and other international agreements, and Cross border movement of germplasms.

Block 2: Biosafety and bioethics

Unit I : Biosafety, biohazard, risk assessment, regulatory protocols and guidelines

Biosafety and bio-hazards; General principles for the laboratory and environmental bio-safety; Biosafety and risk assessment issues; handling and disposal of biohazards; Approved regulatory laboratory practice and principles, The Cartagena Protocol on biosafety; Biosafety regulations in India; National Biosafety Policy and Law; Regulations and Guidelines related to Biosafety in other countries.

Unit II: Concerns of transgenic plants, risk and safety assessment

Potential concerns of transgenic plants – Environmental safety and food and feed safety. Principles of safety assessment of transgenic plants – sequential steps in risk assessment. Concepts of familiarity and substantial equivalence. Risk -Environmental risk assessment – invasiveness, weediness, gene flow, horizontal gene transfer, impact on non-target organisms; food and feed safety assessment –toxicity and allergenicity.

Unit III: Monitoring and detection of transgenics and Bioethical issues

Monitoring strategies and methods for detecting transgenics. Field trails, biosafety research trials, standard operating procedures, labeling of GM food and crop, Bio-ethics. Mankind and religion, social, spiritual & environmental ethics; Ethics in Biotechnology, labeling of GM food and crop; Biopiracy.

Reference

- GOEL, D. AND PARASHAR, S., 2013, IPR, biosafety and bioethics.
- JOSHI, R., 2006, Biosafety and Bioethics.
- NAMBISAN, P., 2017, An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology.

MBB 513 IMMUNOLOGY AND MOLECULAR DIAGNOSTICS (3+0)

Objectives

- To familiarize the students about immune system and molecular diagnostic tools.

Theory

Block 1: Immune system

Unit I: Types of Immunity and immune system

Immunity and its classification; Components of innate and acquired immunity; Lymphatic system; Hematopoiesis; Organs and cells of the immune system- primary, secondary and tertiary lymphoid organs Descriptions of Antigens – immunogens, hapten and adjuvants.

Unit II: Immunoglobulins and diversity

Immunoglobulins-basic structure, classes & subclasses of immunoglobulins, antigenic determinants; Multigene organization of immunoglobulin genes; B-cell receptor; Immunoglobulin superfamily; Principles of cell signaling; Basis of self and non-selfdiscrimination; Kinetics of immune response, memory; B cell maturation, activation and differentiation; Generation of antibody diversity; T-cell maturation, activation and differentiation and T-cell receptors; Functional T Cell Subsets; Cell-mediated immune responses, ADCC; Cluster of Differentiations (CDs), Cytokines-properties, receptors and therapeutic uses.

Unit III: Antigens and Immune response

Phagocytosis; Complement and Inflammatory responses; Major Histocompatibility Complex-MHC genes, MHC and immune responsiveness and disease susceptibility, HLA typing; Antigen processing and presentation- endogenous antigens, exogenous antigens, non-peptide bacterial antigens and super-antigens; Cell-cell co-operation, Hapten-carrier system.

Block 2: Molecular Diagnostics

Unit I: Immunological techniques

Precipitation, agglutination and complement mediated immune reactions; Advanced immunological techniques – RIA, ELISA, Western blotting, ELISPOT assay, immunofluorescence, flow cytometry and immunoelectron microscopy; Surface plasmon resonance, Biosenor assays for assessing ligand –receptor interaction, CMI techniques-lymphoproliferation assay, Mixed lymphocyte reaction, Cell Cytotoxicity assays, Apoptosis, Transgenic mice, Gene knock outs.

Unit II: Vaccines and immune therapies

Active and passive immunization; Live, killed, attenuated, sub unit vaccines; Vaccine technology- Role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, Antibody genes and antibody engineering- chimeric and hybrid monoclonal antibodies, Immunity to Infection,Bacteria, viral, fungal and parasitic infections, Hypersensitivity – Type I-IV; Autoimmunity; Types of autoimmune diseases, MHC and TCR in autoimmunity; Transplantation, Immunological basis of graft rejection, immunosuppressive therapy; Tumor immunology – Tumor antigens.

References

- OWEN J. A., PUNT, J. AND STRANFORD, S. A., 2013, Kuby immunology (p. 692). New York: WH Freeman.
- KENNETH, M. AND WEAVER, C., 2017, Janeways Immunobiology, 9th Edition, New York, USA: Garland Science, Taylor & Francis publisher.
- WILLIAM, P., 2013, Fundamental of Immunology, 7th edition, Lippencott, William and Wilkins publisher

MBB 514 NANO BIOTECHNOLOGY (2+1)

Objective

- Understanding the molecular techniques involved in structure and functions of nano-biomolecules in cells such as DNA, RNA and proteins.

Theory

Block I: Overview of nanobiotechnology and nanomaterials

Unit I: Nanomaterial synthesis and characterization

Introduction to Nanotechnology - Nanomaterials - Self-assembly to artificial assembly for creation of useful nanostructures – Bottoms up and Top down approach (Nano rods, nano cages, nanotubes, quantum dots, nanowires, metal/ polymer-based nanostructures) – Preparation and Characterization of nanoparticles (particle size analyzer, microscopy, *viz.* electron microscopy, atomic force microscopy, etc).

Unit II: Bionanomaterials

Cell structure – Bio macromolecules: Types, Structure, Dynamics and interaction with water – Cellular nano machines – cellular transducers, membrane channels, membrane transporters, Membrane motors – Creation of bio-nanostructures (Nano liposomes, Nano micelles, Nanomotors, *etc.*).

Unit III: Properties of nanomaterial

Chemical, physical and biological properties of biomaterials and bio response: biomineralization, biosynthesis, and properties of natural materials (proteins, DNA and polysaccharides), structure-property relationships in polymeric materials (synthetic polymers and structural proteins); Aerosol properties, application and dynamics; Statistical Mechanics in Biological Systems.

Block 2: Applications of nanotechnology

Unit I: Biosensors and nanocarriers

Nano particular carrier systems; Micro- and Nano-fluidics; Drug and gene delivery system; Micro fabrication, Biosensors, Chip technologies, Nano- imaging, Metabolic engineering and Gene therapy.

Reference

- NALWA, H. S., 2005, Handbook of Nano structured Biomaterials and Their Applications in Nano biotechnology. American Scientific Publications.

- NIEMEYER, C. M. AND MIRKIN, C. A., (Eds), 2005, Nano biotechnology: Concepts Applications and Perspectives, Wiley Inter-science publications.
- CAO, G. AND WANG, Y., 2004, Nanostructures and Nano materials: Synthesis, Properties and Applications, Imperial College Press.

MBB 515 ENVIRONMENTAL BIOTECHNOLOGY (3+0)

Objective

- To apprise the students about the role of biotechnology in environment management for sustainable eco-system and human welfare.

Theory

Block 1: Scope and Importance of Biotechnology in environment

Unit I: Environmental pollution and control

Basic concepts and environmental issues; types of environmental pollution; problems arising from high-input agriculture; methodology of environmental management; air and water pollution and its control; waste water treatment - physical, chemical and biological processes; need for water and natural resource management.

Unit II: Applications of Microorganisms in pollution control

Microbiology and use of micro-organisms in waste treatment; biodegradation; degradation of Xenobiotic, surfactants; bioremediation of soil & water contaminated with oils, pesticides and toxic chemicals, detergents *etc*;

Block 2: Energy sources and Waste water treatment

Unit I: Energy, Biofuels and Biofertilizer

Renewable and non-Renewable resources of energy; energy from solid waste; conventional fuels and their environmental impact; biogas; microbial hydrogen production; conversion of sugar to alcohol; gasohol; biodegradation of lignin and cellulose; biopesticides; biofertilizers; composting; vermiculture *etc.*

Unit II: Waste water treatment

Treatment schemes of domestic waste and industrial effluents; food, feed and energy from solid waste; aerobic processes (activated sludge, oxidation ditches, trickling filter, rotating drums, *etc*); anaerobic processes: digestion, filtration, etc.bioleaching; enrichment of ores by microorganisms; global environmental problems: ozone depletion, UV-B, greenhouse effects, and acid rain; biodiversity and its conservation; biotechnological approaches for the management environmental problems.

References

- EVANS, G. M. AND FURLONG, J. C., 2010, Environmental Biotechnology: Theory and Application. 2nd edition, Wiley-Blackwell.
- JORDENING, H. J. AND WINTER, J., 2006, Environmental Biotechnology: Concepts and Applications. Wiley-VCH Verlag.

MBB 516 BIO-ENTREPRENEURSHIP (1+0)

Objective

- The objective of this course is to teach students about fundamentals of entrepreneurship, launching a venture or a start up in biotechnology-based theme.

Theory

Block 1: Scope and Importance of Bio-entrepreneurship

Unit I: Overview of bio-industries and entrepreneurship development programs

Scope in biotechnology; types of bio-industries – bio-pharma, bio-agri, bio-services and bio-industrial; Importance of entrepreneurship; introduction to bioentrepreneurship – biotechnology in a global scale; – skills for successful entrepreneur–creativity, leadership, managerial, team building, decision making; opportunities for bio-entrepreneurship-entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Startup & Make in India).

Unit II: Business development and SWOT analysis

Business plan preparation; business feasibility analysis by SWOT, socio-economic costs benefit analysis; funds/ support from various agencies; statutory and legal requirements for starting a company/ venture.

Block II: Incubation and Market linkages

Unit I: Incubation and technology transfer

Knowledge centers e.g., in Universities, innovation centres, research institutions (public & private) and business incubators; R&D for technology development and upgradation; assessment of technology development; managing technology transfer.

Unit II: Market study and analysis

Entry and exit strategy; identifying needs of customers; Market linkages, branding issues; developing distribution channels - franchising; policies, promotion, advertising; branding and market linkages for 'virtual startup company'. Pricing strategy.

References

- ADAMS, D. J. AND SPARROW, J. C., 2008, Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences. Bloxham: Scion.
- SHIMASAKI, C. D., 2014, Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.
- ONETTI, A. AND ZUCCHELLA, A., 2014, Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge. Routledge.
- JORDAN, J. F., 2014, Innovation, Commercialization, and Start-Ups in Life Sciences. London: CRC Press.
- Desai, V., 2009, The Dynamics of Entrepreneurial Development and Management. New Delhi: Himalaya Pub. House.

MBB 517 STRESS BIOLOGY AND GENOMICS (2+0)

Objective

To provide advanced knowledge on genomics with reference to abiotic stress tolerance and biotic stress resistance in plants tolerance**.**

Theory

Block 1: Stress Biology and Stress response

Unit I: Kinds of stresses and adaptation strategies

Different kinds of stresses (biotic and abiotic) and adaptation strategies: Plant cell as a sensor of environmental changes; role of cell membranes in signal perception; Ways of signal transduction in cells and whole plants as a response to external factors. Abiotic stresses affecting plant productivity – Drought, salinity, water logging, temperature stresses, light stress and nutrient stress; Drought stress – Effects on plant growth and development; Components of drought resistance; Physiological, biochemical and molecular basis of tolerance mechanisms; Biotic stress (insect and pathogen) resistance mechanism.

Unit II: Drought stress

Strategies to manipulate drought tolerance – Osmotic adjustment and Osmoprotectants - synthesis of proline, glycine betaine, poly amines and sugars; ROS and antioxidants; hormonal metabolism - ABA signaling; signaling components – transcription factors. Water logging stress – effects on plant growth and metabolism; adaptation to water logging,tolerance mechanisms -hormones and flooding tolerance. Strategies for improving submergence tolerance.

Unit III: Salinity and heavy metal stress

Salinity stress – effects on physiology and metabolism of plants, SOS pathways and ion homeostasis,Strategies to improve salinity tolerance in plants. Water logging stress – effects on plant growth and metabolism; tolerance mechanisms. Physiological and biochemical changes – High & Low temperature tolerance mechanisms - molecular basis of thermo tolerance. Morphological and physiological changes in plants due to high and low light stresses - photo oxidation -plastid

development. Characters of heliophytes and sciophytes – solar tracking – sieve effect and light channeling. Heavy metal stress – Al and Cd stress - effects on plant growth and development, Strategies to overcome heavy metal stress Nutrient stress-effects on plant growth and development. Genetic manipulation strategies to overcome the stress effects.

Block 2 : Advanced techniques for stress tolerance

Unit I: Genomics and transgenic approaches for stress management

Transfer of tolerance/resistant genes to model plants and validation of gene function. Different techniques for the functional validation of genes. Signaling pathway related to defense gene expression, R proteins, RNAi approach and genes from pathogens and other sources, coat protein genes, detoxification genes, transgenic and disease management. Bt proteins, resistance management strategies in transgenic crops, ecological impact of field release of transgenic crops. Genomics; transcriptomes, small RNAs and epigenomes; functional genomics;

Unit II: Bioinformatics for stress management

Bioinformatics approaches to determine gene function and network in model plants under stress.

Reference

- BUCHANAN, B. B., GRUISSEM, W. AND JONES, R., 2015, Biochemistry and Molecular Biology of Plants, 2nd edition, Wiley and Blackwell Publications.
- SARWAT, M., AHMAD, A., ABDIN, M. Z., 2013, Stress Signaling in Plants: Genomics and Proteomics Perspective, Volume 1, Springer.
- HERIBERT HIRT., 2010, Plant Stress Biology: From Genomics to Systems Biology, John Wiley.
- PANDEY, G. K., 2015, Elucidation of Abiotic Stress Signaling in Plants, Stringer.

MBB 518 GENE REGULATION (2+0)

Objective

- To understand the basics of gene regulation including a wide range of mechanisms that are used by organisms to increase or decrease the production of specific gene products in terms of time, space, conditions or their combinations.

Theory

Block I: Transcriptional regulation and regulatory factors

Unit I: Transcriptional regulation - cis- and trans-acting factors

Transcriptional regulation – Regulatory proteins, Activators and Repressors, Binding of RNA polymerase, Allosteric regulation, DNA looping, Cooperative binding, Anti-termination, Combinatorial control – Regulation of lac, trp and ara Operons. Gene regulation in Lambda phage – lytic or lysogenic establishment.

Unit II: Regulatory sequences and signal transduction

Regulatory sequences – Promoters, Enhancers, Silencers, Insulators, Locus Control Region. Activator proteins and their binding sites, DNA binding domain–Homeodomain, Zinc containing proteins, Leucine Zipper Motif, Helix-Loop-Helix, HMG proteins. Recruitment of RNA polymerase to promoter region, Nucleosomes and their modifiers. Signal integration. Signal transduction and transcriptional regulation. Gene Silencing. Epigenetic gene regulation.

Block 2: Non-coding RNA and gene regulation

Unit I: Non-coding RNAs

Regulation by RNA in prokaryotes and eukaryotes, RNA as defense agents. Ribo-switches. Gene Silencing by RNA - siRNA & miRNA – synthesis and function. Non-coding RNAs their impact, categories and role in gene regulation, chromatin assembly *etc.*

Unit II: Auto-regulation

Negative auto-regulation, Positive auto-regulation, Bistable and Bimodal switch, Oscillating pattern of gene expression.

References

- NELSON, D. L. AND COX, M. M., 2017, Lehinger's Principles of Biochemistry, 7th edition, W H Freeman Publication New York
- KREBS, J. E., GOLDSTEIN, E. S. AND KILPATRICK, S. T., 2017, Lewin's Genes XII 12th edition, Jones & Bartlett Learning publisher, Inc
- WATSON, J. D., BAKER, T. A., BELL, S. P., GANN, A., LEVINE, M., AND LONICK, R., 2014, Molecular Biology of the Gene, 7th Edition, Cold Spring Harbor Laboratory Press, New York.
- GARDNER, E. J., SIMMONS, M. J. AND SNUSTAD, D. P., 2006, Principles of Genetics (2006) eighth Edition. Wiley.

M.Sc. (Agri.) in Plant Pathology

Course Code	Course Title	Credit Hours
PAT 501	Mycology	3 (2+1)
PAT 502	Plant Virology	3 (2+1)
PAT 503	Plant Pathogenic Prokaryotes	3 (2+1)
PAT 504	Plant Nematology	3 (2+1)
PAT 505	Principles of Plant Pathology	3 (2+1)
PAT 506	Techniques in Detection and Diagnosis of Plant Diseases	2 (0+2)
PAT 507	Principles of Plant Disease Management	3 (2+1)
PAT 508	Epidemiology and Forecasting of Plant Diseases	1 (1+0)
PAT 509	Disease Resistance in Plants	2 (2+0)
PAT 510	Ecology of Soil-Borne Plant Pathogens	2 (1+1)
PAT 511	Chemicals and Botanicals in Plant Diseases Management	3 (2+1)
PAT 512	Detection and Management of Seed Borne Pathogens	3 (2+1)
PAT 513	Biological Control of Plant Diseases	2 (1+1)
PAT 514	Integrated Diseases Management	3 (2+1)
PAT 515	Diseases of Field and Medicinal crops	3 (2+1)
PAT 516	Diseases of Fruit, Plantation and Ornamental crops	3 (2+1)
PAT 517	Diseases of Vegetable and Spices crops	3 (2+1)
PAT 518	Post-Harvest Diseases	3 (2+1)
PAT 519	Plant Quarantine and Regulatory Measures	1 (1+0)
	Total	**49 (32+17)**
PAT 580	Qualifying Examination	2 (0+2)
PAT 581	Seminar-I	1 (0+1)
PAT 582	Seminar-II	1 (0+1)
PAT 591	Research-I	13 (0+13)
PAT 592	Research-II	14 (0+14)

PAT 501 MYCOLOGY (2+1)

Objectives

To study the nomenclature, classification and characters of fungi.

Theory

Block –1: Introduction, Importance, concepts and morphology of Fungi

Unit 1: Introduction, definition of different terms, basic concepts. Importance of mycology in agriculture, relation of fungi to human affairs.

Unit 2: History of mycology. Importance of culture collection and herbarium of fungi. Somatic characters and reproduction in fungi.

Unit 3: Modern concept of nomenclature and classification of fungi.

Block 2: Kingdom: Protists and Stramenopila and their characters and classification

Unit 1 : kingdom fungi: Protists. The general characteristics of protists and lifecycle in the Phyla Plasmodiophoromycota,

Unit 2: Dictyosteliomycota, Acrasiomycota and Myxomycota.

Unit 3: Kingdom Stramenopila: characters and life cycles of respective genera under Hypochytriomycota, Oomycota and Labyrinthulomycota.

Block 3- Kingdom: Fungi and their characters and classification

Unit 1: Phylum: Chytridiomycota: General characters, ultrastructure and life cycle patterns in representative genera under Chytridiomycota.

Unit 2: Phylum: Ascomycota;Archiascomycetes, Ascomycetous, yeasts, Pyrenomycetes, Plectomycetes, Discomycetes and Loculoascomycetes, filamentous ascomycetes Erysiphales.

Unit 3: Phylum: Zygomycota: charactersitics of Zygomycets fungi.

Block 4 -Phylum: Basidiomycota and Deuteromycota characters and classification

Unit- 1: Basidiomycota; general characters, mode of reproduction, types of basidiocarps and economic importance of Hymenomycetes.

Unit- 2: Uridinales and Ustilaginales; variability, host specificity and life cycle pattern in rusts and smuts.

Unit- 3: Mitosporic fungi; status of asexual fungi, their teliomorphic relationships, Molecular characterization of plant pathogenic fungi.

Practical

- Detailed comparative study of different groups of fungi
- Collection of cultures and live specimens
- Saccardo an classification and classification based on conidiogenesis
- Vegetative structures and different types of fruiting bodies produced by slime molds, stramenopiles and true fungi.
- Myxomycotina: Fructification, plasmodiocarp, sporangia, plasmodium and aethalia Oomycota;
- Somatic and reproductory structures of Pythium, Phytophthora, downy mildews and Albugo, Zygomycetes: Sexual and asexual structures of Mucor, Rhizopus
- General characters of VAM fungi. Ascomycetes; fruiting structures, Erysiphales and Eurotiales
- General identification characters of Pyrenomycetes, Discomycetes, Loculo-ascomycetes and Laboulbenio-mycetes, Basidiomycetes; characters, ultrastructures and life cycle patterns in Ustilaginomycetes and Teliomycetes, Deuteromycetes
- Characters of Hyphomycetes and Coelomycetes and their teliomorphic andanamorphic states, Collection, preservation, culturing and identification of plantparasitic fungi
- Application of molecular approaches and techniques for identification of fungal pathogens.

Reference

- AINSWORTH, G. C., SPARROW, F. K. AND SUSMAN, H. S., 1973, The Fungi-An Advanced Treatise. Vol IV (A & B), Academic Press, New York.

- ALEXOPOULOS, C. J., MIMS, C. W. AND BLACKWELL, M., 2000, Introductory Mycology, 5th Ed. John Wiley & Sons, New York.
- MAHESHWARI, R., 2016, Fungi: Experimental Methods in Biology 2ndedn. CRC Press, US.
- MEHROTHRA, R. S. AND ARNEJA, K. R., 1990, An Introductory Mycology, Wiley Eastern, New Delhi.
- SINGH, R. S. 1982, Plant Pathogens-The Fungi, Oxford & IBH, New Delhi.
- WEBSTER, J., 1980, Introduction to Fungi. 2nd Ed. Cambridge Univ. Press, Cambridge, New York

PAT 502 PLANT VIROLOGY (2+1)

Objectives

To acquaint with the structure, virus-vector relationship, biology and management of plant viruses.

Theory

Block 1– Introduction, History, importance, general characteristics and classification of plant viruses

Unit 1: History and economic significances ofplant viruses. General and morphological characters, composition and structure of viruses

Unit 2: Myco-viruses, arbo and baculo viruses, satellite viruses, satellite RNAs, phages,viroids and prions.

Unit 3: Origin and evolution ofviruses and their nomenclature and classification.

Block 2- Plant viral genome, replication and pathometabolism

Unit 1: Genome organization, replication in selected groups of plant viruses and their movement in host.

Unit 2: Response of the host to virus infection: biochemical, physiological, and symptomatical changes.

Unit 3: Transmission of viruses and virus-vector relationship. Isolation and purification of viruses.

Block 3- Detection and management of plant viruses

Unit 1: Detection and identification of plant viruses by using protein and nucleic acid based diagnostic techniques.

Unit 2: Natural (R-genes) and engineering resistance to plant viruses. Virus epidemiology and ecology (spread of plant viruses in fields, host range and survival).

Unit 3: Management of diseases caused by plant viruses.

Practical

- Study of symptoms caused by plant viruses (followed by field visit)
- Isolation and biological purification of plant viruses cultures
- Bioassay of virus cultures on indicator plants and host differentials
- Transmission of plant viruses (Mechanical, graft and vector and study of disease development)
- Plant virus purification (clarification, concentration, centrifugation, high resolution separation and analysis of virions), Electron microscopy for studying viral particle morphology
- Antisera production, Detection and diagnosis of plant viruses with serological (ELISA), nucleic acid (Non-PCR–LAMP, Later flow micro array and PCR basedtechniques)
- Exposure to basic bio-informatics tools for viral genome analysis and their utilization in developing detection protocols and population studies (BLASTn tool, Primer designing software, Bioedit tool, Claustal X/W, MEGA Software).OGY 2+1

Reference

- BOS, L., 1964, Symptoms of Virus Diseases in Plat s. Oxford & IBH., New Delhi.
- BRUT, A. A., KRABTREE, K., DALLWITZ, M. J., BIBBS, A. J. AND WATSON, L., 1995, Virus of Plants: Descriptions and Lists from VIDE Database. CABI, Wallington.
- GIBBS, A. AND HARRISON, B., 1976, Plant Virology – The Principles. Edward Arnold, London, Hull R., 2002, Mathew's Plant Virology. 4th Ed. Academic Press, New York.

• NOORDAM D., 1973, Identification of Plant Viruses. Methods and Experiments. Oxford & IBH, New Delhi.

PAT 503 PLANT PATHOGENIC PROKARYOTES (2+1)

Objectives

To acquaint with plant pathogenic prokaryote (procarya) and their structure, nutritional requirements, survival and dissemination.

Theory

Block-1: Introduction, History, importance and characteristics of Plant Pathogenic prokaryotes

Unit 1: Prokaryotic cell, History and development of Plant bacteriology, history of plant bacteriology in India.

Unit 2: Evolution of prokaryotic life, Prokaryotic cytoskeletal proteins. Structure of bacterial cell.

Unit 3: Structure and composition of gram negative and grampositive cell wall; synthesis of peptidoglycan; Surface proteins; Lipopolysaccharide structure; Membrane transport; fimbriae and pili (Type IV pili);

Block 2- Plant Prokaryotic motility, physiology, genome characteristics and their survival and spread.

Unit 1: Mechanism offlagellar rotatory motor and locomotion, and bacterial movement

Unit 2: Glycocalyx (S-layer; capsule); the bacterial chromosomes and plasmids; Operon and other structures in cytoplasm; Morphological feature of fastidious bacteria, spiroplasmas and Phytoplasmas.

Unit 3: Growth and nutritional requirements. Infection mechanism, role of virulence factors in expression of symptoms. Survival and dispersal of phytopatho genic prokaryotes. Plant Protection–Plant Pathology.

Block 3- Classification and variability of plant pathogenic prokaryotes

Unit 1: Taxonomy of phytopatho genic prokarya: Taxonomic ranks hierarchy; Identification, Classification and nomenclature of bacteria, phytoplasma and spiroplasma.

Unit 2: The codes of Nomenclature and characteristics. Biochemical and molecular characterization of phytopathogenic prokaryotes.

Unit 3: Variability among phytopatho genicprokarya: general mechanism of variability (mutation); specialized mechanisms of variability (sexual like process in bacteria-conjugation; transformation; transduction); and horizontal gene transfer.

Block 4- Bacteriophages and management of diseases caused by Phyto pathogenic prokaryotes

Unit 1: Bacteriophages, L form of bacteria, plasmids and bdellovibrios: Structure; Infection of host cells; phage multiplication cycle;

Unit 2: Classification of phages, Use of phages in plant pathology/ bacteriology, Lysogenic conversion; H Plasmids and their types,

Unit 3: Plasmid borne phenotypes. Introduction to bacteriocins. Strategies for management of diseases caused by phytopathogenic prokaryotes.

Practical

- Study of symptoms produced by phytopathogenic prokaryotes
- Isolation, enumeration, purification, identification and host inoculation of phytopathogenic bacteria
- Stains and staining methods
- Biochemical and serological characterization
- Isolation of genomic DNA, plasmid
- Use of antibacterial chemicals/ antibiotics
- Isolation of fluorescent Pseudomonas
- Preservation of bacterial cultures
- Identification of prokaryotic organisms by using 16S rDNA, and other genesequences
- Diagnosis and management of important diseases caused by bacteria and mollicutes

Reference

- GOTO, M., 1990, Fundamentals of Plant Bacteriology, Academic Press, New York.
- JAYARAMAN, J. AND VERMA, J. P., 2002., Fundamentals of Plant Bacteriology. Kalyani Publishers, Ludhiana.
- MOUNT, M. S. AND LACY, G. H., 1982, Phytopathogenic Prokaryotes. Vols. I, II Academic Press, New York
- SALLE, A. J., 1979, Fundamental Principles of Bacteriology 7th edn.
- VERMA, J. P., VARMA, A. AND KUMAR, D. (EDs), 1995, Detection of Plant Pathogens and their Management. Angkor Publ., New Delhi.

PAT 504 PLANT NEMATOLOGY (2+1)

Objectives

To project the importance of nematodes in agriculture and impart basic knowledge on all aspects of plant nematology.

Theory

Block 1: Introduction, History and characteristics of Plant parasitic nematodes

Unit 1: Characteristics of Phylum Nematoda and its relationship with other related phyla, history and growth of Nematology;

Unit 2: Nematode habitats and diversity- plant, animal and human parasites; useful nematodes; economic importance of nematodes to agriculture, horticulture and forestry.

Unit 3: Gross morphology of plant parasitic nematodes; broad classification, nematodebiology, physiology and ecology.

Block-2- Plant nematode interactions and Physiological races

Unit 1: Types of parasitism; nature of damage and general symptomatology; interaction of plant-parasitic nematodes with other organisms.

Unit 2: Plant nematode relationships, cellular responses to infection by important phytonematodes;

Unit 3: Physiological specialization among phytonematodes.

Block –3- Integrated management of plant parasitic nematodes

Unit 1: Principles and practices of nematode management; integrated nematode management.

Unit 2: Emerging nematode problems

Unit 3: Importance of nematodes in international trade and quarantine.

Practical

- Studies on kinds of nematodes- free-living, animal, insect and plant parasites
- Nematode extraction from soil
- Extraction of migratory endoparasites, staining for sedentary endoparasites
- Examination of different life stages of important plant parasitic nematodes, their symptoms and histopathology. Study of perennial pattern in Root knot nematodes.

Reference

- DROPKIN, V. H., 1980, An Introduction to Plant Nematology, John Wiley & Sons. New York.
- MAGGENTI, A. R., 1981, General Nematology, Springer-Verlag, New York.
- PERRY, R. N. AND MOENS, M., 2013, Plant Nematology. 2nd Ed. CABI Publishing. Willingford, UK
- SIKORA, R. A., COYNE, D., HALLMAN, J. AND TIMPER, P., 2018, Plant Parasitic Nematodes in Subtropical and Tropical Agriculture. 3rdedn. CABI Publishing, England.
- THORNE, G., 1961, Principles of Nematology, McGraw Hill, New Delhi.

- WALIA, R. K. AND BAJAJ, H. K., 2003, Text Book on Introductory Plant Nematology ICAR, New Delhi
- WALIA, R. K. AND KHAN, M. R., 2018, A Compendium of Nematode Diseases of Crop Plants, ICAR, AICRP (Nematodes), IARI, New Delhi.

PAT 505 PRINCIPLES OF PLANT PATHOLOGY (2+1)

Objectives

To introduce the subject of Plant Pathology, its concepts and Principles.

Theory

Block-1- Importance, history, physiology of plant pathogen and epidemiology of plant diseases

Unit 1: Importance, definitions and concepts of plant diseases, history and growth of plant pathology, biotic and abiotic causes of plant diseases.

Unit 2: Growth, reproduction, survival and dispersal of important plant pathogens.

Unit 3: Role of environment and host nutrition on disease development.

Block –2- Plant pathogen interaction

Unit 1: Host parasite interaction, recognition concept and infection, symptomatology,

Unit 2: Disease development- role of enzymes, toxins, growth regulators;

Unit 3: Defense strategies- oxidative burst; Phenolics, Phytoalexins, PR proteins, Elicitors. Altered plant metabolism as affected by plant pathogens.

Block –3: Variability of plant pathogen and host plant resistance

Unit 1: Genetics of resistance; 'R' genes; mechanism of genetic variation in pathogens

Unit 2: molecular basis for resistance; marker-assisted selection;

Unit 3: Genetic engineering for disease resistance.

Practical

- Basic plant pathological techniques;
- Isolation, inoculation and purification of plant pathogens and proving Koch's postulates;
- Techniques to study variability in different plant pathogens;
- Purification of enzymes, toxins and their bioassay;
- Estimation of growth regulators, phenols, phytoalexins in resistant and susceptible plants.

Reference

- AGRIOS, G. N., 2005, Plant Pathology, 5th Ed. Academic Press, New York.
- HETEFUSS, R. AND WILLIAMS, P. H., 1976, Physiological Plant Pathology, Springer Verlag, Berlin, New York.
- MEHROTRA, R. S. AND AGGARWAL, A., 2003, Plant Pathology, 2nd Ed. Oxford & IBH, New Delhi.
- SINGH, R. P., 2012, Plant Pathology 2ndedn. Kalyani Publishers, New Delhi.
- SINGH, R. S., 2017, Introduction to Principles of Plant Pathology. 5thedn. MedTech.New Delhi.
- SINGH, D. P. AND SINGH, A., 2007, Disease and Insect Resistance in Plants. Oxford & IBH, New Delhi.
- UPADHYAY, R. K. AND MUKHERJEE, K. G., 1997, Toxins in Plant Disease Development and Evolving Biotechnology, oxford & IBH. New Delhi.

PAT 506 TECHNIQUES FOR DETECTION AND DIAGNOSIS OF PLANT DISEASES (0 + 2)

Objectives

To impart training on various methods/techniques/instruments used in the study of plant diseases/pathogens.

Practical

- Detection of plant pathogens 1. Based on visual symptoms, 2. Biochemical test 3. Cultural studies; (use of selective media to isolatepathogens). 5. Biological assays (indicator hosts, differential hosts) 6. Serologicalassays 7. Nucleic acid based techniques (Non-PCR–LAMP, Later flow microarray and PCR based- multiplex, nested, qPCR, immune capture PCR, etc.).
- Phenotypic and genotypic tests for identification of plant pathogens;
- Molecular identification (16S rDNA and 16s-23S rDNAintergenic spacer regionsequences-prokaryotic organisms; and eukaryotic organism by ITS region) and whole genome sequencing
- Volatile compounds profiling by using GC-MS and LC-MS;
- FAME analysis, Fluorescence in-situ Hybridization (FISH), Flow Cytometry, Phagedisplay technique, biosensors for detection of plant pathogens;
- Genotypic tools such as genome/ specific gene sequence homology comparison by BLAST (NCBI and EMBL) and electron microscopy techniques of plant virus detection and diagnosis.

Reference

- BOS, L., 1964, Symptoms of Virus Diseases in Plants. Oxford IBH., New Delhi.
- BRUNT, A. A., KRABTREE, K., DALLWITZ, M. J., BIBBS, A. J. AND WATSON, L., 1995, Virus of Plants: Descriptions and Lists from VIDE Database. CABI, Wallington.
- GIBBS, A. AND HARRISON, B., 1976, Plant Virology – The Principles. Edward Arnold, London, Hull R, 2002, Mathew's Plant Virology. 4th Ed. Academic Press. New York.
- NOORDAM, D., 1973, Identification of Plant Viruses, Methods and exponents. Oxford & IBH, New Delhi.
- WILSON, C., 2014, Applied Plant Virology, CABI Publishing England.

PAT 507 PRINCIPLES OF PLANT DISEASE MANAGEMENT (2+1)

Objectives

To acquaint with different strategies for management of plant diseases.

Theory

Block- 1- Methods of plant disease management

Unit 1: Principles of plant disease management by cultural, physical, biological, chemical methods of plant disease control

Unit 2: Organic amendments and botanicals methods of plant disease control, integrated control measures of plant diseases.

Unit 3: Disease resistance and molecular approach for disease management.

Block –2- Agrochemicals in plant disease management

Unit 1: History of fungicides, bactericides, antibiotics, concepts of pathogen and immobilization

Unit 2: chemical protection and chemotherapy, nature, properties and mode of action of antifungal

Unit 3: Antibacterial and antiviral chemicals. Label claim of fungicides.

Block- 3- Methods of application of agro chemicals and bio agents

Unit 1: Application of chemicals on foliage, seed and soil, role of stickers, spreaders and other adjuvants

Unit 2: health vis-a-vis environmental hazards, residual effects and safety measures

Unit 3: Integrated disease management, organic management of plant diseases, biological management under protected cultivation.

Practical

- Phytopathometry

- Methods of in-vitro evaluation of chemicals, antibiotics, bio agents against plantpathogens
- Field evaluation of chemicals, antibiotics, bio agents against plant pathogens
- Soil solarisation, methods of soil fumigation under protected cultivation
- Methods of application of chemicals and bio control agents
- ED and MIC values, study of structural details of sprayers and dusters
- Artificial epiphytotic and screening of resistance

Reference

- FRY, W. E., 1982, Principles of Plant Disease Management. Academic Press, New York.
- HEWITT, H. G., 1998, Fungicides in Crop Protection, CABI, Wallington, Marsh RW, 1972, Systemic Fungicides. Longman, New York.
- NENE, Y. L. AND THAPLIYAL, P. N., 1993, Fungicides in Plant Disease Control. Oxford & IBH, New Delhi.
- PALTI, J., 1981, Cultural Practices and Infectious Crop Diseases. Springer Verlag, New York.
- VYAS, S. C., 1993, Handbook of Systemic Fungicides. Vols. I-III. Tata McGraw Hill, New Delhi.

PAT 508 EPIDEMIOLOGY AND FORECASTING OF PLANT DISEASES (1+0)

Objectives

To acquaint with the principles of epidemiology and its application in disease forecasting.

Theory

Block 1- Concepts, history and modeling in plant diseases

Unit 1: Epidemic concepts, simple interest and compound interest disease**,** historical development.

Unit 2: Elements of epidemics and their interaction. Structures and patterns of epidemics.

Unit 3: Modeling, system approaches and expert systems in plant pathology.

Unit 4: Genetics of epidemics. Models for development of plant disease epidemics.

Block 2- Models in plant disease loss assessment

Unit 1: Common and natural logarithms function fitting, area under disease progress curve and correction factors, inoculum dynamics.

Unit 2: Population biology of pathogens, temporal and spatial variability in plant pathogens.

Unit 3: Epidemiological basis of disease management. Survey, surveillance and vigilance. Remote sensing techniques and image analysis. Crop loss assessment.

Block- 3- Forecasting of plant diseases

Unit 1: Principles and pre-requisites of forecasting, systems and factors affecting various components of forecasting,

Unit 2: Some early forecasting and procedures based on weather and inoculum potential, modelling disease growth and disease prediction.

Unit 3: Salient features of important forecasting models.

Reference

- CAMPBELL, C. L. AND MADDEN, L.V., 1990, Introduction to Plant Disease Epidemiology. John Wiley & Sons, New York
- COOKE, B., JONES, D. M. AND GERETH, K. B., 2018, The Epidemiology of Plant Diseases. Springer Publications.
- COWLING, E. B. AND HORSEFALL, J. G.,1978, Plant Disease. Vol.II. Academic Press, New York
- LAURENCE, V. M., GARETH, H. AND FRAME VAN DEN BOSCH, (Eds.)., The Study of Plant Disease Epidemics. APS. St. Paul. Minnesota.

- NAGARAJAN, S. AND MURLIDHARAN, K.,1995, Dynamics of Plant Diseases. Allied Publ. New Delhi.
- THRESH, J. M., 2006, Plant Virus Epidemiology, Advances in Virus Research 67, Academic Press, New York.
- VAN DER PLANK, J. E., 1963, Plant Diseases Epidemics and Control. Academic Press, New York
- ZODOKS, J. C. AND SCHEIN, R. D., 1979, Epidemiology and Plant Disease Mangement. Oxford Univ. Press. London.

PAT 509 DISEASE RESISTANCES IN PLANTS (2+0)

Objectives

To acquaint with the disease resistance mechanism in crop plants.

Theory

Block-1- Introduction, History, Variability of plant pathogens and types of resistance in crop plants

Unit 1: Introduction and historical development, dynamics of pathogenicity, process of infection,

Unit 2: Variability in plant pathogens, gene centers as sources of resistance, disease resistance terminologies.

Unit 3: Disease escape, non-host resistance and disease tolerance.

Block 2- Mechanisms and types of host resistance to diseases

Unit 1: Genetic basis of disease resistance, types of resistance, identification of physiological races of pathogen,

Unit 2: Disease progression in relation to resistance, stabilizing selection pressure in plant pathogens.

Unit 3: Host defense system, morphological and anatomical resistance, pre-formed chemicals in host defense.

Block –3- Host defense strategies and management of resistance gene in plants

Unit 1: Post infectional chemicals in host defence, phytoalexins, hypersensitivity and its mechanisms

Unit 2: Genetic basis of relationships between pathogen and host, Gene-for-gene concept, protein-for-protein and immunization basis

Unit 3: Management of resistance genes. Strategies for gene deployment.

Reference

- DEVERALL, B. J., 1977, Defence Mechanisms in Plants. Cambridge Univ. Press, Cambridge, New York.
- MILLS DALLICE, *et al.,* 1996, Molecular Aspects of Pathogenicity and Resistance: Requirement for Signal Transduction. APS, St Paul, Minnesota.
- PARKER, J., 2008, Molecular aspects of Plant Diseases Resistance, Blackwell Publ.
- ROBINSON, R. A., 1976, Plant Pathosystems, Springer Verlag, New York.
- SINGH, B. D., 2005, Plant Breeding-Principles and Methods. 7th Ed. Kalyani Publishers, Ludhiana
- VAN DER PLANK, J. E.,1978, Genetic and Molecular Basis of Plant Pathogenesis Springer Verlag, New York.
- VANDER PLANK, J. E., 1982, Host Pathogen Interactions in Plant Disease. Academic Press, New York.
- VAN DER PLANK, J. E., 1984, Disease Resistance in Plants. Academic Press, New York.

PAT 510 ECOLOGY OF SOIL-BORNE PLANT PATHOGENS (1+1)

Objectives

To provide knowledge on soil-plant disease relationship.

Theory

Block 1- Soil and Soil borne plant pathogens and its interaction

Unit 1: Soil as an environment for plant pathogens, nature and importance of rhizosphere and rhizoplane,

Unit 2: Host exudates, soil and root inhabiting fungi.

Unit 3: Interaction of micro organisms.

Block 2- Bio control agents and its mode of action

Unit 1: Types of bio control agents.

Unit 2: Inoculum potential and density in relation to host and soil variables, competition, predation, antibiosis and fungistasis.

Unit 3: Conducive and suppressive soils.

Block 3- Biological management of plant diseases

Biological control-concepts and potentialities for managing soil borne pathogens. Potential of Trichoderma and fluorescent Pseudomonas in managing plant diseases.

Practical

- Quantification of rhizosphere and rhizoplanemicro flora with special emphasis on pathogens
- Pathogenicity test by soil and root inoculation techniques, correlation between inoculum density of test pathogens and disease incidence, demonstration of fungistasis in natural soils
- Suppression of test soil-borne pathogens by antagonistic microorganisms;
- Isolation and identification of different bio control agents
- Study of various plant morphological structures associated with resistance, testing the effect of root exudates and extracts on spore germination and growth of plant pathogens
- Estimating the phenolic substances, total reducing sugars in susceptible and resistant plants
- Estimating the rhizosphere and root tissue population of microorganisms(pathogens) in plants

Reference

- BAKER, K. F. AND SNYDER, W. C., 1965, Ecology of soil-borne Plant Pathogens. John Wiley, New York

- COOK, R. J. AND BAKER, K. F., 1983, The Nature and Practice of Biological Control of Plant Pathogens. APS, St Paul, Minnesota.
- GARRET, S. D., 1970, Pathogenic Root-infecting Fungi. Cambridge Univ. Press, Cambridge, New York.
- HILLOCKS, R. J. AND WALLER, J. M., 1997, Soil-borne Diseases of Tropical Crops. CABI, Wallington
- MONDIA, J. L. AND TIMPER, P., 2016, Interactions of microfungi and plant parasitic nematodes. In: Biology of Microfungi.
- PARKER, C. A., ROVIRA, A. D., MOORE, K. J. AND WONG, P. T. N., (Eds)., 1983, Ecology and Management of Soil-borne Plant Pathogens.

PAT 511 CHEMICALS AND BOTANICALS IN PLANT DISEASE MANAGEMENT (2+1)

Objectives

To provide knowledge on the concepts, mode of actions, classification and judicious use of chemicals and botanicals in plant disease management**.**

Theory

Block 1- Introduction, importance, history and classification of agro chemicals

Unit 1: History and development of chemicals; definition of pesticides and related terms; advantages and disadvantages of chemicals and botanicals

Unit 2: Classification of chemicals used in plant disease management and their characteristics.

Unit 3: Chemicals in plant disease control, viz., fungicides, bactericides, nematicides, Antiviral chemicals and botanicals.

Block 2

Unit 1: Label claim, Formulation and safe usage: Issues related to label claim

Unit 2: Formulations, mode of action and application of different fungicides; chemotherapy and phytotoxicity of fungicides

Unit 3: Handling, storage and precautions to be taken while using fungicides; compatibility with other agrochemicals, persistence, cost-benefit ratio, factor affecting fungicides.

Block 3- New generation fungicides and plant protection appliances

Unit 1: New generation fungicides and composite formulations of pesticides.

Unit 2: Efficacy of different botanicals used and their mode of action. Important botanicals used against diseases

Unit 3: General account of plant protection appliances; environmental pollution, residues and health hazards, fungicidal resistance in plant pathogens and its management.

Practical

- Acquaintance with formulation of different fungicides and plant protection appliances
- Formulation of fungicides, bactericides and nematicides
- In-vitro evaluation techniques, preparation of different concentrations of chemicals including botanical pesticides against pathogens
- Persistence, compatibility with other agro-chemicals
- Detection of naturally occurring fungicide resistant mutants of pathogen
- Methods of application of chemicals

Reference

- BINDRA, O. S. AND SINGH, H., 1977, Pesticides and Application Equipment. Oxford & IBH, New Delhi
- NENE, Y. L. AND THAPLIYAL, P. N., 1993, Fungicides in Plan Disease Control. 3rd ed. Oxford & IBH. New Delhi.
- TORGESON, D. C., 1969, Fungicides. Vol II. An Advanced Treatise. Academic Press, New York

• VYAS, S. C., 1993, Hand book of Systemic Fungicides. Vols. I-III. Tata McGraw Hill, New Delhi.

PAT 512 DETECTION AND MANAGEMENT OF SEED BORNE PATHOGENS (2+1)

Objectives

To acquaint with seed-borne diseases, their nature, detection, transmission, inoculum potential, epidemiology, impacts/losses and management.

Theory

Block 1- History, importance, quarantine and seed pathology

Unit 1: History and economic importance of seed pathology in seed industry

Unit 2: Plant quarantine and SPS under WTO.

Unit 3: Morphology and anatomy of typical monocotyledonous and dicotyledonous infected seeds.

Block 2- Seed infection, transmission and certification

Unit 1: Recent advances in the establishment and subsequent cause of disease development in seed and seedling.

Unit 2: Localization and mechanism of seed transmission in relation to seed infection, seed to plant transmission of pathogens.

Unit 3: Seed certification and tolerance limits, types of losses caused by seed-borne diseases in true and vegetatively propagated seeds.

Block 3- Adoption of crop plants to seed infection, epidemiology and seed health management

Unit 1: Evolutionary adaptations of crop plants to defend seed invasion by seed-borne pathogens.

Unit 2: Epidemiological factors influencing the transmission of seed-borne diseases, forecasting of epidemics through seed-borne infection.

Unit 3: Production of toxic metabolites affecting seed quality and its impact on human, animal and plant health, management of seed-borne pathogens/ diseases and procedure for healthy seed production. Seed health testing, methods for detecting microorganism.

Practical

- Conventional and advanced techniques in the detection and identification of seed-borne fungi, bacteria, viruses and Nematodes;
- Relationship between seed-borne infection and expression of the disease in the field

Reference

- AGARWAL, K. AND SINCLAIR, J., 1993, Principles of seed Pathology, Vols. I & II CBS Publ., New Delhi.
- HUTCHINS, J. D. AND REEVS, J. E., 1997, Seed Health Testing: Progress Toward the 21st Century CABI, Wallington.
- PAUL NEERGAARD, 1988, Seed Pathology, McMillan, London
- SURYANARAYANA, D, 1978, Seed Pathology, Vikash Publ., New Delhi.

PAT 513 BIOLOGICAL CONTROL OF PLANT DISEASES (1+1)

Objectives

To study principles and application of eco friendly and sustainable management strategies of plant diseases**.**

Theory

Block 1- Importance, concept, history, mode of actions of bio control agents

Unit 1: Concept of biological control, definitions, importance, principles of plant disease management with bio agents,

Unit 2: History of biological control, merits and demerits of biological control.

Unit 3: Types of biological interactions, competition: mycoparasitism, exploitation for hypovirulence,

Unit 4: Rhizospherecolonization, competitive saprophytic ability, antibiosis, induced resistance, Mycorrhizal associations, operational mechanisms and its relevance in biological control.

Block 2- Factors influencing biological control

Unit 1: Factors governing biological control, role of physical environment, agro ecosystem, operational mechanisms and cultural practices in biological control of pathogens.

Unit 2: Pathogens and antagonists and their relationship, bio control agents, comparative approaches to biological control of plant pathogens by resident and introduced antagonists, control of soil-borne and foliar diseases.

Unit 3: Compatibility of bio agents with agrochemicals and other antagonistic microbes.

Block 3- Maas multiplication, quality control and delivery of bio-agents

Unit 1: Commercial production of antagonists, their delivery systems.

Unit 2: application and monitoring, biological control in IDM, IPM and organic farming system

Unit3: Bio-pesticides available in market. Quality control system of bio-control agents.

Practical

- Isolation, characterization and maintenance of antagonists, methods of study of antagonism and antibiosis, application of antagonists against pathogen in-vitro and in vivo conditions;
- Preparation of different formulations of selected bioagents and their mass production;

- Quality parameters of biocontrol agents;
- One week exposure visit to commercial biocontrolagent's production unit.

Reference

- CAMPELL, R., 1989, Biological Control of Microbial Plant Pathogens. Cambridge Univ.
- COOK, R. J. AND BAKER, K. F., 1983, Nature and Practice of Biological Control of Plant Pathogens AP,St. Paul. Minnesota.
- GAANICKAM, S. S., 2002, biological Control of Crop Debases. CRC Press, Florida
- HEIKKI, M. T. AND HOKKANENAMES, M., 1996, Biological Control-Benefits and Risks, CambridgeUniv. Press, Cambrdge.

PAT 514 INTEGRATED DISEASE MANAGEMENT (2+1)

Objectives

To emphasize the importance and the need of IDM in the management of disease of important crops.

Theory

Block I- Introduction, components of IDM

Unit- I: Introduction, definition, concept and tools of disease management.

Unit- II: Components of integrated disease management- their limitations and implications.

Block II- Principles of plant disease management

Unit- I: Development of IDM-basic principles.

Unit- II: Biological, chemical and cultural disease management.

Block III- IDM in Field and Horticulture crops

Unit- I: IDM in important crops- rice, wheat, cotton.

Unit- II: sugarcane, chickpea, rapeseed and mustard, pearl millet, pulses.

Unit- III: Vegetable crops, fruit, plantation and spice crops.

Practical

- Application of physical, biological and cultural methods;
- Use of chemical and biocontrol agents, their compatibility and integration in IDM. Demonstration of IDM and multiple disease management in crops of regional importance as project work

Reference

- Gupta, V. K. and Sharma, R. C., 1995, Integrated Disease Management and Plant Health. Scientific Publ., Jodhpur.
- MAYEE, C. D., MANOHARACHARY, C. TILAK., KVBR, Mukadam DS and DeshpandeJayashree, 2004, Biotechnological Approaches for the Integrated Management of Crop Diseases. Daya Publ. House, New Delhi.
- SHARMA, R. C. AND SHARMA, J. N., 1995, Integrated Plant Disease Management. Scientific Publ., Jodhpur.

PAT 515 DISEASES OF FIELD AND MEDICINAL CROP (2+1)

Objectives

To acquaint with diseases of field and medicinal plants and their management.

Theory

Block 1- Diseases of cereal and pulse crops

Unit 1: Diseases of Cereal crops- Rice, wheat and barley,

Unit 2: Diseases of Pearl millet, sorghum and maize.

Unit 3: Diseases of Pulse crops- Gram, urdbean, mungbean, lentil, pigeonpea, soybean and cowpea.

Block 2- Diseases of oil seed and cash crops

Unit 1: Diseases of Oilseed crops- Rapeseed and mustard, sesame and linseed,

Unit 2: Diseases of sunflower, groundnut and castor.

Unit 3: Diseases of Cash crops- Cotton and sugarcane.

Block 3- Diseases of fodder legumes and medicinal crops

Unit 1: Diseases of Fodder legume crops- Berseem, oats, guar and lucerne.

Unit 2: Diseases of medicinal crops- Plantago, liquorice, mulathi androsagrass

Unit 3: Diseases of sacred basil, menthe, ashwagandha and Aloe vera.

Practical

- Detailed study of symptoms and host parasite relationship of important diseases of above mentioned crops;
- Collection and dry preservation of diseased specimens of important crops

Reference

- JOSHI, L. M., SINGH, D. V. AND DRIVASTAVA, K. D., 1984, Problems and Progress of Wheat pathology in South Asia. Malhotra Publ. House, New Delhi.
- RANGASWAMI, G., 1999, Diseases of crop Plants in India, 4th Ed. Prentice Hall of India, New Delhi.
- RICANEL, C., EGAN, B. T., GILLASPIE, JR. A. G. AND HUGHES, C. G., 1989, Diseases of sugarcane, Major Diseases, Academic Press, New York
- SINGH, R. S., 2017, Plant Diseases, 10th Ed. Medtech. New Delhi.
- SINGH, U. S., MUKHOPADHYAY, A. N., KUMAR, J. AND CHAUBE, H. S, 1992, Plant Diseases of International Importance Vol I Diseases of Cereals and Pulses. Prentice Hall, Englewood Cliffs, New Jersey.

PAT 516 DISEASES OF FRUITS, PLANTATION AND ORNAMENTAL CROPS (2+1)

Objectives

To acquaint with diseases of fruits, plantation, ornamental plants and their management.

Theory

Block 1- Diseases of fruit crops

Unit 1: Introduction, symptoms and etiology of different fruit diseases.

Unit 2: Factors affecting disease development in fruits like apple, pear, peach, plum, apricot, cherry, walnut, almond, strawberry and their management.

Unit 3: Factors affecting disease development citrus, mango, grapes, guava, ber, banana, pineapple, papaya, fig, pomegranate, date palm, custard apple and their management.

Block 2- Diseases of plantation crops

Unit 1: Symptoms, mode of perpetuation of diseases of plantation crops such as tea, coffee and their management

Unit 2: Symptoms, mode of perpetuation of diseases rubber and coconut and their management.

Block 3- Diseases of ornamental crops

Unit 1: Symptoms and life cycle of pathogens.

Unit 2: Factors affecting disease development ofornamental plants such as roses, gladiolus, tulip, carnation and their management.

Unit 3: Factors affecting disease development of gerbera orchids, marigold, chrysanthemum and their management.

Practical

- Detailed study of symptoms and host parasite relationship of representative diseases of plantation crops

- Collection and dry pre Etiology of the disease observation of diseased specimens of important crops.

Reference

- GUPTA, V. K. AND SHARMA, S. K., 2000, Diseases of Fruit Crops, Kalyani Publishers, New Delhi
- PATHAK, V. N., 1980, Diseases of Fruit Crops. Oxford & IBH, New Delhi.
- SINGH, R. S., 2000, Diseases of Fruit Crops. Oxford & IBH, New Delhi
- WALKER, J. C., 2004, Diseases of Vegetable crops TTPP.India.

PAT 517 DISEASES OF VEGETABLE AND SPICES CROPS (2+1)

Objectives

To impart knowledge about symptoms, epidemiology of different diseases of vegetables and spices and their management

Theory

Block 1- Epidemiology of vegetable crop diseases under natural and protected conditions

Unit 1: Nature, prevalence, factors affecting disease development of tuber, bulb and leafy vegetable

Unit 2: Nature, prevalence, factors affecting disease development crucifers, cucurbits and solanaceaous vegetables.

Unit 3: Diseases of crops under protected cultivation.

Block 2- Symptomatology and management of vegetable crop diseases

Unit 1: Symptoms and management of diseases of different root, tuber and bulb

Unit 2: Symptoms and management of diseases Leafy vegetables, crucifers and cucurbits

Unit 3: Symptoms and management of diseases solanaceaous vegetable crops.

Block 3- Symptomatology, Epidemiology and management of spice crop diseases

Unit 1: Symptoms, epidemiology and management of diseases of different spice crops such as black pepper, nutmug and saffron,

Unit 2: Symptoms, epidemiology and management of diseases cumin, coriander, turmeric, fennel, fenugreek and ginger.

Unit 3: Biotechnological approaches in developing disease resistant transgenic.

Practical

- Detailed study of symptoms, etiology and host pathogen interaction of important diseases of vegetable and spice crops.

Reference

- CHAUBE, H. S., SINGH, U. S., MUKHOPADHYAY, A. N. AND KUMAR, J., 1992, Plant Diseases of International Importance. Vol.II. Diseases of Vegetable and Oilseed Crops. Prentice Hall, Englewood Cliffs, New Jersey.
- GUPTA, V. K. AND PAUL, Y. S., 2001, Diseases of Vegetable Crops, Kalyanai Publishers, New Delhi
- GUPTA, S. K. AND THIND, T. S., 2006, Disease Problem in Vegetable Production. Scientific Publ., Jodhpur.
- SHERF, A. F. AND MCNAB, A. A., 1986, Vegetable Diseases and their Control. Wiley Inter Science, Columbia.
- SINGH, R. S., 1999, Diseases of Vegetable Crops. Oxford & IBH, New Delhi.
- WALKER, J. C., 1952, Diseases of Vegetable Crops. McGraw-Hill, New York.

PAT 518 POST HARVEST DISEASES (2+1)

Objectives

To acquaint with the post-harvest diseases of agricultural produce and their eco-friendly management.

Theory

Block 1- Introduction and principles of pre and Post-harvest diseases

Unit 1: Concept of post-harvest diseases, definitions, importance with reference to management and health

Unit 2: principles of plant disease management as pre-harvest and post-harvest

Unit 3: Types of post-harvest problems both by biotic and abiotic factors.

Block 2- Epidemiology and management of Pre and post-harvest diseases

Unit 1: Role of physical environment, agro-ecosystem leading to quiescent infection, operational mechanisms and cultural practices in perpetuation of pathogens

Unit 2: pathogens and antagonist and their relationship, role of bio control agents and chemicals in controlling post-harvest diseases,

Unit 3: comparative approaches to control of plant pathogens by resident and introduced antagonists.

Block 3- Integrated approaches for management of post-harvest diseases and Mycotoxins

Unit 1: Integrated approaches in controlling diseases and improving the shelf life of produce using nutritional, bio-control agents and other agents

Unit 2: Control of aflatoxigenic and mycotoxigenic fungi; Application and monitoring for health hazards.

Unit 3: Study of symptoms, toxicosis of various pathogens, knowledge of Codex Alimentarious for each product and commodity.

Unit 4: Physical and biological agents/practices responsible for development/ prevention of post-harvest diseases- traditional and improved practices.

Practical

- Isolation, characterization and maintenance of post-harvest pathogens, application of antagonists against pathogens in vivo condition
- Comparative efficacy of different fungicides and bioagents
- Study of different post-harvest disease symptoms on cereals, pulses, oilseed, commercial crops, vegetables, fruits and flowers
- Visit to cold storage

Reference

- CHADDHA, K. L. AND PAREEK, O. P., 1992, Advances in Horticulture Vol. IV, Malhotra Publ. House, New Delhi.
- PATHAK, V. N., 1970, Diseases of Fruit Crops and their Control. IBH Publ., New Delhi.

PAT 519 PLANT QUARANTINE AND REGULATORY MEASURES (1+0)

Objectives

To acquaint the learners about the principles and the role of plant quarantine in containment of pests and diseases, plant quarantine regulations and plant quarantine station set up.

Theory

Block 1- History and importance of plant quarantine

Unit 1: Historical development in plant quarantine, Definitions of pest, and transgenic as per Govt. notification; Organizational set up of plant quarantine in India.

Unit 2: Relative importance; quarantine–domestic and international. Quarantine restrictions in the movement of agricultural produce, seeds and planting material;

Unit 3: Case histories of exotic pests/ diseases and their status.

Block 2- quarantine legislations

Unit 1: Acts related to registration of pesticides and transgenic. History of quarantine legislations, Salient features of PQ Order 2003.

Unit 2: Environmental Acts, Industrial registration; APEDA, Import and Export of bio-control agents.

Unit 3: Identification of pest/ disease free areas; contamination of food with toxigens, microorganisms and their elimination;

Block 3- Detection and diagnosis of seed borne diseases

Unit 1: Symptomatic diagnosis and other techniques to detect pest/ pathogen infestations; VHT and other safer techniques of disinfestation/ salvaging of infected material.

Unit 2: WTO regulations; non-tariff barriers; Pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry;

Unit 3: Sanitary and Phytosanitary measures. Visit to plant quarantine station and PEQ facilities.

Reference

- RAJEEV, K. AND MUKHERJEE, R. C., 1996, Role of Plant Quarantine inIPM, Aditya Books
- RHOWER, G. G., 1991, Regulatory Plant Pest Management. In: Handbook of Pest Management in Agriculture, 2nd Ed.Vol.II. CRC press.

M.Sc. (Agri.) in Plant Physiology

Course Code	Course Title	Credit Hours
PPH 501	Principles of Plant Physiology-I: Plant Water Relations and Mineral Nutrition	3 (2+1)
PPH 502	Principles of Plant Physiology-II: Metabolic Processes and Growth Regulation	3 (2+1)
PPH 503	Plant Developmental Biology: Physiological and Molecular Basis	3 (2+1)
PPH 504	Physiological and Molecular Responses of Plants to Abiotic Stresses	3 (2+1)
PPH 505	Hormonal Regulation of Plant Growth and Development	3 (2+1)
PPH 506	Physiological and Molecular Mechanisms of Mineral Nutrient Acquisition and their Functions	3 (2+1)
PPH 507	Photosynthetic Processes, Crop Growth and Productivity and Concepts of Crop Modelling	3 (2+1)
PPH 508	Physiology of Field Crops	2 (2+0)
PPH 509	Physiology of Horticulture Crops	2 (2+0)
PPH 510	Seed Physiology	3 (2+1)
PPH 511	Phenotyping Physiological Processes	2 (2+0)
PPH 512	Crop Growth Regulation and Management	2 (2+0)
	Total	**32 (24+8)**
PPH 580	Qualifying Examination	2 (0+2)
PPH 581	Seminar - I	1 (0+1)
PPH 582	Seminar - II	1 (0+1)
PPH 591	Research - I	13 (0+13)
PPH 592	Research - II	14 (0+14)

PPH 501 PRINCIPLES OF PLANT PHYSIOLOGY I – PLANT WATER RELATIONS AND MINERAL NUTRITION 2+1

Objectives

Plant's growth and development and therefore, agricultural productivity dependson two major inputs like water and nutrients. In this regard, this course being afundamental course will acquaint the students with the basic concepts of plantwater relations and mineral nutrition. The course provides a basic knowledge on water and nutrient acquisition and their transport throughout the phenologicalstages. Further, it also provides hands on experience in assessing the plant and soil water status besides nutrient acquisition by plants.

Aim of the Course

The aim of this course is to impart knowledge in the field of water relations and mineral nutrition and how plants acquire water and transportit under different soil water regimes and also make use of the water in an effective way to maximize use efficiency. Inaddition, the other aim is to impart knowledge of how plants minimize water loss under stress conditions besides educating the students of how plants make use of nutrients in a best possible way. The course is organized as follows:

No.	Blocks	No.	Units
1.	Plant Water Relations	1.	Soil and Plant Water Relations
		2.	Water Absorption and Translocation
		3.	Transpiration and Evaporative Cooling
		4.	Water Productivity and Water Use Efficiency
		5.	Moisture Stress and Plant Growth
2.	Mineral Nutrition	1.	Nutrient Elements and their Importance
		2.	Nutrient Acquisition
		3.	Concept of Foliar Nutrition

Theory

Block 1: Plant Water Relations

Unit 1: Soil and Plant Water Relations

Water and its importance; Molecular structure of water; Properties and functions of water. Concept of water potential; Plant cell and soil water potential and their components; Methods to determine cell and soil water potential; Concept of osmosis and diffusion. Soil physical properties and water availability in different soils; Water holding polymers and their relevance.

Unit 2: Water Absorption and Translocation

Root structure and functions; Root architecture and relevance in water mining; Mechanism of water absorption and translocation; Theories explaining water absorption and translocation; Aquaporins. Mycorrhizal association and its relevance in water mining.

Unit 3: Transpiration and Evaporative Cooling

Evaporation and transpiration; relevance of transpiration; factors regulating transpiration; Measurement of transpiration; approaches to minimize evaporation and transpiration; Concept of CCATD and its relevance. Energy balance: Solar energy input and output at crop canopy level. Stomata- its structure, functions and distribution; Molecular mechanisms of stomatal opening and closing; Concept of guard cell turgidity; role of K and other osmolytes; role of ABA in stomatal closure; Guard cells response to environmental signals; Signaling cascade associated with stomatal opening and closure. Antitranspirants and their relevance in agriculture.

Unit 4: Water Productivity and Water Use Efficiency

WUE and its relevance in water productivity; Transpiration efficiency, a measure of intrinsic WUE; Approaches to measure WUE; Stomatal and mesophyll regulation on WUE; Passioura's yield model emphasizing WUE.

Unit 5: Moisture Stress and Plant Growth

Physiology of water stress in plants; Effect of moisture stress at molecular, cellular, organ and plant level. Drought indices and drought tolerance strategies. Drought tolerance traits.

Block 2: Mineral Nutrition

Unit 1: Nutrient Elements and Their Importance

Role of mineral nutrients in plant's metabolism; Essential elements and their classification; Beneficial elements; factors influencing the nutrients availability; critical levels of nutrients. Functions of mineral elements in plants. Deficiency and toxicity symptoms in plants.

Unit 2: Nutrient Acquisition

Mechanism of mineral uptake and translocation; Ion transporters; genes encoding for ion transporters; localization of transporters; xylem and phloem mobility; Nutrient transport to grains at maturity; Strategies to acquire and transport minerals under deficient levels. Role of mycorrhiza, root exudates and PGPRs in plant nutrient acquisition.

Unit 3: Concept of Foliar Nutrition

Foliar nutrition; significance and factors affecting total uptake of minerals; Foliar nutrient droplet size for effective entry; role of wetting agents in entry of nutrients.

Practicals

- Standard solutions and preparation of different forms of solutions.
- Studies on the basic properties of water.
- Demonstration of surface tension of water and other solvents.
- Measurement of plant water status: Relative water content and rate of water loss.
- Determination of water potential using pressure bomb, osmometer, psychrometer.
- Determination of soil moisture content and soil water potential.
- Use of soil moisture probes and soil moisture sensors.
- Measurement of transpiration rate in plants; use of porometry.
- Measurement of CCATD and its relevance.
- Demonstration and use of anti-transpirants to reduce transpiration.

- Influence of potassium and ABA on stomatal opening and closing respectively.
- Deficiency and toxicity symptoms of nutrients.
- Effect of water stress on plant growth and development.

Teaching methods/activities

– Lecture

– Assignment (Reading/Writing)

–Student presentation

– Practicals

Learning outcome

By the end oft his course, the student will be able to:

- Comprehend the fundamental concepts of plant physiological processes associated with water relation and mineral nutrition.
- Describe the physiological mechanisms of water relation and mineral nutrition.
- Recognize and describe how plants respond to mineral deficiency and toxicity.

References

- VILALTA J.M AND FORNER N.G. 2017.*Water potential regulation, stomatal behaviour and hydraulic transport under drought: deconstructing the iso / anisohydri cconcept Plant, Cell and Environment* 40,962–976.
- MANGRICH A.S, CARDOSO E.M.C, DOUMERM.E, ROMÃOL.P.C, VIDAL.M, RIGOLA, NOVOTNY E.H. *Improving the Water Holding Capacity of Soils of Northeast Brazilby Biochar Augmentation*. Chapter16, pp339–354.
- MCELRONE A.J, CHOAT B, GAMBETTA G.A AND BRODERSEN C.R. 2013. *Water Uptake and Transportin Vascular Plants*. *Nature Education Knowledge* 4(5):6
- HODSON R.C AND J ACUFF. 2006. *Water transport in plants: anatomy and physiology*. Pages163-183, *Tested Studies for*

Laboratory Teaching, Volume 27 (M.A. O'Donnell, Editor).Proceedings of the 27th Workshop/Conference of the Association for Biology Laboratory Education (ABLE), 383pages.

- CHATER CCC, CAINE RS, FLEMING AJ, GRAY JE. 2017. *Plant Physiology,* 174 (2) 624-638; DOI:10.1104/pp.17.00183
- DIETRICHP, SANDERSD, HEDRICHR.2001. *The roleofion channel sinlight dependent stomata opening, Journal of Experimental Botany*, Volume 52, Issue 363, Pages 1959–1967, https://doi.org/10.1093/jexbot/52.363.1959
- SREEMAN S.M,VIJAYA RAGHAVAREDDY P, SREEVATHSA R, RAJENDRA REDDY S, ARAKESH S, BHARTI P, DHARMAPPA P, SOOLANAYAKANAHALLY R. 2018. *Introgression of Physiological Traitsfora Comprehensive Improvement of Drought Adaptationin Crop Plants. Front. Chem*. 6,92.
- S E Y E D Y A H Y A S A L E H I - L I S A R H A M I D E H - BAKHSHAYESHAN-AGDAM, (2016). Drought Stress in Plants: Causes, Consequences, and Tolerance. Drought Stress Tolerance in Plants, Vol 1 pp1-16
- PANDEY R. 2015. *Mineral Nutrition of Plants*.10.1007/978-81-322-2286-6_20.
- BARKER A.VAND D.J.P IL BEAM. 2015. Handbook of Plant Nutrition, Second Edition. Booksin Soils, Plants, and the Environment Series, the 2nd Edition, CRC Press.
- VATANSEVERR, OZYIGIT II AND FILIZ E. 2017. *Essential and beneficial trace lements in plants, and their transport in roots : are view. Applied bio chemistry and biotechnology* 181(1), 464 - 482.
- TAHAT M.M AND SIJAM K. 2012. *Arbuscular mycorrhizal fungi and plant root exudates bio-communications in the rhizosphere. African Journal of Microbiology Research*, 6(46), 7295-7301.
- RAJASEKAR M.D, NANDHINI D.U AND SUGANTHIS.2017. *Supplementation of Mineral Nutrients through Foliar Spray – A Review .Int. J. Curr. Microbiol. App. Sci.* 6 (3): 2504-2513. https://doi.org/10.20546/ijcmas.2017.603.283.

• TAREK.A AND HASSAN E.R. 2017. *Foliar application: from plant nutrition to bio fortification*. Environment, Biodiversity and SoilSecurity. 10.21608/jenvbs.2017.1089.1006.

General Source of Information

• TaizT, Zeiger E and Max Mller IM, 2018, *Fundamentals of PlantPhysiology*
• TaizL and Zeiger E.2015. *Plant Physiology and development*.6thEd
• Salisbury F.B and Ross C. 1992 (4thEd.) *Plant Physiology*
• Epste in E and Bloom AJ.2004. *Mineral nutrition of plants : principles and perspectives*. 2ndEd.
• Hopkins W.G and Huner NPA. 2004. *Introduction to Plant Physiology*
• Kramer, P. J.,*Water relations of plants*
• Kirkham, M.B., *Principles of soil and plant waterrelations*
• HopkinsW.G, 2008, *Introduction to Plant Physiology*

PPH 502 PRINCIPLES OF PLANT PHYSIOLOGY-II: METABOLIC PROCESSES AND GROWTH REGULATION 2+1

Objectives

Mechanisms associated with growth and development determine crop performance under any given condition. Metabolic and growth processes are quite sensitive to environmental factors and hence comprehensive understanding of the physiological basis of growth and development would be essential.

Aim of the course

This course will impart knowledge on cellular structure and function that determine of carbon and nitrogen metabolism, lipids, enzymes and secondary metabolites in plants. Relevance of metabolic processes on growth and development leading to productivity will be dealt.

The course is organized as follows:

No.	Blocks	No.	Units
1.	Metabolic processes and growth regulation	1.	Carbon Metabolism–Photochemical Processes
		2.	Carbon Metabolism: Biochemical Processes
		3.	Carbon Metabolism: Respiration
		4.	Product Synthesis and Translocation Leading to Crop Growth
		5.	Nitrogen Assimilation and Protein Synthesis
		6.	Lipid Metabolism and Secondary Metabolites
		7.	Hormonal Regulation of Plant Growth and Development
		8.	Synthetic Growth Promoters
2.	Morphogenesis and development	1.	Morphogenesis and Reproductive Phase

Theory

Block 1: Metabolic Processes and Growth Regulation

Unit 1: Carbon Metabolism – Photochemical Processes

- Chloroplast ultrastructure with special mention of lamellar system
- Excitation, electron and proton transfers and their relevance in energy conservation
- Concepts of pigment systems and generation of powerful reductant and oxidant
- Water oxidation, Water-water cycle and other aspects of electron transfer

Unit 2: Carbon Metabolism: Biochemical Processes

- CO_2 diffusion mechanisms and diffusive conductances, concept of Ci determining Photosynthesis
- RuBisCO enzyme kinetics and Calvin cycle mechanisms, Regulation of Calvin cycle and metabolite fluxes
- Photorespiration: the advantages and inefficiencies of photosynthesis because of photorespiration

- Concepts of CO_2 concentrating mechanisms (CCM) and spatial and temporal differences in carboxylation
- Ecological aspects of $C_4$and CAM photosynthesis
- Product synthesis, Starch and Sucrose biosynthesis

Unit 3: Carbon Metabolism: Respiration

- Mitochondrial organization and functions
- Aspects of Glycolysis, TCA cycle and mitETC.
- Relevance of growth and maintenance respiration
- Concepts of CN resistance respiration – Alternate and SHAM sensitive ETC

Unit 4: Product Synthesis and Translocation Leading to Crop Growth

- Phloem loading and sugar transporting, concepts of bi-directional transport of sugars and other metabolites
- Source-Sink relationship and modulation of photosynthesis
- Concepts and definitions of Growth and Differentiation
- Growth and yield parameters, NAR, CGR, HI and concepts of LAI, LAD

Unit 5: Nitrogen Assimilation and Protein Synthesis

- Developments in di-nitrgen fixation
- Nitrate reduction and assimilation GS-GOGAT process for amino acid synthesis
- Inter-Dependence of carbon assimilation and nitrogen metabolisms

Unit 6: Lipid Metabolism and Secondary Metabolites

- Storage, protective and structural lipids.
- Biosynthesis of fatty-acids, diacyl and triacyl glycerol, fatty acids of storage lipids.
- Secondary metabolites and their significance in plant defense mechanisms.

Unit 7: Hormonal Regulation of Plant Growth and Development

- Growth promoting and retarding hormones: biosynthesis, transport, conjugation
- Mode of action of these hormones and their application in plant physiology

Unit 8: Synthetic Growth Promoters

- Different synthetic hormones: Salicylic acid, strigolactonesetc
- Roles and biological activities of various synthetic hormones
- Commercial application of hormones to maximize growth and productivity

Block 2: Morphogenesis and development.

Unit 1. Morphogenesis and Reproductive Phase

- Photoperiodism: Phytochromes, their structure and function
- Circadian rhythms,
- Blue light receptors: Cryptochrome and morphogenesis.
- Vernalization and its relevance in germination.

Practicals

- Radiant energy measurements
- Separation and quantification of chlorophylls
- Separation and quantification of carotenoids
- O_2 evolution during photosynthesis
- Anatomical identification of C3 and C4 plants
- Gas exchange Measurement: conductance, photosynthetic rate,photorespiration
- Measurement of respiration rates
- Estimation of reducing sugars, starch
- Estimation of NO3, free amino acids in the xylem exudates, quantification of soluble proteins
- Bioassays for different growth hormones- Auxins, Gibberellins, Cytokinins, ABA and ethylene

- Demonstration of photoperiodic response of plants in terms of flowering

Teaching methods /activities

– Lecture

– Assignment (Reading/Writing)

– Student presentation

– Practicals

Learning outcome

By the end of this course, the student will be able to:

– Figure out the fundamental metabolic processes in plant

– Describe the physiological mechanisms and metabolic events associated with regulation of plant growth

References

- KIRCHHOFFH.2019.*Chloro plast ultra structure inplants*, New Phytologist. Doi.org /10.1111/nph.15730
- JAFARI.T, MOHARRERI. E, AMIN. A, MIAO. R, SONG WANDSUIB. S. 2016. *Photocatalytic water splitting—the untamed dream : are view of recent advances*. *Molecules*, *21*(7),900.
- JENSEN. E, CLEMENT. R, MABERLY S.C, GONTERO. B. 2017. *Regulation of the Calvin – Benson–Bassham cycle in the enigmatic diatoms: biochemical and evolutionary variations on anoriginaltheme*. *Phil. Trans .R.Soc .B*372:20160401.doi.org/ 10.1098/rstb.2016.0401
- RAVEN,J. A., AND BEARDALL, J. 2015. *The in sandouts of CO2*. *Journal of experimental botany*, *67*(1), 1-13.
- RAE,B.D., LONG,B.M., FÖRSTER,B., NGUYEN,N.D., VELANIS,C.N., ATKINSON,N.. AND MCCORMICK, A.J.2017. *Progress and challenges of engineering a biophysical CO2-concentrating mechanism into higher plants*. *Journal of Experimental Botany*, *68*(14), 3717-3737.
- HAGEMANN M,WEBER A.P AND EISENHUT.M. 2016. *Photorespiration: origins and metabolic integration in interacting compartments*.*Journal of experimental botany*, 67(10), 2915.

- KÜHLBRANDT.W. 2015. *Structure and function of mitochondrial membrane eprotein complexes. BMCbiology*, 13(1), 89.
- LIESCHE.J., AND PATRICK,J. 2017. *An update on phloem transport: a simple bulk flow under complex regulation*. *F1000 Research*, 6.
- JENSEN K.H, BERG - SØRENSEN. K, BRUUSH, HOLBROOK N. M, LIESCHEJ, SCHULZA AND BOHRT. 2016. *Sap flow and sugar transport in plants*. *Reviews of modern physics*, 88(3), 035007.
- JULIUSBT, LEACHKA, TRANTM, MERTZ R A AND BRAUN D M. 2017. *Sugar transporter sinplants: new insights and discoveries*. Plant and Cell Physiology, 58(9), 1442-1460.
- RAODLN. 2014. *Recent advance in biological nitrogen fixation in agricultural systems*. In *Proc Indian Natl Sci Acad* (Vol.80,(2),pp.359-378).
- HOFFMAN, B.M.,LUKOYANOV, D.,YANG, Z.Y., DEAN, D.R., AND SEE FELDT, L.C.2014. *Mechanism of nitrogen fixation by nitrogenise : the next stage*. *Chemical reviews*,114(8), 4041-4062.
- MUS,F., CROOK, M. B.,GARCIA, K., COSTAS, A.G., GEDDES, B.A., KOURI, E.D. AND UDVARDI, M.K. 2016. *Symbioticnitrogen fixation and the challenges to it sex tension to nonlegumes. Appl. Environ. Microbiol.*, *82*(13), 3698-3710.
- PAGARES, BHATIA M, TRIPATHI, N., PAGARE, S., AND BANSAL, Y. K.2015. *Secondary metabolites of plants and the irrole: Overview*. *Curr Trends BiotechnolPharm*,9(3), 293-304.
- JAIN C, KHATANA S AND VIJAYVERGIA R. 2019. *Bioactivity of secondary metabolites of various plants: are view. Int JPharm Sci and Res*10(2):4904.doi:10.13040/IJPSR.0975-8232.10(2).494-04.
- LI,C.,LI,J.,CHONG,K.,HARTER,K.,LEE,Y., LEUNG, J., AND SCHROEDER, J. 2016. *Toward amolecula runderstanding of plant hormoneactions*. *Molecularplant*, 9(1),1-3.
- ECKARDT, N.A.2015. *The plant cell reviews dynamic aspects of plant hormonesignaling and cross talk.*

- JIANG, K.,AND ASAMI,T.2018.*Chemical regulators of planthormones and their applicationsin basic research and agriculture*. *Bio science, biotechnology, and biochemistry*, 82(8), 1265-1300.
- ZWANENBURG,B., POSPÍŠIL,T., AND ZELJKOVIÆ, S.Æ. 2016. *Strigolactones: new planthormones in action. Planta*, 243(6), 1311-1326.
- KUMAR, R., KHURANA, A., AND SHARMA, A.K. 2014. *Role of planthormones and their inter play in development and ripening of fleshy fruits*. *Journal of experimental botany*, *65*(16), 4561-4575.
- GURURANI, M., MOHANTA,T., AND BAE, H. 2015. *Current understanding of the interplay between phytohormones and photosynthesis under environmental stress*. *International journal of molecular sciences*,*16* (8), 19055-19085.
- SONG,Y.H.,SHIM, J.S., KINMONTH- SCHULTZ, H .A., AND IMAIZUMI, T. 2015. *Photoperiodic flowering: time measurement mechanisms in leaves. Annual review of plant biology*, *66*, 441-464.
- SANCHEZ, S.E., AND KAY, S.A. 2016. *The plant circadianc lock: from asimple time keeper to a complex develop mental manager*.*Cold Spring Harborperspectives inbiology*, *8*(12), a027748.

General Textbooks

- Taiz, Lincoln, Zeiger. 2007 Plant Physiology, Eduardo Original American edition Sinauer Associates ,Inc.,2006;4thed., XXVI, ISBN:978 -3-8274-1865-4;©Springer.
- *Plant Physiology* Frank Boyer Salisbury and Cleon Ross.
- *Introduction to Plant Physiology* (Wie) by WilliamG. Hopkins.

PPH 503 PLANT DEVELOPMENTAL BIOLOGY 2+1 PHYSIOLOGICAL AND MOLECULAR BASIS

Objectives

From the conventional description information on plant growth and development based on morphology and anatomy, phenomenal

changes and leads taken place in the last one and half decade to address these processes at physiological, biochemical and molecular levels. This basic understanding has provided options to regulate these processes genetically using genetic and molecular tools and by interventions using chemicals and external factors. To give an example on flowering, the progress made regarding the molecular players that regulate flowering, initiation, the photo receptors like phytochromes and the irregulation by the photo period-short and long days has provided options to manipulate the flowering time to bring in synchrony, etc. Phenomenal progress also made in several other processes like germination, viability, root development and pollination, etc. The other major area of contribution is in tissue culture where is understanding of plant developmental biology has been put opractical use and knowledge on morpho genesis is exploited to maximum. It is very essential that the students get exposed on these aspects to complement the research programs on crop improvement.

Aim of the course

To explain about basic physiological and molecular processes concerning various facets of growth and development of plants. It provides knowledge on basic physiological processes governing developmental events in plants including senescence and fruit development and ripening. Developmentof vegetativet issue like shoot, leaf and root and morphogenetic phenomena like flower induction and development, factors associated with photo period and thermo period response. Regulation of morpho genesis would be studied at the molecular level providing information on genes involved. Inaddition, students will study how to apply the knowledge on plant development and morphogenes is using tissue culture.

The course is organized as follows:

No.	Blocks	No.	Units
1.	Plant Developmental Biology	1. 2. 3 4. 5 6.	Evolutionary Development of Plants and Role of Environment Physiological and Molecular Determinants of Seed Biology Vegetative Growth and Organ Development Physiological and Molecular Aspects of Reproductive Growth and Development Ripening and Senescence Physiological and Molecular Regulation of Plant Development Influenced by Light and Temperature
2.	Practical application of morphogenesis	1. 2.	Tissue culture and micro-propagation Application of in-vitro techniques for crop improvement

Theory

Block 1: Plant Developmental Biology

Unit 1: Evolutionary Development of Plants and Role of Environment Plant development and plasticity, evolution, Biodiversity. Novel features of plant growth and development, Concept of plasticity-evolution and biodiversity, Modelplants for study; Environment and development. Developmental stages and program; Cell-cycle, totipotency and regeneration.

Unit 2: Physiological and Molecular Determinants of Seed Biology

Seed development- Physiology of seed development, role of hormones in embryo development; seed development and maturation. Seed dormancy- Physiological and molecular mechanism of seed dormancy regulation. Seed germination- seed structure and Hormonal regulation of germination, Mobilization of food reserves during seed germination.

Unit 3: Vegetative Growth and Organ Development

Regeneration and totipotency- organ differentiation and development – role of hormones- developmental control genes in crop plants. Meristems in plant development. Shoot, Leaf, Trichome and stomatal development and differentiation. Axillary shoot branching; Bud dormancy and growth**.** Root development; Nodule development; Tuber development- hormonal control, signaling and molecular regulation-genes involved. Vascular bundle development- xylem and phloem differentiation.

Unit 4: Physiological and Molecular Aspects of Reproductive Growth and Development

Floral Induction and Development: Molecular and physiological mechanism of transition -vegetative to reproductive phase- floral organ initiation and development their controls. Development of male and female gametophyte; gametophytic mutants: pollen-stigma interaction-Pollen germination and tube growth; role of imprinting; Male sterility: and fertility restoration; Self incompatibility; Sterility and fertility restoration, Maternal gene effects, Zygotic gene effects. Sex determination in plants, mate choice in plants. Embryo and endosperm development- fertilization, role of imprinting; Parthenocarpy and apomixes

Unit 5: Ripening and Senescence

Fruit development, enlargement, maturation and ripening; climacteric and non- climacteric fruit ripening mechanism. Hormonal, biochemical & Molecular aspects of fruit ripening. Senescence and its regulation; Hormonal and environmental control of senescence; PCD in the life cycle of plants.

Unit 6: Physiological and Molecular Regulation of Plant Development Influenced by Light and Temperature

Light control of plant development: Phytochromes and cryptochromes, phototropins, their structure, biochemical properties and cellular distribution. Molecular mechanisms of light perception, signal transduction and gene regulation. Photoperiodism and its significance,

vernalization and hormonal control. Circadian rhythms-biological clocks and their genetic and molecular determinants. Thermomorphogenesis - Thermoperiodism.

Block 2: Application of Morphogenesis and its Practical Application

Unit 1: Tissue culture and micro-propagation

Applications of tissue culture for plant production, callus induction, somatic embryogenesis, regeneration from different explants. Micro-propogation, tip and axillary node culture of commercially important crops, hardening and ex-vitro establishment, concept of somatic hybridization and protoplast culture.

Unit 2: Application of *in-vitro* techniques for crop improvement

Development of somoclones, identification and exploitation of somoclonal variants.Haploid production, pollen/anther, ovule/ovary culture. Production of secondarymetabolites by tissue culture, concept of bio-fermenters. Plant transformation, development of transgenic plants and their characterization. Germplasm storage, cryopreservation and regulation.

Practicals

- Studying shoot apical meristem, floral meristem development and pollen tube development
- Phenotyping photomorphogenesis: (a) Studying effect of day length (short day and long day) in regulating floral induction/ flowering time in short day/long day/day neutral plants and (b) effect of light on seed germination in light-sensitive and - insensitive seeds.
- Studying effect of temperature on– (a) thermo-morphogenesis-measuring hypocotyl elongation under different temperature conditions and (b) sex determination using cucurbits/sesame plants.
- Measure physiological parameters of fruit ripening and study the expression of key genes regulating ripening.
- Study the effect of ethylene, its inhibitor and scrubber on ripening (tomato).
- Study different sterilization techniques, prepare media stocks and plant hormones.

- Inoculate explant (seed and leaf tissue) of model plant for call us induction.
- Subculture the call us and standardize regeneration protocol for shoot and root induction using call us and leaf explant.
- Micro-propagation using meristem tip and axillary node culture.
- Standardize anther/ pollen culture for haploid production in model/ crop/horticultural plant.
- Isolation of protoplast from Arabidopsis/tobacco and its culturing
- Study about selectable marker, reporter gene, PCR, southern and northern blotting techniques.
- Transformation of tobacco callus or leaf explant by *Agrobacterium tume facines* and *Agrobacterium rhizogenes* for production of transgenic. Molecular characterization of transgenic- PCR, southern blotting, gene expression.

Teaching methods/activities

– Lecture
– Assignment (Reading/Writing)
– Student presentation

Learning outcome

After completion of this course students are expected to have knowledge on and insight into the physiological and molecular basis of plant growth and development. The student will develop critical insight in physiological aspects of vegetative growth and reproductive development at molecular level.

Suggested Reading

- NIKLAS K.J. *Plant Evolution- An Introduction to the History of Life*.
- BAHADUR B *et al*. (eds.), *Plant Biology and Biotechnology:* Volume I: Plant Diversity, Organization, Function and Improvement
- JONG M.D AND LEYSER O. *Developmental Plasticity in Plants*. Cold Spring Harbor Symposiaon Quantitative Biology. 63-73.

- INZE D AND VEYLDER LD. 2006. *Cell Cycle Regulation in Plant Development*. Annu. Rev. Genet. 2006. 40: 77–105
- J. DEREK BEWLEY *et al*., Seeds-Physiology of Development, Germination and Dormancy.
- KENT J. BRADFORD AND HIROYUKI NONOGAKI (2007). *Seed Development, Dormancy and Germination*. Blackwell publishing.
- EVANS MMS AND BARTON MK. 1997. *Genetics Of Angiosperm Shoot Apical Meristem Development. Annu. Rev. Plant Physiol. Plant Mol. Biol.* 48: 673–701.
- JIANG K AND FELDMAN LJ. 2005. *Regulation of Root Apical Meristem Development*. Annu. Rev. Cell Dev. Biol. 21: 485–509.
- PIAZZA *et al*. 2005. *Evolution of leaf developmental mechanisms*. New Phytologist. 167: 693–710.
- TOOKE F AND BATTEY N. 2003. *Models of shoot apical meristem function*. *New Phytologist*. 159: 37–52.
- ZHENG-HUA YE. 2002. *Vascular Tissue Differentiation And Pattern Formation In Plants*.Annu. Rev. Plant Biol. 53: 183–202.
- MAUREEN L. CONDIC (2014). *Totipotency*: *What It Is and What It Is Not. Stem Cells And Development*. 23(8). 796- 812.
- KOMEDA, Y. 2004. *Genetic regulation of time to flower in Arabidopsis thaliana. Annu. Rev. Plant Biol*. 55: 521-535.
- ZEEVAART, J.A.D. 1976. *Physiology of flower formation. Annu. Rev. Plant Physiol*. 27: 321-348. Zeevaart, J.A.D. 2006. *Florigen coming of age after 70 years. Plant Cell* 18: 1783-1789.
- JOHN R. PANNEL. (2017). *Plant Sex Determination. Current Biology* 27, R191–R197.
- JOHNSON M.A *et al*. 2019. *A Fruitful Journey: Pollen Tube Navigation from Germination to Fertilization. Annu*. Rev. Plant Biol. 70: 20.1–20.29
- CALLOW J.A. *Advances in Botanical Research- Incorporating Advances in Plant Pathology*Vol. 44, Developmental Genetics Of The Flower.

- JACK T. 2004. *Molecular and Genetic Mechanisms of Floral Control*. The Plant Cell. 16: S1– S17.
- KOLTUNOW A.M AND GROSSNIKLAUS U. 2003. *APOMIXIS: A Developmental Perspective. Annu.Rev. Plant Biol*. 54: 547–74.
- VERNONICA E. FRANKLIN-TONG. *Self-Incompatibility in Flowering Plants-Evolution, Diversity, and Mechanisms*, Springer
- THOMAS H. 2013. *Senescence, ageing and death of the whole plant. New Phytologist*. 197:696–711.
- LAM E, FUKUDA H AND GREENBERG J. *Programmed cell death in higher plants*. Reprinted from Plant Molecular Biology, Volume 44 (3).
- PUA E C AND DAVEY M R. *Plant Developmental Biology - Biotechnological Perspectives*.
- MENG CHEN. 2004. *Light Signal Transduction In Higher Plants Annu. Rev. Genet*. 38: 87– 117.
- FANKHAUSER C AND CHORY J. 1997. *Light Control Of Plant Development Annu. Rev. Cell Dev.Biol*. 13: 203–229.
- MIEKEDE WIT. 2016. *Light-Mediated Hormonal Regulation of Plant Growth and Development. Annu. Rev. Plant Biol*. 67:22.1–22.25
- FRANKLIN K.A AND WIGGE PA. *Temperature and Plant Development*. Wiley Blackwell.
- FRANKLIN K.A *et al*. 2014. *Interaction of light and temperature signaling. Journal of Experimental Botany*. 65(11): 2859–2871.
- BHOJWANI S.S AND RAZDAN M.K. *Plant tissue culture: theory and practice, a revised edition*. Elsiver publication.
- BHOJWANI S.S, DANTU S.S AND KUMAR P. *Plant Tissue Culture: An Introductory Text*.
- GEORGE E.F AND HALL M.A. *Plant Propagation by Tissue Culture* 3rd Edition.
- KRISHNA H, ALIZADEH M, SINGH D, SINGH U, CHAUHAN N, EFTEKHARI M AND SADH RK. 2016. *Somaclonal variations and their applications in horticultural crops improvement. 3 Biotech*, 6(1), 54.

- EVANS D A. 1989. *Somaclonal variation-genetic basis and breeding applications. Trends ingenetics*, 5, 46-50.
- BENSON E.E, DUMET D.J AND HARDING K. 2009. *Cry opreservation of plant cells, tissues andorgans. Encyclopedia of Industrial Biotechnology: Bioprocess, Bioseparation, and Cell Technology*, 1-22.
- SCHUMACHER HM, WESTPHAL M AND HEINE-DOBBERNACK E. 2015. *Cry opreservation of plantcell lines. In Cry opreservation and Freeze-Drying Protocols* (pp.423-429). Springer, New York, NY.
- KALAISELVI R, RAJASEKAR M AND GOMATHI S. 2017. *Cryopreservation of plant materials-a review*. IJCS, 5(5), 560-564.
- MUROVEC J AND BOHANEC B. 2012. *Haploids and doubled haploids in plant breeding*. Intechopen. DOI:10.5772/29982
- GERMANÀ M.A. 2011. *Anther culture for haploid and doubled haploid production*. Plant Cell, Tissue and Organ Culture. Volume 104, Issue 3, pp 283–300
- REN J, WU P, TRAMPE B, TIAN X, LÜBBERSTEDT T AND CHEN S. 2017. *Novel technologies in doubled haploid line development. Plant biotechnology journal*, 15(11), 1361-1370.
- DUNWELL J.M. 2010. *Haploids in flowering plants: origins and exploitataion. Plant Biotechnol*J. 8(4): 377-424. doi: 10.1111/ j.1467-7652.2009.00498.x
- FERRIE M.R AND CASWELL K.L. 2011. *Isolated microspore culture techniques and recent progress for haploid and doubled haploid plant production*. Plant Cell, Tissue and Organ Culture. Volume 104, Issue 3, pp 301–309
- THIJS S, SILLEN W, RINEAU F, WEYENS N AND VANGRONSVELD J. 2016. *Towards an enhanced understanding of plant–microbiome interactions to improve phytoremediation: engineering the metaorganism*. *Frontiers in Microbiology*, 7, 341.

General Source Information

- Eng-Chong Pua and Michael R.Davey: *Plant Developmental Biology - Biotechnological Perspectives*.

- B. Bahadur *et al*. (eds.), *Plant Biology and Biotechnology*: Volume I: Plant Diversity, Organization, Function and Improvement.
- Bewley J.D *et al*., *Seeds-Physiology of Development, Germination and Dormancy*.
- Jong M.D and Leyser O. *Developmental Plasticity in Plants. Cold Spring Harbor Symposia on Quantitative Biology*. 63-73.
- Bae G and Choi G. 2008. *Decoding of Light Signals by Plant Phytochromes and TheirInteracting Proteins*. Annu. Rev. Plant Biol. 59: 281–311
- Willemsen V and Scheres B. 2004. *Mechanisms of pattern formation in plant embryogenesis*. *Annu. Rev. Genet*. 38: 587–614
- MomokoIkeuchi*et al*. 2016. *Review- Plant regeneration: cellular origins and molecularmechanisms*. *Development*, 143: 1442-1451.
- Pannel J.R. 2017. *Plant Sex Determination. Current Biology* 27, 191–197.
- Vernonica E. Franklin-Tong. *Self-Incompatibility in Flowering Plants -Evolution, Diversity, and Mechanisms*. Springer.
- Dijk P.V and Damme J.V. 2000. *Apomixis technology and the paradox of sex. Trends in PlantSciences* 5(2): 81-84.

PPH 504 PHYSIOLOGICAL AND MOLECULAR RESPONSES OF PLANTS TO ABIOTIC STRESSES **2+1**

Objectives

With the changing climate, plants are being more frequently exposed to abiotic stresses like, water, salinity, temperature, nutrient, radiation, etc. limiting the productivity. This will not only affect livelihoods of individual farmers but also the food security. Concerted efforts have been made to grow crops under resource limited/stressful environmental conditions and advances in physiology, molecular biology and genetics have significantly helped in this endeavor. In recent years, our understanding of the physio-morphological, biochemical and molecular adaptation of plants to resource limited/stressful environment is

phenomenal. This course will outline different abiotic stresses, their impacts on agricultural productivity, stress tolerance mechanisms, stress mitigation strategies, crop improvement approaches and traits for stress tolerance.

Aim of the course

This course aims to describe students the abiotic-stress physiology and their effects on plant growth and productivity. This will also help students gain insights into latest developments in stress physiology and stress tolerance mechanisms, approaches for crop improvement under stressful environment.

The course is organized as follows:

	Blocks		Units
1.	Abiotic Stresses	1.	Introduction to Abiotic Stresses
2.	Drought Stress	1.	Moisture Stress Responses in Plants
		2.	Stress Perception and Molecular Responses of Plants to Drought Stress
		3.	Plant Adaptive Mechanisms to Drought
		4.	Approaches to Improve Drought Tolerance
3.	Salt, Heavy Metal, Water Logging, Temperature and Light Stress	1.	Salt Stress
		2.	Heavy Metal Stress and Water Logging
		3.	Temperature and Light Stress

Theory

Block 1: Abiotic Stresses

Unit 1: Introduction to Abiotic Stresses

Abiotic stresses major constraints to realize potential yields of crop plants, yield losses. Drought prone areas in India- Frequency of occurrence of drought, Rainfed, kharif, Rabi, Areas affected by salinity, heavy metals, water logging, high temperature scenario due to global warming.

Block 2: Drought Stress

Unit 1: Moisture Stress Responses in Plants

Drought-characteristic features; water potential in the soil-plant-air continuum. Physiological and biochemical processes affected by drought.Oxidative stress- generation of ROS and other cytotoxic compounds, their effect on cellular process. Effect on total carbon gain-decrease in photosynthetic area and function, protein turn over and lipid characters, phenology-reproductive aspects, critical stages.

Unit 2: Stress Perception and Molecular Responses of Plants to Drought Stress

Stress perception andsignal transduction leading to expression of regulatory genes, stress specific kinases, stress specific transcription factors, functional genes associated with adaptive mechanisms.

Unit 3: Plant Adaptive Mechanisms to Drought

(a) Drought escape and desiccation avoidance mechanism-Maintenance of cell turgor, water mining by root characters. Moisture conservation- Regulation of transpiration- traits reducing heat load, Stomatalfactors guard cell metabolism, moisture conservation by waxes. Water use efficiency (WUE) and concept of water productivity- regulation of transpiration efficiency-stomatal conductance, mesophyll efficiency relevance of WUE and Passioura's model.

(b) Desiccation tolerance- Concept of acquired tolerance

Decreased turgor mediated upregulation of cellular tolerance mechanisms, Osmolytes, managing cytotoxic compounds, ROS,

RCC, scavenging - enzymatic and non-enzymatic, protein turnover, stability, chaperones, membrane stability, photo- protection of chlorophylls.

Unit 4: Approaches to Improve Drought Tolerance

Development of genetic resources- donor genotypes for specific traits, Genomic resources- genes, QTL's regulating adaptive mechanisms, Conventional, transgenic and molecular breeding approaches to improve relevant adaptive traits, concept of trait introgression.

Block 3: Salt, Heavy Metal, Water Logging, Temperature and Light Stress

Unit 1: Salt Stress

Soil Salinity-Effect of salt stress, ionic and osmotic effects; species variation in salt tolerance; glycophytes and halophytes, Salt tolerance mechanisms - exclusion, extrusion and compartmentalization, Signaling during salt stress – SOS pathway, Approaches to improve salt tolerance.

Unit 2: Heavy Metal Stress and Water Logging

Heavy metal toxicity in plants (eg., Al, Cd), tolerance mechanisms and approaches to improve. Plant response to water logging, role of hormones- ethylene, mechanism of tolerance and approaches to improve.

Unit 3: Temperature and Light Stress

High and low temperatures; effect on plants; adaptive mechanisms, evaporation cooling, concept of cellular tolerance, protein stability, chaperones, HSPs, HSFs, membranes. High light and high ionizing radiation- photo oxidation and photo- inhibition; mechanisms of tolerance, plant adaptation to low light, concept of shade avoidance response (SAR).

Practicals

- Measurement of soil and plant water status.
- Drought stress imposition and measurement of physiological and biochemical changes in plants under stress –gas exchange and fluorescence measurements.
- Determination of water use efficiency as a drought resistant trait.

- Drought Susceptibility Index (DSI) -precise field technique to identify productive genotypes under stress.
- Approaches to quantify root characters
- Determination of stomatal parameters and canopy temperature as a reflection of transpiration and root activity.
- Determination of Salinity Tolerance Index.
- Studying acclimation response - Temperature induction response.
- Quantification of osmolytes – proline under stress.
- Oxidative stress imposition- Quantification of oxidative stress
- Quantification of ROS under stress.
- Estimation of ABA content in leaf and root tissues under stress.
- Determination of Sodium and Potassium in plant tissue under salt stress.
- Estimation of antioxidant enzymes.

Teaching methods/activities

– Lecture
– Assignment (Reading/Writing)
– Student presentation
– Practicals

Learning outcome

After completion of this course students are expected to have knowledge on and insight into the physiological and molecular responses of plants to abiotic stresses. The student will develop critical insight in adaptive mechanisms of plants against various abiotic stresses.

References

- *Plant Physiology Book by Eduardo Zeiger and Lincoln Taiz.*
- Plant Physiology Book by Frank B. Salisbury, Cleon W. Ross Salisbury, Frank B
- PEREIRA A. 2016. *Plant Abiotic Stress Challenges from the Changing Environment. Front. Plant Sci*. 7: 1123. doi: 10.3389/ fpls. 2016.01123

- SERGEY SHABALA, 2012. *Plant Stress Physiology*. https://www.mapsofindia.com/maps/india/drought-prone-areas.html
- ABID M, ALI S, QI LK, ZAHOOR R, TIAN Z, JIANG D, SNIDER JL AND DAI T. 2018. *Physiological and biochemical changes during drought and recovery periods at tillering and jointing stages in wheat (Triticum aestivum L.). Scientific Reports*, 8(1), p.4615.
- FATHI, AMIN AND BARARI, DAVOOD. 2016. *Effect of Drought Stress and its Mechanism in Plants*. *International Journal of Life Sciences*. 10. 1. 10.3126/ijls.v10i1.14509.
- PAREEK A, SOPORY SK, BOHNERT HJ AND GOVINDJEE 2010. *Abiotic Stress Adaptation in Plants*, Springer, The Nether lands.
- DUMONT S AND RIVOAL J. 2019. *Consequences of oxidative stress on plant glycolytic and respiratory metabolism*. Frontiers in plant science, 10.
- MITTLER R. 2002. *Oxidative stress, antioxidants and stress tolerance. Trends in Plant Science*, 7(9), pp.405-410.
- DEMIDCHIK V. 2015. *Mechanisms of oxidative stress in plants: from classical chemistry to cellbiology. Environmental and experimental botany*, 109, pp.212-228.
- DAS K AND ROYCHOUDHURY A. 2014. *Reactive oxygen species (ROS) and response of antioxidants as ROS-scavengers during environmental stress in plants*. *Frontiers in Environmental Science*, 2, p.53.
- YADAV P, KUMAR S AND JAIN V. 2016. *Recent Advances in Plant Stress Physiology*. Daya Publishing House, New Delhi.
- http://threeissues.sdsu.edu/three_issues_droughtfacts03.html
- ROUT GR AND DAS AB. 2013. *Molecular Stress physiology of plants*. Springer, India.
- MAHALINGAM, RAMAMURTHY (Ed.) 2015. *Combined Stresses in Plants Physiological, Molecular,and Biochemical Aspects*

- LATA C AND MUTHAMILARASAN M AND PRASAD M. 2015. *Drought Stress Responses and Signal Transduction in Plants. In elucidation of abiotic stress signaling in plants* (PP.195-225). Springer, New York, Ny. DOI: 10.1007/978-1-4939-2540-7_7.
- ZHU JK. 2016. *Abiotic stress signaling and responses in plants. Cell*, 167(2), pp.313-324.
- OSAKABE Y, YAMAGUCHI-SHINOZAKI K, SHINOZAKI K AND TRAN LSP. 2013. Sensing *the environment: key roles of membrane-localized kinases in plant perception and response to abiotic stress. Journal of experimental Botany*, 64(2), pp.445-458.
- XIONG L AND ZHU JK. 2001. *Abiotic stress signal transduction in plants: molecular and genetic perspectives. Physiologia Plantarum*, 112(2), pp.152-166.
- GILL SS, ANJUM NA, GILL R AND TUTEJA N, 2016. *Abiotic Stress signaling in plants–an overview. Abiotic Stress Response in Plants*, 3, pp.1-12.
- DEVASCONCELOS MWPL, MENGUER P.K, HU Y, REVERS L.F AND SPEROTTO R.A. 2016. Stress signalingresponses in plants. *BioMed Research International*, 2016.
- KHAN, A., PAN, X., NAJEEB, U., TAN, D.K.Y., FAHAD, S., ZAHOOR, R. AND LUO, H., 2018. *Copingwith drought: stress and adaptive mechanisms, and management through cultural and molecular alternatives in cotton as vital constituents for plant stress resilience and fitness. Biological research* 51(1), p.47.
- ABOBATTA WALEED. 2019. *Drought adaptive mechanisms of plants -a review. Adv.Agr.EnvironSci*., 2(1). 42-45. DOI: 10.30881/aaeoa.00021.
- BASU S, RAMEGOWDA V, KUMAR A AND PEREIRA A. 2016. *Plant adaptation to drought stress. F1000 Research*, 5.
- GILBERT ME AND MEDINA V. 2016. *Drought adaptation mechanisms should guide experimental design. Trends in Plant Science*, 21(8), pp.639-647.
- KAMANGA R.M, MBEGA E, NDAKIDEMI P. 2018. *Drought Tolerance Mechanisms in Plants: Physiological Responses*

Associated with Water Deficit Stress in Solanum lycopersicum. Adv Crop Sci Tech 6: 362. DOI: 10.4172/2329-8863.1000362

- FARRANT, JILL AND COOPER, KEREN AND NELL J. 2012. Desiccation tolerance.
- M.A., WANI, S.H., BHATTACHARJEE, S., BURRITT, D.J., TRAN, L.-S.P. (Eds.) *Drought Stress Tolerance in Plants*, Vol 1, Physiology and Biochemistry, Editors: Hossain.
- PRAKASH M AND DR K BALAKRISHNAN. 2014. *Abiotic Stress tolerance in crop plants*. Satish Serial Publishing House. Delhi. ISBN: 978-93-81226-92-6.
- KUMAR S, MUTHAPPA (Ed.) 2017. *Plant Tolerance to Individual and Concurrent Stresses*
- FERNANDO V.D AND SCHROEDER D.F. 2016. *Role of ABA in Arabidopsis salt, drought, anddesiccation tolerance. In Abiotic and Biotic Stress in Plants-Recent Advances and Future Perspectives*. Intech Open.
- LE GALL H, PHILIPPE F, DOMON JM, GILLET F, PELLOUX AND RAYON C. 2015. Cell wall metabolismin response to abiotic stress. Plants, 4(1), pp. 112-166.
- HASANUZZAMAN M, NAHAR K, ALAM M, ROYCHOWDHURY R AND FUJITA M. 2013. Physiological, biochemical, and molecular mechanisms of heat stress tolerance in plants. International *Journal of Molecular Sciences*, 14(5), pp.9643-9684.
- KHAN MIR, FATMA M, PER T.S, ANJUM N.A AND KHAN N.A. 2015. *Salicylic acid-induced abioticstress tolerance and underlying mechanisms in plants. Frontiers in Plant Science,* 6, p.462.
- TUBEROSA R AND SILVIO S. 2006. *Genomic based approaches to improve drought tolerance in crops.Trends Plant Sci*. 11. 1260-1285.
- ALI A, ALI Z, QURAISHI U.M, KAZI A.G, MALIK R.N, SHER H AND MUJEEB-KAZI A. 2014. *Integrating physiological and genetic approaches for improving drought tolerance in crops. In*

Emerging technologies and management of crop stress tolerance (pp. 315-345). Academic Press.

- SAHEBI M, HANAFI M.M, RAFII M.Y, MAHMUD T.M.M, AZIZI P, OSMAN M, ABIRI R, TAHERI S,KALHORI N, SHABANIMOFRAD M AND MIAH G. 2018. *Improvement of drought tolerance in rice (Oryza sativa L.): Genetics, genomic tools, and the WRKY gene family*. Bio Med research international, 2018.
- MANAVALAN L.P, GUTTIKONDA S.K, PHAN TRAN L.S AND NGUYEN H.T. 2009. *Physiological andmolecular approaches to improve drought resistance in soybean. Plant and Cell Physiology,* 50(7), pp.1260-1276.
- SHAH A.A, SALGOTRA R.K, WANI S.A AND MONDAL S.K. 2017. *Breeding and genomics approachesto increase crop yield under drought stress in climate change scenario. European Journal ofExperimental Biology*, 7(4), pp.1-7.
- DIXIT S, YADAW R.B, MISHRA K.K AND KUMAR A. 2017. *Marker-assisted breeding to develop the drought-tolerant version of Sabitri, a popular variety from Nepal. Euphytica*, 213(8), p.184. *genomics, physiology and breeding approaches for improving drought tolerance in crops. Theoretical and Applied Genetics*, 125(4), pp.625-645.
- SINGLA-PAREEK SL, REDDY MK AND SOPORY SK. 2001. *Transgenic approach towards developingabiotic stress tolerance in plants. Proceedings: Indian National Science Academy* Part B, 67(5), pp.265-284.
- GUPTA B AND HUANG B. 2014. *Mechanism of salinity tolerance in plants: physiological, biochemical, and molecular characterization*. *International journal of genomics*, 2014.
- ZHU J.K. 2001. *Plant salt tolerance. Trends in plant science*, 6(2), pp.66-71.
- MOGHIMI A, YANG C, MILLER M.E, KIANIAN S.F AND MARCHETTO P.M. 2018. *A novel approach to assess salt stress tolerance in wheat using hyperspectral imaging.* Frontiers in plant science, 9.

- ISAYENKOV S.V AND MAATHUIS F.J. 2019. *Plant Salinity Stress: Many Unanswered QuestionsRemain. Frontiers in plant science*, 10.
- TUTEJA N. 2007. *Mechanisms of high salinity tolerance in plants. In Methods in enzymology* (Vol. 428, pp. 419-438). Academic Press.
- CARILLO P, ANNUNZIATA MG, PONTECORVO G, FUGGI A AND WOODROW P. 2011. *Salinity stress andsalt tolerance. In Abiotic stress in plants-mechanisms and adaptations*. IntechOpen.
- SAIEMA R AND ASIYA H, MOHAMED A , MUNEEB R AND SIDDIQI OT AND PARVAIZ A. 2013. *Salt Stress: Causes, Types and Responses of Plants*. 10.1007/978-1-4614-4747-4_1.
- NEGRÃO S, SCHMÖCKEL S.M AND TESTER M. 2017. *Evaluating physiological responses of plantsto salinity stress. Annals of Botany*, 119(1), pp.1-11.
- FUKAO T, BARRERA-FIGUEROA B.E, JUNTAWONG P AND PEÑA-CASTRO J.M. 2019. *Submergence and Water logging Stress in Plants: A Review Highlighting Research Opportunities and Understudied Aspects. Frontiers in Plant Science*, 10, p.340.
- EMAMVERDIAN A, DING Y, MOKHBERDORAN F AND XIE Y. 2015. *Heavy metal stress and some mechanisms of plant defense response. The Scientific World Journal*, 2015.
- MANI A AND SANKARANARAYANAN K. 2018. *Heavy Metal and Mineral Element-Induced Abiotic Stress in Rice Plant. In Rice Crop-Current Developments.* Intech Open.
- BARCELÓ JUAN AND POSCHENRIEDER CHARLOTTE. 2008. *Plant Water Relations as Affected by HeavyMetal Stress: A Review. Journal of Plant Nutrition*. 13. 1-37. 10.1080/01904169009364057.
- YAMAUCHI T, COLMER TD, PEDERSEN O, NAKAZONO M, *PLANT PHYSIOLOGY.* 2018. *Regulation of root traits for internal aeration and tolerance to soil water logging-flooding stress*. 176(2) 1118-1130. DOI: 10.1104/pp.17.01157.
- SZYMAÑSKA R, ELESAK I, ORZECHOWSKA A AND KRUK J. 2017. *Physiological and biochemicalresponses to high light and*

temperature stress in plants. Environmental and Experimental Botany 139: 165-177.

- NAHAR K, HASANUZZAMAN M, AHAMED KU, HAKEEM KR, OZTURK M AND FUJITA M. 2015. *Plant responses and tolerance to high temperature stress: role of exogenous phytoprotectants. In Crop production and global environmental issues* (pp. 385-435). Springer, Cham.
- MATHUR S, AGRAWAL D AND JAJOO A. 2014. *Photosynthesis: response to high temperaturestress. Journal of Photochemistry and Photobiology B: Biology*, 137, pp.116-126.
- ORT DR. 2001. *When there is too much light. Plant physiology*, 125(1), pp.29-32.
- DEMMIG-ADAMS B AND ADAMS III WW. 1992. *Photoprotection and other responses of plants to high light stress. Annual review of plant biology*, 43(1), pp.599-626.
- DIETZ KJ. 2015. *Efficient high light acclimation involves rapid processes at multiple mechanistic levels. Journal of Experimental Botany*, 66(9), pp.2401-2414.

PPH 505 HORMONAL REGULATION OF PLANT GROWTH AND DEVELOPMENT 2+1

Objectives

Many plant growth and developmental processes are regulated by phytohormones. It is important to understand the hormone biosynthesis, structure, function, signal transduction and their practical application. It is also important to provide basic knowledge on manipulating growth and developmental processes using plant hormones.

Aim of the course

It provides knowledge on the fundamentals of hormone biosynthesis, homeostasis, transport and signaling and the role in regulating basic physiological processes governing developmental events in plants. The role of classical hormones on developmental processes from germination, shoot and root apical meristem differentiation, flowering, seed maturation

and senescence. The aim of this course is to appraise the students about structure and function of plant growth regulators.

The course is organized as follows:

No.	Blocks	No.	Units
1	Plant Growth and Development: Hormonal Regulation	1.	Introduction to Plant Hormones
		2.	Plant Hormones - Discovery and Metabolism
		3.	Physiological Role of Hormones in Plant Growth and Development
		4.	Endogenous Growth Substances other than Hormones
		5.	Hormone signaling
		6.	Key Genes Regulating Hormone Levels and Functions
		7.	Crosstalk of Hormones in Regulation of Plant Growth and Development Processes
		8.	Practical Utility of Growth Regulators in Agriculture and Horticulture

Theory

Block 1: Plant Growth and Development: Hormonal Regulation

Unit 1: Introduction to Plant Hormones

Growth, differentiation and development regulated by plant growth substances, Definition and classification of growth regulating substances: Classical hormones, Definition and classification of growth regulating substances: Endogenous growth substances other than hormones, Synthetic chemicals.

Unit 2: Plant Hormones – Discovery and Metabolism

Discovery, biosynthetic pathways and metabolism of Auxin, Gibberellins, Cytokinins, Abscisic acid, Ethylene, Brassinosteroids, Strigolactones.

Unit 3: Physiological Role of Hormones in Plant Growth and Development

Physiological functions of Auxin and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of Gibberellins anduse of mutants and transgenic plants in elucidating the physiological functionsofCytokinins and use of mutants and transgenic plants inelucidating the physiological functions, Physiological functions of Ethylene and use of mutants and transgenic plants in elucidating the physiological functions, Physiological functions of BrassinosteroidsandStrigolactones and use of mutants and transgenic plants in elucidating the physiological functions, Discovery, biosynthetic pathways metabolism and physiological roles of Salicylic acid and Peptide hormones.

Unit 4: Endogenous Growth Substances other than Hormones

Discovery, biosynthetic pathways metabolism and physiological role of Polyamines and Karrikins, Discovery, biosynthetic pathways metabolism and physiological roles of Jasmonates and Tricontanol, Discovery, biosynthetic pathways metabolism and physiological roles of systemins Concept of death hormone, Recent developments in elucidating responses of Salicylic acid, Peptide hormones and Polyamines at physiological and molecular level, Recent developments in elucidating responses of Jasmonates, Systemins, Karrikins and Tricontanol at physiological and molecular level.

Unit 5: Hormone Signaling

Hormone signal perception, transduction - Receptors, components and mechanism (Auxin, Gibberellin, Cytokinin, ABA and Salicylic acid), Hormone signal perception, transduction - Receptors, components and mechanism (Ethylene, Jasmonate, Brassinosteroids and strigolactones), Advances in elucidating the structure and function of receptors and signaling components of important hormones.

Unit 6: Key Genes Regulating Hormone Levels and Functions

Genomics approaches to regulate hormone metabolism and its effect on plant growth and development – case studies.

Unit 7: Crosstalk of Hormones in Regulation of Plant Growth and Development Processes

Crosstalk of Hormones in Regulation of Plant Growth and Development Processes: Floral transition, reproductive development, Shoot and root apical meristem development

Unit 8: Practical Utility of Growth Regulators in Agriculture and Horticulture

Practical Utility of Growth Regulators in Agriculture and Horticulture: Rooting of cuttings, Vine and brewing industry, Promotion of gynoecious flowers, hybrid rice production, induction of flowering in pine apple, cucurbits, Practical Utility of Growth Regulators in Agriculture and Horticulture: Delaying of senescence and ripening, Production of dwarf plants for ornamental purpose, As herbicides, Reduction in flower and fruit drop.

Practicals

- Extraction of Auxins from plant tissue
- Separation and detection of Auxins by GC / GC-MS / HPLC / Immunological technique
- Bioassay of auxin- effect on rooting of cuttings
- Extraction of abscisic acid (ABA) from plant tissue
- Separation and detection of ABA by HPLC/Immunological technique
- ABA bioassays- effect on stomatal movement
- Estimation of ethylene in plant tissues using gas chromatography
- Ethylene bioassays, estimation using physico-chemical techniques- effect on breaking dormancy in sunflower and groundnut
- Extraction of Gibberellins from plant tissue- GC / GC-MS / HPLC
- Separation and detection of GA by GC / GC-MS / HPLC/ Immunological technique
- GA bioassays- effect on germination of dormant seeds
- Cytokinin- extraction from plant tissue

- Separation and detection of cytokinin by GC / GC-MS / HPLC
- Cytokinin bioassays- effect on apical dominance and senescence / stay green

Teachingmethods/activities

- Lecture
- Assignment (Reading / Writing)
- Student presentation
- Practicals

Learning outcome

After successful completion of this course, the students are expected to be able to:

– Acquire basic knowledge about plant hormones and plant growth regulators.

– Understand the physiological roles and mechanisms of actions of plant hormone.

– Obtain practical knowledge about application of plant growth regulators in agricultural and horticulture.

References

- DAVIES P.J. 2004, *Plant Hormones: Biosynthesis, Signal Transduction and Action,* 2ndEdition. Kluwer Academic Publishers, Dordrecht, The Netherlands.
- HEDDEN,P. AND THOMAS,S.J. 2006. *Plant Hormone Signalling*, Black well Publishing Ltd., Oxford, UK.
- OSBORNE, D.J. AND MC MANUS, M.T. 2005. *Hormones, Signals and Target Cells in Plant Development*. Cambridge University Press, NewYork, USA.
- TUCKER,G.A. AND ROBERTS, J.A. 2000. *Plant Hormone Protocols.* Humana Press-Springer Science, NewYork,USA.
- BUCHANAN B.B, GRUISSEM W AND J ONES R.L. *Bio chemistry and Molecular biology of Plants*, 2nd Edition.

- LINCOLNTAIZ AND EDUARDO ZEIGER. *Plant Physiology and Development*, 6th Edition.
- *Teaching Tools in Plant Biology*, The American Society of Plant Biologists
- *The Arabidopsis* BOOK (HTTP://WWW.ARABIDOPSISBOOK.ORG/)

PPH 506 PHYSIOLOGICAL AND MOLECULAR MECHANISMS OF MINERAL NUTRIENT ACQUISITION AND THEIR FUNCTIONS 2+1

Objectives

In both basic and applied plant sciences, an understanding of the mineral nutritionof plants is of fundamental importance. Nutrient element forms the skeleton of anyorganicmoleculeintheorganismvis-à-v is plant. A part from the conventional information on criteria of essentiality, nutrient up take pathways, function of essential elements and their deficiency and to xicitysymptoms, remarkable advances have been made at physiological and molecular level. Exploration of the physiological mechanisms adopted by plants to tolerate the deficiency of specific nutrient element provides an opportunity alter the plants' ability to cope with the low nutrient condition. Identification and functional validation of various transporters involved in nutrient up take and distribution, deciphering the sensing and signaling of nutrient star vation response and the irregulatory network provides options to develop nutrient up take and utilization efficient crops. In the era of Omics, 'ionomics' provides the total elemental composition of the plant and is a powerful approach to the functional analysis of its genes and the gene networks. Besides, it is also essential to expose the students to various conventional and high-through put phenotyping techniques to identify the nutrient efficient 'donors', traits and QTLs / candidate genes to complement the research program on crop improvement.

Aim of the course

It provides knowledge on basic physiological processes governing nutrient uptake, physiological role of elements, factors influencing up

take, internal remobilization of nutrient element during starvation and adaptation strategies. Regulation of nutrient uptake and translocation would be studied at the molecular level providing information on genes and other signaling factors involved. The aim of this course is to make the students understand the physiological and molecular basis of nutrient up take, translocation and utilization and to apply this knowledge in genetic improvement of crop plants.

The course is organized as follows:

No.	Blocks	No.	Units
1.	Mineral Nutrient: Classification, Function, Availability, Deficiency and Toxicity	1.	Mineral Elements: Classification, Function, Deficiency and Toxicity
		2.	Nutrient Availability at Rhizosphere
2.	Nutrient Uptake, Translocation and Acquisition	1.	Ion Uptake Mechanisms
		2.	Ion Transport to Shoot and Grains
		3.	Physiological and Molecular Mechanism of Nutrient Acquisition and Transport: Macronutrients
		4.	Physiological and Molecular Mechanism of Nutrient Acquisition and Transport: Micro and Beneficial Nutrients
		5.	Microbes, Fungal Association for Nutrient
		6.	Acquisition Nutrient Delivery
3.	Nutrient Efficiency of Crop	1.	Improving Nutrient Acquisition and Efficiency of Crops

Theory

Block 1: Mineral Nutrient: Classification, Function, Availability, Deficiency and Toxicity

Unit 1: Mineral Elements: Classification, Function, Deficiency and Toxicity Classification based on mobility and characteristic features; physiological role in regulating plant growth, metabolism, development and human health- Regulatory.

Dietary Allowance (RDA), Deficiency and toxicity of macro, micro and beneficial elements, Tolerance of plants to nutrient toxicity, hyper-accumulators of nutrients: Concept of phytoremediation.

Unit 2: Nutrient Availability at Rhizosphere

Biological and chemical reactions influencing nutrient availability near the root system, interaction between ions in the rhizosphere, Rhizosphere chemistry in relation to plant nutrition- chemical reactions, root exudates to mobilize nutrients.

Block 2: Nutrient Uptake, Translocation and Acquisition

Unit 1: Ion Uptake Mechanisms

Mineral salt absorption- chemical potential of solute- Nernst equation- passive uptake- diffusion, ion exchange-Donnan Equilibrium, mass flow of ions, Mediated transport- Facilitated diffusion-ionophores; membrane transport proteins- active transport-ion channels, Primary and secondary transport- carriers and pumps.

Unit 2: Ion Transport to Shoot and Grains

Long distance transport in plants - Mechanism of xylem and phloem transport, Radial movement of ions across the root, Mechanism of phloem transport, remobilization of mineral nutrients - phloem loading, phloem unloading.

Unit 3: Physiological and Molecular Mechanism of Nutrient Acquisition and Transport: Macronutrients

Molecular structures of LAT and HAT, their localization and regulation by various external factors, Nitrate transporters and their functional regulation - Nitrate transporters (NRT1, NRT2, dual-affinity nitrate transporter NRT1.1/CHL1), Phosphate transporters and their functional regulation - PT1/PHT1, PHT2, PHT3, PHT4, Potassium transporters and their functional regulation - KT/HAK/KUP family Ion transporters involved in transport of multiple elements, for example, sulphate, phosphate Arsenate, etc.

Unit 4: Physiological and Molecular Mechanism of Nutrient Acquisition and Transport: Micro and Beneficial Nutrients

Plant Strategies: Different Strategies I & II adopted by plants for uptake of Fe under Fe deficient condition, Transporters and genes regulating uptake and transport of micronutrients, genes encoding transport/channel proteins, Examples of genes encoding mineral ion transporters for Zn, Fe, Mn, Cu, B, Mo, Ni, Cl, Na, Si, Se, Beneficial nutrients and their role in plant growth and development – Sodium, Silicon, and Cobalt.

Unit 5: Microbes, Fungal Association for Nutrient Acquisition

Microbes to improve nutrient availability – Bio-inoculation technology- P solubilizers and Zinc solubilizers in nutrient absorption, Microbial systems for biological nitrogen fixation – process of nodulation, biochemistry of N2-fixation, Endophytes to improve nutrient availability, Mycorrhiza- Mycorrhizal symbiosis on nutrient uptake by root. Role of AMF on nitrogen, phosphorus and zinc uptake.

Unit 6: Nutrient Delivery

Foliar application of nutrients, absorption and their compartmentation, Concept of slow release fertilizers and chelates (organic and inorganic), Soil less cultures- aeroponics, hydroponics, fertigation.

Block 3: Nutrient Efficiency of Crop

Unit 1: Improving Nutrient Acquisition and Efficiency of Crops

Concept of nutrient uptake and use efficiency- Genotypic differences- physiology and molecular mechanisms, Nutrient use efficiency in selected crops, Root system architecture (RSA), root characters associated with nutrient acquisition, Genes and QTLs to improve nutrient acquisition and efficiency for important nutrients in few crop species, Transgenic and molecular breeding approaches to improve traits associated with acquisition and efficiency – Case studies, Biofortification strategies for micronutrients, agronomic approaches, Influence of nutrition status on plant response to biotic and abiotic stresses.

Practicals

- Techniques to develop the deficiency symptoms of nutrients – Hydroponics/ Aeroponics- diagnosis of deficiency symptoms in agriculturally important crop plants
- Physiological and biochemical markers to identify nutrient deficiency levels
- Biochemical markers for essential elements: Assay of nitrate reductase activity for N
- Estimation of chlorophyll concentration in leaves of N deficient and N sufficient plants
- Collection of acid phosphatase from root exudates and enzyme assay for P
- Measuring anthocyanin and chlorophyll pigments concentration in leaves for P
- Collection of organic acid in root exudates, characterization and quantification for P
- Assay of carbonic anhydrase activity for Zn
- Assay of SOD Activity for Cu, Zn and Mn
- Estimation of nitrogen concentration in plant tissue - Kjeldhal and Dumas method
- Estimation of phosphorus concentration in plant tissue – colorimetric method
- Estimation of potassium, magnesium and sodium concentration in plant tissue – flame photometer
- Estimation of micronutrients (Zn, Cu, Fe, Mn, Co etc) concentration in plant tissue

  – atomic absorption spectrometer/ ICP-OES
- Measurement of simple root traits such as root length, angle, volume, surface area, etc. (using conventional methods or root scanner and WinRhizo)
- 'Shovelomics' in the field grown crops (for measuring root architecture) and using 'ImageJ' for analysis

Non-invasive techniques to quantify nutrients – XRF (X-Ray Fluorescence) and hyper spectral reflectance.

Teaching methods / activities

- Lecture
- Assignment (Reading / Writing)
- Student presentation
- Practicals

Learning outcome

By the end of this course, the student will be able to:

– Comprehend the fundamental concepts of mineral nutrition of plant.

– Describe the physiological and molecular mechanisms of acquisition and translocation of nutrient.

–Describe the basis of differential nutrient efficiency.

Suggested Reading

- *Recommended Dietary Allowances*: 10th Edition (https:// www.ncbi.nlm.nih.gov /books/ NBK234932/pdf/Bookshelf_ NBK234932.pdf)
- DASILVALOBATO, A.K., LIMA, E.J.A., LOBATO, E.M.S.G., MACIEL, G.M. AND MARQUES, D.J. 2016. *Tolerance of Plants to Toxicity Induced by Micronutrients. In Abiotic and Biotic Stress in Plants-Recent Advances and Future Perspectives*. Intech Open.
- RENWICK, A.G., 2006. *Toxicology of micronutrients: adverse effects and uncertainty. The Journal of nutrition,* 136(2),493S-501S.
- KRÄMER, U.,2018. *The Plants that Suck Up Metal. German Research*, 40(3), 18-23.
- SURRIYAO, SALEEMSS, WAQAR, K.ANDKAZI, A.G., 2015. *Phytore mediation of soils: prospects and challenges. Soil remediation and Plants: Prospects and challenges*,p.1.
- SARMA,H., 2011. *Metalhy per accumulation in plants: are view focusing on phyto remediation technology. Journal of Environmental Science and Technology*, 4(2), pp.118-138.

- MARSCHNERH. *Mineral Nutrition of Higher Plants* 3rdEdn
- ZEIGERAND TAIZL. *Plant Physiology*
- *Mineral Nutrition of Plants*, *In: Plant Biology and Biotechnology.* B. Bahadur *et al*. (eds.), Volume I: *Plant Diversity, Organization, Function and Improvement*, DOI: 10.1007/978-81-322-2286-6_20, SpringerIndia,Pp.499-538.
- LÓPEZ-ARREDONDO D L, LEYVA - GONZÁLEZ, M A, ALATORRE - COBOS F AND HERRERA-ESTRELLAL. 2013. *Biotechnology of nutrient up take and assimilation in plants. International Journal of Developmental Biology*, 57(6-7-8), pp.595-610.
- SUGITA,R., KOBAYASHI, N.I., HIROSE, A., TANOI, K. AND NAKANISHI, T.M., 2019. *Visualization of I on Transportin Plants. In Agricultural Implications of the Fukushima Nuclear Accident* (III) (pp.221-231). Springer, Singapore.
- RUSSELL, R.S. AND CLARKSON, D.T., 2016. *Iontransport in rootsystems. Perspect*.Exp. Biol, 2,pp. 401-411.
- JENNINGS, M.L., 2018. *Carriers, exchangers, and cotransporters in the first 100 years of the Journal of General Physiology. The Journal of General Physiology*, 150(8),pp. 1063-1080.
- AIBARA, I. AND MIWA, K.,2014. *Strategies for optimization of mineral nutrient transportin plants:multi level regulation of nutrient dependent dynamics of root architecture and transporter activity. Plant and Cell Physiology*, 55 (12), pp. 2027-2036.
- BARBERON, M. AND GELDNER, N., 2014. *Radial transport of nutrients: the plant root as apolarized epithelium. Plant Physiology*, 166(2), pp.528-537.
- DE SCHEPPER, V., DE SWAEF, T., BAUWERAERTS, I. AND STEPPE, K., 2013. *Phloem transport: are view of mechanisms and controls*. *Journal of Experimental Botany*,64 (16), 4839-4850.
- COMTET, J.,JENSEN, K.H.,TURGEON, R., STROOCK, A.D. AND HOSOI, A. E., 2017. *Passive phloem loading and long-distance transport in asynthetic tree-on-a-chip. Nature Plants,* 3(4), p.17032.

- MITRA G.N. *Regulation of NutrientUptake by Plants: A Biochemical and Molecular Approach*
- URAGUCHI, S., KAMIYA, T., SAKAMOTO, T., KASAI, K., SATO, Y., NAGAMURA, Y., YOSHIDA, A., KYOZUKA, J., ISHIKAWA, S. AND FUJIWARA, T., 2011. *Low-affinity cation transporter (OsLCT1) regulates cadmium transport in to ricegrains. Proceedings of the National Academy of Sciences*, 108(52), pp.20959-20964.
- PHOSPHATE-STARVED PLANTS. *Plant Physiology*, 156:1006–1015.
- ELANCHEZHIAN *ETAL*. 2015. *Physiological and molecular approaches for improving phosphorus up take efficiency of crops.Current Science*, 108(7):1271-1279.
- O'BRIEN*ETAL*. (2016) *Nitrate Transport, Sensing, and Responses in Plants*. *Molecular Plant* 9,837–856.doi.org/10.1016/j.molp.2016.05.004
- RAGEL, P., RADDATZ, N., LEIDI, E.O., QUINTERO, F.J. AND PARDO, J.M., 2019. *Regulation of K+ nutrition in plants. Frontiers in Plant Science*, 10.
- BRIANG. FORDE(2000) *Nitratetrans porters in plants: structure ,function and regulation. Biochimicaet Biophysic aActa*1465:219-235.
- WEI XUAN, TOM BEECKMAN AND GUOHUA XU 2017. *Plant nitrogen nutrition: sensing and signalling.CurrentOpinion in Plant Biology*, 39:5765.doi.org/10.1016/j.pbi. 2017.05.010 *to application. Plant Physiology*,156,1202–1216,doi.org /10.1104/ pp.111.175471.
- GAMUYAO *et al*. (2012) *The protein kinase PSTOL1 from traditional rice conferstolerance of phosphorus deficiency*. Nature, 488-535.doi.org/10.1038/nature11346.
- RAGEL, P., RÓDENAS, R., GARCÍA- MARTÍN, E., ANDRÉS, Z., VILLALTA, I., NIEVES-CORDONES, M.,RIVERO, R.M., MARTÍNEZ, V., PARDO, J.M., QUINTERO, F.J. AND RUBIO, F., 2015. *The CBL-interactingprotein kinase CIPK23 regulates HAK5-mediated high-affinity K+ uptake in Arabidop sisroots. Plant Physiology*, 169(4), pp.2863-2873.

- VOLPE,V., GIOVANNETTI, M.,SUN, X.G., FIORILLI,V. AND BONFANTE, P.,2016. *The phosphate transporters LjPT4 and MtPT4 mediate early root responses to phosphate*status in non-my corrhizalroots. Plant, cell and environment, 39(3), pp. 660-671.
- LI,Y., PENG, L., XIE, C., SHI, X., DONG, C., SHEN, Q. AND XU, Y., 2018. *Genome-wide identification, characterization, and expressionanalyses of the HAK/KUP/KT potassiumtransporter gene family reveals their involvement in K+ deficient and abiotic stress responses in pearroot stock seedlings. Plant Growth Regulation*, 85(2),pp.187-198.a
- LÓPEZ-ARREDONDO,D.L., SÁNCHEZ-CALDERÓN, LANDYONG-VILLALOBOS, L.,2017. *Molecular and genetic basis of plant macro nutrient use efficiency : concepts ,opportunities, and challenges. In Plant Macronutrient Use Efficiency* (pp.1-29). Academic Press.
- INOSTROZA-BLANCHETEAU, C.,AQUEA, F.,MORAGA, F.,IBAÑEZ, C.,RENGEL, Z.ANDREYES-DÍAZ, M., 2017. *Genetic Engineering and Molecular Strategies for Nutrient Manipulation in Plants. In Essential Plant Nutrients* (405-441). Springer, Cham.
- SPEROTTO, R.A., RICACHENEVSKY, F.K.,WILLIAMS, L.E., VASCONCELOS, M.W. AND MENGUER,P.K.,2014. *From soil to seed : micro nutrient move mentinto and with in the plant. Frontiers in Plant Science*, 5,p.438.
- TSAI, H.H. AND SCHMIDT, W., 2017. *Oneway. Oranother? Iron up take in plants New Phytologist*, 214 (2), pp.500-505.
- CONNORTON, J.M.,BALK, J. AND RODRÍGUEZ-CELMA, J., 2017. *Iron homeo stasisinplants abriefoverview. Metallomics*, 9(7), pp.813-823.
- CURIE, C.ANDMARI, S.,2017. *New routes for plant ironmining. New Phytologist*, 214(2), pp. 521-525.
- HIMENO,S. AND FUJISHIRO, H., 2017. *Roles of Zinc Transporters in Cellular Transport of Cadmium and Manganese. In Metallomics* (265-283).Springer,Tokyo.

- GRILLET, L., LAN, P., LI, W., MOKKAPATI, G. AND SCHMIDT, W., 2018. *IRONMAN is aubiquitous family of peptides that control iron transport inplants. Nature Plants*, 4(11), p.953.
- LAMBERS, H., HAYES, P.E., LALIBERTE, E., OLIVEIRA, R.S. AND TURNER, B.L., 2015. *Leaf manganese accumulation and phosphorus - acquisition efficiency. Trends in Plant Science*, 20(2), 83-90.
- SHAO, J.F.,YAMAJI, N., SHEN, R.F. AND MA, J.F., 2017. *The key to Mnhomeostasis in plants: regulation of Mntransporters. Trends in Plant Science*, 22(3):215-224.
- SALOMÉ, P.A., 2017. *Manganese IsaPlant's Best Friend:Intracellular MnTransport by the Transporter NRAMP2*.
- MANUEL, T.J., ALEJANDRO, C.A., ANGEL, L., AURORA, G. AND EMILIO, F., 2018. *Roles of Molybdenumin Plants and Improvement of Its Acquisition and Use Efficiency. In Plant Micronutrient Use Efficiency* (pp.137-159). Academic Press.
- ZIELIÑSKA-DAWIDZIAK, M.,2015. *Plant ferritin—a source ofiron toprevent itsdeficiency. Nutrients*,7(2),pp. 1184-1201.
- CASTRO, P.H., LILAY, G.H. AND ASSUNÇÃO, A.G., 2018. *Regulation of micronutrient homeostasis and deficiency response in plants. In Plant Micronutrient Use Efficiency* (pp. 1-15). AcademicPress.
- YOSHINARI, A. AND TAKANO, J., 2017. *Insights into the mechanisms underlying boron homeostasis inplants. Frontiers in Plant Science*, 8,p.1951.
- CAMACHO-CRISTÓBAL, J.J., NAVARRO-GOCHICOA, M.T., REXACH, J., GONZÁLEZ-FONTES, A. AND HERRERA-RODRÍGUEZ, M.B., 2018. *Plant Response to Boron Deficiency and Boron Use Efficiency in Crop Plants. In Plant Micronutrient Use Efficiency* (109-121). Academic Press.
- MA, J.F. AND YAMAJI, N.,2015. *A cooperative system of sili contransport inplants. Trendsin Plant Science*, 20(7). 435-442.2017. *Rapid transporter regulation prevents substrate flow traffic jams in boron transport. Elife,* 6,. e27038.

- AFZAL, I2019. *Plant beneficial end ophytic bacteria: Mechanisms, diversity, hostrange and genetic determinants, Microbiological research*
- BERTOLAZI A. A. *et al*. 2018. *Linking Plant Nutritional Status to Plant-AMF Interactions. In*: Egamberdieva D., Ahmad P. (eds) *Plant Microbiome: Stress Response. Microorganisms for Sustainability,* 5. Springer, Singapore
- BHALE, U.N., BANSODE, S.A., AND SINGH, S. 2018. *Multifactorial Role of Arbuscular Mycorrhizaein Agro ecosystem. Fungi and Their Role in Sustainable Development: Current Perspectives*, 205–220. doi:10.1007/978-981-13-0393-7_12
- DIPTA, B., BHARDWAJ, S., KAUSHAL, M., KIRTI, S., AND SHARMA, R. (2019). *Obliteration of phosphorus deficiency inplants by micro bialinter ceded approach. Symbiosis*. doi:10.1007/s13199-019-00600-y
- GAHAN, J.AND SCHMALENBERGER, A.2014. *The role of bacteria and my corrhiza in plants ulfur supply. Frontiers in plant science*, 5.723.
- GARCIA, K.AND ZIMMERMANN, S.D.2014. *The role of my corrhiza associations inplant potassium nutrition. Frontiers in Plant Science*, 5,p.337.
- NADEEM, S.M.,AHMAD, M., ZAHIR, Z.A., JAVAID, A. AND ASHRAF, M., (2014). *The role of my corrhiza and plant growth promoting rhizo bacteria (PGPR) inimproving crop productivity under stress ful environments. Biotechnology Advances*, 32(2):429-448.
- NATH, M., BHATT, D., BHATT, M. D., PRASAD, R., ANDTUTEJA, N. 2018. *Microbe-Mediated Enhancement of Nitrogen and Phosphorus Content for Crop Improvement. Crop Improvement Through Microbial Biotechnology* ,293–304. doi:10.1016/b978-0-444-63987-5.00014-1
- LAKHIAR, I.A., GAO, J., SYED, T.N., CHANDIO, F.A. AND BUTTAR, N.A., 2018. *Modern plant cultivation technologies in agriculture under controlled environment : Are view on aeroponics. Journal of Plant Interactions*, 13(1):338-352.

- PRADHAN, B. AND DEO, B., 2019. *Soilless farming - the next generation green revolution. Current Science* 116(5).
- SHARMA, N., ACHARYA, S., KUMAR,K., SINGH,N. AND CHAURASIA, O.P., 2019. *Hydroponics as an advanced technique for vegetable production : An overview. J. Soil Water Conserv*, 17,364.
- FU, J., WANG, C., CHEN, X., HUANG, Z. AND CHEN, D., 2018. *Classification research and types of slow controlled release fertilizers (SRFs) used-areview. Communications in Soil Science and Plant Analysis*, 49(17), pp.2219-2230.
- TRENKEL, M.E. 2010. *Slow-and Controlled - Release and Stabilized Fertilizers: An Option for Enhancing Nutrient Use Effciency in Agriculture*, 1133. Paris, France: International Fertilizer Industry Association (IFA).
- MEENA, B.P., K.RAMESH, S.NEENU, P. JHA, AND I. RASHMI. 2017. *Controlled Release fertilizers for improving nitrogen use efficiency*, 59–79. New India Publishing Agency, New Delhi.
- NAZ, M. Y., AND S. A. SULAIMAN. 2016. *Slow release coating remedy for nitrogen loss from conventional urea: Areview. Journal of Controlled Release* 225:10920. doi:10. 1016/j.j conrel.2016.01.037.
- FAGERIA, N.K., FILHO, M.B., MOREIRA, A. AND GUIMARÃES, C.M., 2009. *Foliar fertilization of crop plants. Journal of Plant Nutrition*, 32(6):1044-1064.
- MALHOTRAH, PANDEYR, SHARMA SAND BINDRABANP (2019) *Foliar fertilization : Possible routes of iron transport from leaf surface to cell or ganelles. Archives of Agronomy and Soil Science,* DOI:10.1080/03650340.2019.1616288
- REYNOLDS, M.P.,J.I. ORTIZ MONASTERIO, AND A. MCNAB(eds.). 2001. *Application of Physiology in Wheat Breeding. Mexico*, D.F.: CIMMYT.
- HAWKES FOR DAND BARRACLOUGHP. (Eds). *The Molecular and Physiological Basis of Nutrient Use Efficiency in Crops*J.

- WEIH, M., HAMNÉR, K. AND POURAZARI, F., 2018. *Analyzing plant nutrient uptake and utilization efficiencies: comparison between crops and approaches. Plant and Soil*, 430(1-2), 7-21. *Science*, 8, p.1021.
- JEWEL, Z.A.,ALI, J.,MAHENDER, A.,HERNANDEZ, J.,PANG, Y.AND LI, Z., 2019. *Identification of Quantitative Trait Loci Associated with Nutrient Use Efficiency Traits, Using SNP Markers in an Early Backcross Population of Rice (OryzasativaL.). International Journal of Molecular Sciences*, 20(4), p.900.
- FERRANTE, A., NOCITO, F.F., MORGUTTI, S. AND SACCHI, G.A., 2017. *Plant breeding for improving nutrient up take and utilization efficiency. In Advances in Research on Fertilization Management of Vegetable Crops* (pp.221-246). Springer, Cham.
- WANG,Y. AND WU, W.H., 2015. *Genetic approaches for improvement of the croppotassium acquisition and utilization efficiency .Current Opinionin Plant Biology*, 25,pp.46-52.
- WAN, T.E.N.G., XUE, H.E. AND TONG, Y.P., 2017. *Transgenic approaches for improving use efficiency of nitrogen, phosphorus and potassiumin crops. Journal of Integrative Agriculture*, 16 (12), 2657-2673.
- ROSE, T.J., IMPA, S.M., ROSE, M.T., PARIASCA - TANAKA, J., MORI, A., HEUER, S., JOHNSON-BEEBOUT, S.E. AND WISSUWA, M., 2012. *Enhancing phosphorus and zinc acquisition efficiency in rice: acritical review of roottraits and their potential utility inrice breeding. Annals of Botany*, 112(2),. 331-345.
- ALI, J., JEWEL , Z., MAHENDER, A., ANANDAN, A., HERNANDEZ, J. AND LI, Z., 2018. *Molecular genetics and breeding fornutrient use efficiency in rice. International Journal of Molecular Sciences*, 19(6), p.1762.
- HEUER, S., GAXIOLA, R., SCHILLING, R., HERRERA ESTRELLA, L., LÓPEZ ARREDONDO, D., WISSUWA, M., DELHAIZE, E. AND ROUACHED, H., 2017. *Improving phosphorus use efficiency: A complex trait with emerging opportunities. The Plant Journal*, 90(5),868-885.

- GARG ,M., SHARMA, N., SHARMA, S., KAPOOR, P., KUMAR ,A., CHUNDURI, V. AND ARORA, P., 2018. *Biofortified cropsgenerated by breeding, agronomy, and transgenic approaches are improving lives of millions of people around the world. Frontiers in Nutrition*, 5,12.
- RIAZ, A .,ABBAS, A. AND RAZA, S., 2017. *Techniques for the Enrichment of Micronutrients in Crops through Biofortification: A Review. Journal of Advances in Biology and Biotechnology*,1-7.

PPH 507 PHOTOSYNTHETIC PROCESSES, CROP GROWTH PRODUCTIVITY AND CONCEPTS OF CROP MODELLING 2+1

Objectives

Agronomic inputs and environmental factors enhance crop growth by improving photo synthetic processes and photo synthatepartitioning. Carbon metabolism is the most important physiological process that has a direct influence on crop growth and productivity which is quite sensitive to biotic and abiotic constraints. Hence acomprehensive understanding can opy photo synthetic process is crucial. This is an important component in crop improvement program, especially in the scenario of plateauing yields. These photo synthetic processes and their response to environmental factors form the basis for developing growth and yield predicting models.

Aim of the Course

The course provides a comprehensive the oretical and hands on experience and expertise to students on various aspects of photosynthesis including biophysical, biochemical and molecular regulations. While canopy photo synthesis drives crop growth rates, factors associated with sink activity and partitioning determine productivity. Hence, adequate emphasis would be given to canopy photosynthesis, translocation and its feedback regulation, Crop growth and yield structure analysisand their responses to environmental factors. Growth and yield prediction models and the irrelevance will be adequately discussed.

The course is organized as follows:

	Blocks		Units
1.	Photosynthetic Processes	1.	Canopy Architecture and Energy Utilization
		2.	Photochemical Processes
		3.	Biochemical Processes
		4.	Product Synthesis and Translocation
		5.	Growth and Yield forming Mechanisms
2.	Yield Improvement and Modelling	1.	Molecular Options to Improve Photosynthesis, Growth and
		2.	Productivity Fundamentals of Dynamic Simulation Models
		3.	Description of Well-established yield Models
		4.	Examples of Robust Models Extensively Used

Theory

Block 1: Photosynthetic Processes

Unit 1: Canopy Architecture and Energy Utilization

Parameters associated with canopy architecture that determine radiation interception and absorption, Energy absorption by primary and accessory pigments and energy utilization efficiency, Light distribution inside the canopy and concepts of light extinction coefficient.

Unit 2: Photochemical Processes

Ultrastructure of chloroplast: structure and composition of lamellar system, Components of electron transport, Water oxidation system and energy conservation processes, Pigment systems and the generation of a powerful oxidant and a powerful reductant, Chlorophyll fluorescence and fluorescence quenching: qN, qP, NPQ.

Unit 3: Biochemical Processes

CO_2 diffusion and resistances (gs and gm). Concept of Ci determining CO_2 diffusion. RuBisCO activation state, kinetics and catalytic properties, Carboxylation processes in C_3, C_4 and CAM plants and their relevance, CO2 concentrating mechanisms and their importance in improving carbon assimilation, Ecological significance of C_4 and CAM photosynthesis, Photorespiration and Mitochondrial respiration and net carbon gain, Carbon isotope discrimination and its importance as a surrogate of Ci.

Unit 4: Product Synthesis and Translocation

Triose phosphate utilization and regulation of Calvin cycle mechanisms, Product synthesis and partitioning between starch and sucrose, Concepts of end-product inhibition or Pi-regeneration limitation, Phloem transport and factors that regulate phloem loading and un-loading.

Unit 5: Growth and Yield forming Mechanisms

Carbon gain and the concepts of Canopy photosynthesis. Relevance of LAI and LAD in determining total carbon gain and crop growth rates, Source: Sink relationship and its relevance in governing differences in crop growth rates andfrom vegetative organs to reproductive structures, Growth analysis and parameters that explain growth rates: NAR, CGR, HI and their inter-dependence.

Block 2: Yield Improvement and Modelling

Unit 1: Molecular Options to Improve Photosynthesis, Growth and Productivity

Characteristic features of the Chloroplast genome: its structure and genes associated with various photosynthetic mechanisms, coordinated expression of chloroplast and nuclear genome for maintaining photosynthetic activities. Genomic and genetic resources such as specific genes and QTL associated with photosynthetic processes Transgenic options to enhance photosynthetic performance such as transferring genes to mitigate oxidative stress damage (SOD, APX, AKR etc), Theoretical conceptsof crop improvement through inducing CCM in C3 plants and reducing photorespiration.

Unit 2: Fundamentals of Dynamic Simulation Models

Collection of crop specific genetic coefficient, Crop, soil and historic weather data.

Unit 3: Description of Well-established Yield Models

Application and limitations of modeling, Yield prediction models such as APSYM, Peanut Grow etc, Machine learning approaches and IoT for making informed on- farm decisions.

Unit 4: Examples of Robust Models Extensively Used

Duncan's yield prediction model, Passioura's model for growth maximising.

Practicals

- Plant sampling for leaf area and biomass estimation; analysis of growth and yield parameters – LAD, NAR. CGR, LAI, LAR, SLA portioning efficiency, HI.
- Measurement of light interception, light extinction coefficient, energy utilization efficiency based energy intercepted, and realized.
- Gas exchange: principles and uses to assess variations in CO2 and water vapour transfer, determination of A/gs and intrinsic WUE
- Quantification of chlorophyll content by various methods: colorimetric and SPAD meter. The concept of SLN
- Chlorophyll fluorescence and quenching coefficients
- Theoretical aspects of carbon isotope fractional and its use in determining WUE
- Quantification of RuBisCO content by ELISA (if possible)
- Determination of RuBisCO activity and activation state using radioactive CO2
- CO2 and light response curves and computation of carboxylation efficiency, quantum efficiency, relative limitations of photosynthesis at single leaf level.
- Adoption of crop models: Growth and yield prediction by Duncan's and Passioura's models

Teaching methods / activities

- Lecture
- Assignment (Reading/Writing)
- Student presentation
- Practicals

After completion of this course students are expected to have in depth knowledge on Photosynthetic processes associated with product synthesis and yield development. Students will also obtain current knowledge on various crop models.

Suggested Reading

- GOYNE, P.J., MILROY, S.P., LILLEY, J.M., AND HARE , J.M.(1993). Radiation interception, radiationuse efficiency and growth of barleycultivars. *Australian Journal of Agricultural Research*, 44(6), 1351-1366.
- https:// www.sciencedirect.com/ topics/ chemistry/ photosynthetic - pigment.
- FRANK, H.A., YOUNG, A., BRITTON, G., AND COGDELL, R.J. (Eds.). (2006). *The photochemistry of carotenoids* (Vol.8). Springer Science and Business Media.
- RUBAN,A.V. (2016). Non photo chemical chlorophyll fluorescence quenching : mechanism and effectiveness inprotecting plants from photo damage. *Plant Physiology*, 170(4),1903-1916.
- MAXWELL, K., AND JOHNSON, G.N. (2000). Chlorophyll fluorescence—apractical guide. *Journal of Experimental Botany*, 51(345),659-668.
- https://www.researchgate.net/publication/38051229,_ The_photo-chemical_reaction_in_photosynthesis.
- WANG,Y., STESSMAN, D.J., AND SPALDING, M.H. (2015). The CO_2 concentrating mechanism and photo synthetic carbon assimilation in limiting CO_2 : how Chlamy domonas works against the gradient. *The Plant Journal*, 82(3), 429-448.
- DIETZ, K.J., AND PFANNSCHMIDT, T. (2011). Novel regulators in photosyntheticred ox control of plant metabolis mandgeneex pression. *Plant Physiology*, 155(4),1477-1485.

- FARQUHAR, G.D., EHLERINGER, J.R., AND HUBICK, K.T. (1989). Carbon is otope discrimination and photosynthesis. *Annual Review of Plant Biology*, 40(1), 503-537.
- PAUL,M.J.,ANDFOYER,C.H.(2001).Sink regulation of photosynthesis. *Journal of experimental botany*. 52(360), 1383-1400.
- DESCHEPPER,V., DESWAEF, T. BAUWERAERTS, I., AND STEPPE, K. (2013). Phloemtransport : are view of mechanisms and controls. *Journal of experimental botany*. 64(16),4839-4850.
- WERADUWAGE, S.M., CHEN, J., ANOZIE, F.C., MORALES, A.,WEISE, S.E., AND SHARKEY, T.D. (2015). The relationship between leaf are a growth and bio massaccumulation in Arabidopsisthaliana. *Frontiers in Plant Science*, 6,167.
- HAY, R.K.M. (1995). Harvest index : are view of its use inplant breeding and cropphysiology. *Annals of Applied Biology*, 126(1), 197-216.
- IRVING,L. (2015). Carbon assimilation, biomass partitioning and productivity ingrasses. *Agriculture*, 5(4), 1116-1134.
- DEFREITASLIMA, M., ELOY, N.B., DESIQUEIRA, J.A.B., INZÉ,D., HEMERLY, A.S., AND FERREIRA, P.C.G. (2017). Molecular mechanisms of biomass increase inplants. *Biotechnology Research and Innovation*,1(1),14-25.
- RAINES,C.A.(2011).Increasing photosynthetic carbonassimilation in C3 plants to improve cropyield : current and futurest rategies. *Plant Physiology*, 155(1), 36-42.
- VONCAEMMERER, S., AND EVANS, J. R. (2010). Enhancing C3 photosynthesis. *PlantPhysiology*, *154*(2), 589-592.
- http://ijid.informaticspublishing.com/index.php/ijid/article/download/111838/78332
- https://www.mdpi.com/1424-8220/18/8/2674/pdf
- http://ijid.informaticspublishing.com/index.php/ijid/article/download/111838/78332
- https://www.mdpi.com/1424-8220/18/8/2674/pdf

• SPLINTER,W.E.(1974). Modelling of plant growth for yield prediction. *Agricultural Meteorology*, 14(1-2),243-253.

General Source Information

• Blankenship RE.2014.*Molecular mechanisms of Photosynthesis* 2nd Edition

• *Canopy Photosynthesis :From Basics to Applications*. 2016 EdHikosaka, Kouki, Niinemets, Ülo, Anten, Niels P.R. p*hotosynthesis*.

• PessarakliM. 2016. *Handbook of Photosynthesis* 3rd Edition.

PPH 508 PHYSIOLOGY OF FIELD CROPS 2+0

Objectives

In recent years, phenomenal progress has been made in understanding plant processes which are crop specific. Genetic gain in productivity can be achieved only by improving plant physiological traits/ adaptive mechanisms. Even crop management should be based on sound physiological principles. For example, crop's response to the increasing Global warming has to be looked from thermomorpho genesis concept in terms of GDD and its effect on phonological processes in some of the important field crops exposure on crop specific physiological processes is necessary and has particular significance.

Aim of the course

This course provides a broad exposure on the physiological aspects of field crops. The objective is to impart comprehensive information on physiological processes and physiological basis of growth, development and productivity of field crop plants. Besides, the emphasis is on unique crop specific features.

Broad categories of crops that can be selected for this course are as follows.

1. Cereals–Rice, Wheat, Maize etc.
2. Millets–Finger millet, Sorghum etc.

3. Pulsecrops–Greengram, Blackgram, Lentil, Pigeonpea, Chickpeas, Cowpea, Beans etc.
4. Oilseed crops–Groundnut, Rapeseed Mustard, Soybean etc.
5. Sugarcane
6. Fibre crops–Cotton, Jute, Ramie, Hemp etc.

The course is organized as follows:

No.	Blocks		Units
1.	Physiology of Field Crops	1.	Introduction
		2.	Crop Establishment, Crop Growth and Development
		3.	Reproductive Growth
		4.	Seed Nutrient Quality
		5.	Plant Nutrition
		6.	Abiotic Stress Response
		7.	Crop Specific Physiological Processes and Importance

Learning outcome

After completion of this course, students will accrue comprehensive knowledge on various physiological processes of variety of field crops.

Theory

Block 1: Physiology of Field Crops

Unit 1: Introduction

Origin- Variability in physiology of crop plants between wild species and cultivated. Adaptability to growing environments (ecosystems), Importance in food grain contribution.

Unit 2: Crop Establishment, Crop Growth and Development

Seed characteristic features, dormancy, viability, concept of seed priming seedling establishment and crop stand. Different crop growth stages, concept of source establishment and optimum LAI, Canopy architecture, light interception/radiation use efficiency, thermal time, heat units, GDD, determining growth duration.

Unit 3: Reproductive Growth

Photo and thermo-periodic response for flowering, sink development, sink source relationship, partitioning efficiency, improvement in HI, yield determining factors, genetic gain in yield over years, structuring of ideal plant type, limitations to improve source to sink ratio, options to improve yield potential.

Unit 4: Seed Nutrient Quality

Seed quality, seed as a source of nutrients, seed constituents and their improvement, concept of pathway engineering to improve seed quality.

Unit 5: Plant Nutrition

Nutrient requirement, genetic variability in nutrient acquisition under constraint conditions, specific nutrient disorders.

Unit 6: Abiotic Stress Response

Response to different abiotic stresses, plant traits/mechanics to improve adaptation to realize potential yields. Global warming responses, thermo-morphogenesis, approaches to overcome the constraints.

Unit 7: Crop Specific Physiological Processes and Importance

Choosing location specific crop species exposure will be given on physiological process as described above. Besides, emphasis is on providing information on crop specific features/productivity constraints.

Teaching methods/activities

- Lecture
- Assignment(Reading/Writing)
- Student presentation

References

- *GrainLegumes*: EdDeRon, AntonioM. (Ed.) 2015.Springer
- *Legumes under Environmental Stress: Yield, Improvement and Adaptations*. Eds MM AzoozP Ahmad and Hoboken, NJ: John Wiley and Sons, Ltd., 328 pages. ISBN: 978-1-118-91708-4

- *PulseCrops: Biotechnological Strategies to Enhance A biotic Stress Tolerance*. GaneshanS, GaurPM, ChibbarRN, TutejaN, GillSS, TutejaR. chapter17
- *Climate Change and Management of Cool Season Grain* Legume *Crops*. Eds Yadav GS, McNeilDL, ReddenR, PatilSA. Springer.
- *Nature'spulsepower:legumes,food security and climate change.* ConsidineMJ, SiddiqueKHM and Foyer CH,. 2017 *J Exp Bot*. 68(8): 1815–1818. Published online 2017 May 11. doi:10.1093/jxb/erx099
- GLASSOP D, RAEAL AND BONNETTGD. 2014. *Sugarcane flowering genes and pathway sinrelation to vegetative regression . SugarTech*. 16(3):235-240. DOI10.1007/s12355-013-0284-z
- MC CORMICK A J, WATT DA AND CRAMER MD. 2009. *Supply and demand: sink regulation of sugar accumulation in sugarcane. Journal of Experimental Botany*. 60(2): 357-364. DOI10. 1093/jxb/em310
- MOORE P H AND BOTHA F C. 2014. *Sugarcane : physiology, biochemistry, and functional biology*. JohnWiley and Sons ISBN978-1-118-77119-8
- RAM B, RAJULASHANTHY T, VISWANATHAN R, HEMAPRABHA G AND PALANISWAMI C. 2016. *Hand book on sugarcane.* ICAR – Sugarcane Breeding Institute. ISBN978-93-85267-03-1
- SHRIVASTAVA A K, SOLOMON S, RAI R K, SINGH P, CHANDRA A, JAIN R AND SHUKLA S P (2015) *Physiological interventions for enhancing sugarcane and sugar productivity. Sugar Tech*. 17(3):215-226. DOI10.1007/s12355-014-0321-6
- EVANS,L.T., 1996. *Crop Evolution, Adaptation and Yield*. Cambridge University Press.
- JEFF L. BENNETZEN, J.L AND HAKE, S.C.2009. *Hand Book of Maize: Its Biology*, Springer-Verlag NewYork
- SINGH, C.B. AND KHARE, D. 2015. *Genetic Improvement of Field Crops*. Scientific Publishers, Jodhpur.

- TOLLENAAR M., DWYERL. M. 1999. *Physiology of Maize. In: Smith D. L., HamelC. (eds) Crop*Yield. Springer, Berlin, Heidelberg
- YOSHIDA, S., 1981. *Fundamentals of Rice Crop Science*. IRRI.
- REHMAN, A. 2016. *Photosynthesis under heat stress. Handbook of Photosynthesis*, Edition: Third Edition, Publisher: CRC Press Taylor and Francis Group, pp.697-701.
- NEGRÃO S, COURTOIS B, AHMADI N, ABREU I, SAIBO N, OLIVEIRA MM.2011. *Recent updates on salinity stress in rice from physiological to molecular responses. Crit RevPlant Sci* 30:329-377
- VONCAEMMERER, S., QUICK, W.P .AND FURBANK, R.T. ,2012 . *The development of C4rice : current progress and future challenges. Science*, 336 (6089), pp. 1671-1672.
- HUBBARTS, PENGS, HORTONP, CHENY, MURCHIEEH. 2007. *Trends in leaf photosynthesis in historical ricevarieties developed in the Philippinessince 1966; Journal of Experimental Botany*, Vol.58 (12), 3429–3438.
- FAHADS, BAJWAAA, NAZIRU, ANJUMSA, FAROOQA, ZOHAIBA, SADIAS, NASIMW, ADKINSS, SAUDSANDIHSANMZ. 2017. *Cropproduction under drought and heat stress: plant responses and managemen toptions. Frontiers in Plant Science*s (1147) : 1-16.
- PANDEY V AND SHUKLA A. 2015. *Acclimation and Tolerance Strategies of Rice under Drought Stress. Rice Science* 22(4):147-161.
- KOLEC. 2006. *Cereals and millets. Genome Mapping and Molecular Breeding in Plants. Springer.*
- SAMUELA . MATZ. 2006. Cerealscience.
- RINKI, MAMRUTHA H M, SAREEN S, TIWARI V, SINGH G P. 2018. *Dissecting the physiological and anatomical basis for high yield potential in HD2967. Vegetos*.31:121-124.
- KUMAR R, KAUR A, ANKITA P, MAMRUTHA H.M, SINGH G.P 2019. *CRISPR based genomeediting in wheat: A comprehensive review and future prospects. Molecular Biology Reports* 10.1007/s11033-019-04761-3.

- TIWARI R AND MAMRUTHA HM. 2014. *Precision Phenotyping for Mapping of Traits for Abiotic Stress Tolerance in Crops. Biotechnology : Prospects and Applications.* Ed. Salar R.K, Gahlawat S.K, Siwach Pand Duhan JS.Pp79-85. Publisher : Springer.
- SLEPER D.A AND POEHLMAN J.M. 1995. *Breeding for field crops.*
- Reynolds *M. Wheat Physiological Breeding volume I and II (CIMMYT) : Wheat Physiological Breeding : A Field Guide to Wheat Phenotyping*.
- MAMRUTHA H.M *ETAL*. 2019. *Physiological and Molecular Basis of A biotic Stress Tolerance in Wheat*. In: Rajpal V., Sehgal D., Kumar A., Raina S. (eds) *Genetic Enhancement of Crops for Tolerance to A biotic Stress: Mechanisms and Approaches*, Vol. I. Sustainable Development and Biodiversity, vol20. Springer, Cham.
- TIWARI V. *et al*. 2017. *Managing Abiotic Stresses in Wheat.* In: Minhas P., Rane J., Pasala R. (eds) *Abiotic Stress Management for Resilient Agriculture*. Springer, Singapore.

PPH 509 PHYSIOLOGY OF HORTICULTURE CROPS 2+0

Objectives

Improving physiological processes forms the basis to enhance the productivity or to improve a specific growth processes. Several interventions based on principals of physiological processes provide options to enhance crop productivity. Basic insight on photo periodic response is crucial for determining planting dates. Understanding the mechanisms of rooting for vegetative propagation has lead in developing rooting hormones etc., In view of this, a comprehensive exposure on growth and development of horticulture crops and providing insights on major production constraints and physiological approaches to over come is highly essential.

Aim of the Course

This course should provide a broad exposure on the physiological aspects of horticulture crops. The objective is to impart comprehensive

information on physiological processes and physiological basis of growth, development and productivity of horticultural crop plants. To describe basic and applied physiology behind the production and productivity of horticultural crops and their pre and post harvest management, ideal storage conditions, quality retention, processing and value addition.

Broad categories of crops that can be selected for this course are as follows.

1. Fruit crops: Mango, Grapes, Apple, Banana, Citrus etc.
2. Vegetable crops: Tomato, Onion, Brinjal, Cauliflower, Okra etc.
3. Tuberous crops: Potato, Cassava, Sweet potato, Yam etc.
4. Plantation crops: Coconut, Oilpalm, Cashew, Tea, Coffee, Rubber, Arecanut, Cocoaetc.
5. Floriculture crops: Rose, Marigold, Carnation, Chrysanthemum, Gladiolus, Orchids, Tuberose etc.
6. Other groups: Medicinal crops, Aromatic crops, Spices crops.

The course is organized as follows:

No.	Blocks		Units
1.	Physiology of Horticultural Crops	1.	Introduction
		2.	Crop growth and Development
		3.	Reproductive Growth
		4.	Pre and Post-harvest Physiology
		5.	Plant Nutrition and Abiotic Stress Responses
		6.	Specific Aspects and Unique Crop Features

Learning outcome

After completion of this course, students will accrue comprehensive knowledge on various physiological processes of variety of horticultural crops.

Theory

Block 1: Physiology of Horticultural Crops

Unit 1: Introduction

Origin, distribution and adaptability of crops to different agro-climatic conditions.

Unit 2: Crop growth and Development

Internal factors (hormone, etc.) influencing various physiological processes linked to vegetative growth or growth of specific organ, correlative and algometric growth External factors (water, nutrition, temperature, etc.) influencing various physiological processes linked to vegetative growth or growth of specific organ, correlative and algometric growth, Propagation methods, grafting, cutting, budding, air layering. Physiology of pruning, dwarfing, branch bending, canopy management etc., Physiological and biochemical aspects of scion and root stock interaction and compatibility.

Unit 3: Reproductive Growth

Physiology of flowering, photo- and thermo-periodism and response to vernalization, Factors influencing reproductive growth, fruit and seed set/retention, physiology of flower sex ratio, Physiological processes governing source-sink relationship and productivity.

Unit 4: Pre and Post Harvest Physiology

Preharvest factors influencing postharvest physiology, Physiological and molecular mechanisms of ripening, Physiological and molecular mechanisms of senescence, Hormonal and chemical control of postharvest deterioration of fruits/vegetable/ flowers. Regulation of ripening at physiological and molecular levels, Regulation of senescence at physiological and molecular levels, Approaches to improve shelf life and storability. Approaches to improve postharvest management, Approaches to improve processing and value addition.

Unit 5: Plant Nutrition and Abiotic Stress Responses

Nutrient acquisition and requirement, plant phenology and nutrient requirement; Role of rootstocks in nutrient acquisition and in abiotic

stress tolerance, Adaptive mechanisms and approaches to improve performances under drought and high temperature, Adaptive mechanisms and approaches to improve performances under frost, chilling and nutrient deficient conditions, Root physiology in abiotic stress tolerance.

Unit 6: Specific Aspects and Unique Crop Features Specific aspects

Polyhouse cultivation, Hormones/PGRs for improving crop performance, Major and micronutrients for improving crop performance, Light interception, shade regulation, dwarfing root stocks, Chilling requirement for flowering, photoperiodic response, pollen viability, stigma receptivity, Flower (blossom) and fruit drop.

Unique crop features

Maturity and maturity indices, Source-sink relations, Vegetative propagation, Physiology of tuberization and rhizome initiation and formation, Virus free planting material, Bulbs/tubers dormancy, bud break, Physiological disorders, Storage, Packaging, Quality.

Teaching methods/activities

- Lecture
- Assignment (Reading/Writing)
- Student presentation

References

- SETHURAJ MR AND RAGHAVENDRA AS. 2012. *Tree Crop Physiology*. ISBN - 13:978-0444428417, ISBN-10:0444428410, Elsevier Science Publishers.
- BHATNAGAR P. *Physiology of Growth and Development of Horticultural Crops*, ISBN-10:817754666X, ISBN-13:978-8177546668
- SINGH A. *Fruit Physiology and Production*, ISBN - 10:8127211788, ISBN-13:978-8127211783, KalyaniPublishers; 5th edition (March28, 2003).
- HARE K. 2012. *Physiology of Fruit Production*, ISBN-10: 9380012373, ISBN-13: 978-9380012377, Stadium Press India Pvt.Ltd

- DURNER EF. 2013. *Principles of Horticultural Physiology*, ISBN-13:978-1780643069, ISBN-10:1780643063, CABI.
- BLEASDALEJ KA. *Plant Physiology in Relation to Horticulture*, ISBN-10:8192686094, ISBN-13:978-8192686097,SENTIFIC(2014) 2ndedition.
- KUMAR M. 2015. *Physiology of Fruit Production*, ISBN-10:9384568384, ISBN-13:978-9384568382.
- YAHIA EM AND CARRILLO-LOPEZ A. 2018. *POST HARVEST PHYSIOLOGY AND BIOCHEMISTRY OF FRUITS AND VEGetables*, ISBN-10:0128132787, ISBN-13:978-0128132784, Wood head Publishing.
- FREITAS ST AND PAREEK S. *Post harvest Physiological Disordersin Fruits and Vegetables*, ISBN-9781138035508, 1138035505, Taylor and Francis Ltd.
- DHILLONWS AND BHATZA.2012. *Fruit Tree Physiology*. Narendra Publishing House.
- SANDIPM, MAKWANA AN, BARAD AV AND NAWADE BD. 2015. *Physiology of flowering – the case of mango*. Int.J.Appl.Res,1(11),1008-1012.
- SCHAFFER B AND ANDERSEN PC. 2018. *Hand book of environmental physiology of fruit crops*. CRCPress.
- LAKSHMINARAYANA S, SUBHADRA NV AND SUBRAMANYAM H. 1970. *Some aspects of developmental physiology of the mango fruit. Journal of Horticultural Science*,45(2),133-142.
- SWAMYJS.2012. *Flowering manipulation in mango: A science comes of age. Journal of Today's Biological Sciences: Research and Review*, New Delhi,1(1),122-137.
- SINGH VK AND SHARMA K. 2008. *Physiological and biochemical changes during flowering ofmango* (*Mangifera indica l.). International Journal of Plant Developmental Biology,* 2(2),100-105.

- CARRMKV.2014. *The water relations and irrigation requirements of mango (MangiferaindicaL.) :are view. Experimental Agriculture,* 50(1),1-23.
- HAGEMANN MH, ROEMER MG, KOFLERJ, HEGELE M AND WÜNSCHE JN. 2014. *A new approach for analysing and interpreting data on fruit drops in mango. Hort Science*, 49(12), 1498-1505.
- RAMÍREZ F AND DAVENPORT TL. 2010. *Mango (MangiferaindicaL.) flowering physiology. Scientia Horticulturae*, 126(2), 65-72.
- LÉCHAUDELM, LOPEZ-LAURIF, VIDALV, SALLANON HAND JOASJ. 2013. *Response of the physiological parameters of mango fruit (transpiration, water relations and antioxidant system) to its light and temperature environment. Journal of plant physiology,* 170(6), 567-576.
- URBAN L, JEGOUZO L, DAMOUR G,VANDAME MAND FRANÇOIS C. 2008. *Interpreting the decrease in leaf photosynthesis during flowering inmango. Treephysiology*, 28(7), 1025-1036.
- JAMEEL M.A, NAIK SR, MADHUMATHI C, REDDY DS AND VENKATARAMANA KT. 2018. *Physiology of flowering in mango. Journalo f Pharmacognosy and Phytochemistry*, 7(6), 2375-2382.
- LIN H.L, SHIESH CC AND CHEN P J. 2012. *May. Physiological disorder sinrelation to compositional changes inmango (Mangi feraindicaL.'Chiin Hwang') fruit. In VII International*
- DAYAL V, DUBEY AK, SINGH SK, SHARMA RM, DAHUJA A AND KAUR C. 2016. *Growth, yield and physiology of mango (Mangi feraindicaL.) cultivarsas affected bypolyem bryonic root stocks. Scientia horticulturae*, 199,186-197.

Grapes

- KELLER M. 2015.*The science of grapevines: anatomy and physiology.* Academic Press.
- WILLIAMS L.E. 2017. *Grape. In Photo assimilate Distribution Plants and Crops Source-Sink Relationships* (pp.851-882). Routledge.

- SYMONS G.M, DAVIES C, SHAVRUKOV Y, DRYIB, REID JB AND THOMAS MR. 2006. *Grape son steroids. Brassin osteroids are involved in grapeberry ripening. Plant physiology*, 140(1), pp.150-158.
- BALINT GAND REYNOLDS AG. 2013. *Impact of exogenous abscisic acid onvin ephysiology and grape composition of Cabernet Sauvignon. Americ an journal of enology and viticulture*, 64(1),pp.74-87.
- SRINIVASAN CAND MULLINS MG. 1981. *Physiology of flowering in the grapevine—areview. American Journal of Enology and Viticulture*, 32(1),47-63.
- LEBON G, WOJNAROWIEZ G, HOLZAPFEL B, FONTAINE F, VAILLANT-GAVEAU N AND CLÉMENT. C.2008. *Sugars and flowering in the grapevine (Vitis vinifera L.). Journal of experimental botany,* 59(10),pp.2565-2578.
- OWAIS S.J.2015.*Morphological and physiological responses of six grape genotypesto Na Clsaltstress. Pakistan Journal of Biological Sciences*, 18(5), p.240.
- KONDO S AND FUKUDAK. 2001. *Changes of jasmonate singrapeberries and their possible roles in fruit development*. *Scientia Horticulturae*. 91(3-4), 275-288.
- CooMbe B.G and Mc Carthy, MG. 2000. *Dynamics of grapeberry growth and physiology of ripening. Australian journal of grape and winer research*. 6(2),131-135.
- CHERVIN C, EL-KEREAMYA, ROUSTANJP, LATCHÉA, LAMON J AND BOUZAYEN M., 2004. Ethyleneseems required for the berry development and ripening in grape, a non-climacteric fruit. *Plant Science*. 167(6).1301-1305.

Guava

- RODRIGUES AAM, SILVA SDM, DANTAS AL, SILVA AFD, SANTOS LDS AND MOREIRA DDN. 2018. *Physiology and postharvest conservation of 'Paluma'guava under coatings using Jack fruitseed –based starch. Revista Brasileirade Fruticultura*, 40(2).

- SRIVASTAVAHCANDNARASIMHANP.1967. *Physiological studies during the growth and development of different varieties of guavas (Psidiumguajava L.). Journal of Horticultural Science*. 42(1)97-104.
- SINGHSK, MALHOTRASK, BHARGAVAR, SINGHRS AND SHUKLAAK. 2017. *Morphological and physiological characterization of guava (Psidiumguajava) under hot-arid zone of Rajasthan. Indian Journal of Agricultural Sciences*. 87(4), 491-5.
- MONDAL K, MALHOTRA SP, JAIN V AND SINGH R. 2009. *Oxidative stress and antioxidant systems in Guava (Psidiumguajava L.) fruits during ripening. Physiology and Molecular Biology of Plants*, 15(4), 327.
- ADHIKARI SAND KANDEL TP. 2015. *Effect of time and level of pruning on vegetative growth, flowering, yield, and quality of guava. International Journal of Fruit Science*, 15(3)290-301.
- SHARMAS, SEHRAWAT SK AND SHARMA KD. 2017. *Studies on time and duration of flowering, floral bud development and morphology of guava (psidiumguajaval.) Under semi-aridregion of india. Int. J.Curr.Microbiol.App.Sci,* 6(12).4176-4186.
- PATEL RK, MAITICS, DEKA BC. *DESHMUKH, N.A., VERMA, V.K. AND NATH, A., 2015. Physical and biochemical changesinguava (PsidiumguajavaL.) during various stages of fruitgrowth and development*.
- ADHIKARIS. 2012. *Guava Pruning and Its Physiology.*

Tomato

- AIVALAKIS GAND KATINAKIS P. 2008. *Biochemistry and molecular physiology of tomato and pepperfruit ripening. Eur JPlant SciBiotechnol*, *2* (special issue 1), 145-155.
- PEETMM. 2008. *Physiological disorders in tomato fruit development. In International Symposiumon Tomato in the Tropics 821*(151-160).

- PASSAM HC, KARAPANOS IC, BEBELI PJ AND SAVVAS D. 2007. *Areview of recent research on tomato nutrition, breeding and post-harvest technology with reference to fruit quality.The European Journal of Plant Science and Biotechnology,1*(1),1-21.
- FENTIK DA. 2017. *Review ongenetics and breeding of tomato (Lycoper siconesculentum Mill.) .Adv Crop Sci Tech*, *5*(5), 306.

Onion

- BREWSTER JL. 2018. *Physiology of crop growth and bulbing. In Onions and allied crops* (53-88). CRCPress.
- CURRAHL, COOLS K AND TERRY LA. 2012. *Onions, shal lots and garlic*. Teoksessa :Rees, D., Farrell, G. and Orchard, J.(toim.).*Croppost-harvest:science and technology*, 3,360-391.
- BREWSTERJL.1994. *Environmental physiology of the onion: towards quantitative models for the effects of photoperiod, temperature and irradiance on bulbing, flowering and growth In International Symposiumon Edible Alliaceae* 433(347-374).
- COOLONG TW. 2007. *Physiological Factors Affecting Onion* (*AlliumCepaL.) Storability: Cultural Methods for Improving Postharvest Quality,*University of Georgia.
- KHOKHAR, K.M., 2017. *Environmental and genotypic effects onbulb developmenti nonion–areview .The Journal of Horticultural Science and Biotechnology* 92(5):448-454.
- KHOKHAR KM. 2014. *Flowering and seed developmentinonion—Areview.* Open Access Library1(07).

Brinjal

- SHARMA SP AND BRAR JS. 2008. *Nutritional requirements of brinjal (SolanummelongenaL.)-Areview. Agric. Rev,*29(2), pp.79-88.
- BYARI,S.H. AND AL-RABIGHI, S.M., 1995. *Morphological and physiological responses of egg plant cultivars (SolanummelongenaL.) to drought* .J.KAU: *Met. Env, Arid Land Agric. Sci*, *6*,pp.41-47.

PPH 510 SEED PHYSIOLOGY 2+1

Objectives

Seeds are considered as propagule and as a major source of nutrition for humans and other animals. Therefore, all information concerning the irnutritive value, chemical composition; storability, retention of viability are very important. Lookinginto the importance of seeds, emphasis has been given to produce high qualityseeds with excellent genetic potential to improve seed germination and to producevigorous seedlings. In fact, recently techniques are employed to raise healthy andvigorous seeds to obtain vigorous seedlings. Several hormones and chemicals areused to improve the oil, protein, and other economic attributes of seeds. Therefore, to give more insight into the development of quality seeds and also protecting them without losing much of nutritive value, this course has been proposed.

Aim of the course

This course will approach the subjects from two perspectives– physiology of seed development and seed germination. Itaims to describe students the physiological processes involved in regulation and mechanism of seed development, dormancy and germination. Further, to provide an insight in to physiological processes governing seed quality and its survival. Accordingly.

No.	Blocks		Units
1.	Physiology of Seed Development	1.	Introduction to Seed Physiology
		2.	Seed Development
		3.	Seed Maturation
		4.	Metabolism in Developing Seed
2	Physiology of Seed Germination and Dormancy	1.	Seed Germination
		2.	Seed Dormancy and Viability

Theory

Block 1: Physiology of Seed Development

Unit 1: Introduction to Seed Physiology

Importance of seed as a propagule, seed structure and functions; chemical composition of seeds. Embryogenesis: pollination and fertilization, pollen and pistil interaction, signal for interaction; pollen load hypothesis; genetical and environmental influence on seed development. Source-Sink relationship affecting seed yield and quality. Concept of seed viability and seedling vigour and their relevance; approaches to improve the storability of seeds. Physiological and molecular mechanisms of seed germination; approaches to improve seed germination; seed size and its influence on seed germination.

Unit 2: Seed Development

Physiology and molecular mechanisms of embryo, endosperm and seed coat development; cellularization during endosperm development; morphological and cellular changes during seed coat development, anatomy and function of seed coat, programmed cell death (PCD) in seed coat, Deposition of seed storage reserves during development.

Unit 3: Seed Maturation

Seed maturation and maturation indices; physiological and anatomical changes during seed maturation; Seed drying and acquisition of desiccation tolerance in seeds; mechanisms of desiccation tolerance; role of ABA LEA's, HSP's, dehydrins and other stress proteins during seed maturation and drying, Seed abortion and approaches to reduce it.

Unit 4: Metabolism in Developing Seed

Chemical composition of seeds (carbohydrates, proteins, fats etc.), source of assimilates for seed development, pathways of movement of assimilates to developing seed, approaches to increase the chemical composition of seeds. Seed respiration and mitochondrial activity; seed respiration rate and storability of seeds. Seed ageing, Mobilization of stored resource in seeds; Chemistry of oxidation of starch, proteins and fats; Utilization of breakdown products by embryonic axis.

Block 2: Physiology of Seed Germination and Dormancy

Unit 1: Seed germination

Seed germination, types of germination, imbibition kinetics of germinating seed; Physiological events during germination: seed respiration, mitochondrial activity, mobilization of food reserve; energy utilization by the germinating seedhydrothermal time models; Influence of environmental factors on germination; Role of plant hormones/PGR's during seed germination.

Unit 2: Seed Dormancy and Viability

Physiological and molecular basis of seed dormancy, hormonal regulation of dormancy, After ripening, dormancy breaking treatments; Ecological perspective of seed dormancy. Seed viability: concept and physiology of seed viability, theories of seed ageing, seed storage and regulation of storage life of seeds; methods to prolong seed viability; Conservation of orthodox and recalcitrant seeds. Seed vigour: concept, importance, measurement; Physiological, biochemical and molecular basis of seed vigour.

Practicals

- Determination of seed reserves: carbohydrates, proteins and lipids
- Study of different seed structures
- Kinetics of seed imbibition; Seed germination test, enzymatic activities and respiration during germination and vigour testing methods etc.
- Accelerated ageing test to know the seed vigour and storability
- Measurement of seed moisture content
- Determination of amylase activity in germinating seeds
- Measurement of electrical conductivity in seed leachate
- Measurement of seed viability using tetrazolium chloride
- Determination of dehydrogenase activity
- Seed germination study- Determination of Germination Index and seedling growth
- Measurement ofseed vigour index
- Dormancy breaking treatments

- Seed priming techniques
- Effect of environmental stresses on seed germination and seedling growth
- Effect of hormones on seed germination

Teaching methods/activities

–Lecture
–Assignment (Reading/Writing)
–Student presentation
–Practicals

Learning outcome

At the end of the course the students are expected to be able to understand the physiology of seed development and seed germination. The students will be able to identify the physiological processes involved in regulation of seed development, dormancy and germination.

References

- BEWLEY, JD, BRADFORDK, HILHORSTH, NONOGAKIH. (2013). *Seeds: Physiology of Development, Germination and Dormancy*, Springer - Verlag.
- LARKINS BA AND VASILIK (Ed), *Cellular and Molecular Biology of Plant Seed Development*, 2010, Springer.
- VANANGAMUDIK, NATARAJAN KAND VANANGAMUDI M*ETAL.* 2017. *Seed Physiology*. Associated Publishing Company.
- BEWLEY JD AND BLACK M.1994. *Seeds:Physiology of Development and Germination*, Springer
- PAMMENTER NW AND PATRICIABERJAK. 2000. *Aspects of recalcitrant seed physiology*. R. Bras.Fisiol.Veg.,12:56-69.
- PRAKASH.M.2011.*Seed physiology of crops*.(ed).Satish Serial Publishing house,NewDelhi.
- ROBERTOBENECH-ARNOLD, RODOLFOSANCHEZ. 2004. *Handbook of Seed Physiology: Applications to Agriculture*.CRCPress.

- VIJAYAKUMARA.2001. *Seed Dormancy an overview. In: Recent techniques and Participatory Approachs in Quality seed production* (eds.K.Vanangamudi*etal*.) TNAU, Coimbatore.287-396.
- PADMAVATHI SM, PRAKASH S, EZHILKUMAR G, SATHIANARAYANAN AND KAMARAJ A. 2012. *A Text Book of Seed Science and Technology*. New India Publishing Agency, New Delhi.
- TINASTEINBRECHERGERHARDLEUBNER-METZGER. 2017. *The biomechanics of seed germination***.** *Journal of Experimental Botany*, 68(4):765–783.
- http://sbc.ucdavis.edu/Research_pages/Seed_physiology_and_technology/.
- BENCH ALR AND SANCHEZ RA. 2004. *Handbook of Seed Physiology*. Food Product Press.

PPH 511 PHENO TYPING PHYSIOLOGICAL PROCESSES 2+0

Objectives

One of the main mandates of SAU and crop specific institutes is crop improvement.Seed industry and academic institutes need contribution from physiologists onthese aspects. Conceptual changes in breeding approaches in terms of breeding for specific physiological traits necessitates that the students develop conceptual approaches for phenotyping in different physiological processes. Characterizing the parents, germplasm accessions, segregating populations for specific physiological traits like flowering response, variation in root system architecture, etc is crucial for genetic enhancement of these traits. This student ready Course can contributerichly to research and development of the seed sectors and crop specific institutions where the major emphasis in recent years is genetic enhancement of traits.

Aim of the course

The major emphasis in this course is to phenotype well characterized physiological processes / plant traits associated with plant growth,

development and productivity, besides, comprehensive approach to precise imposition of various abiotic stresses and capture genetic variability inadaptivetraits. The aim is to employ these techniques for crop improvement programs.

No.	Blocks		Units
1.	Phenotyping Physiological Processes	1.	Concept of Phenotyping
		2.	Establishment Pheno typing for Traits for Crop
		3.	Concept and Approaches to Identify Genotypes with Superior Growth Rate
		4.	Identifying Photo-insensitive Genotypes- options and Approaches
		5.	Identifying Thermo-insensitive Genotypes- options and Approaches
		6.	Yield Structure Analysis-Relevant Yield Attributes
		7.	Source-sink Relationship-Assessment of Limitation

Theory

Block 1: Phenotyping Physiological Processes

Unit 1: Concept of Phenotyping

Pheno typing technologies are essential component for assessing plant responses, identify superior trait donors, mitigation responses, trait introgression and trait-based breeding.

Unit 2: Pheno typing for Traits for Crop Establishment

Seed viability, seed dormancy, seed hydration rates, seed density and weight, Seedling vigour in normal and adverse conditions.

Unit 3: Concept and Approaches to Identify Genotypes with Superior Growth Rate

Phenotyping for leaf expansion, leaf area index, light interception and crop extinction coefficient. Pigment quantification for nitrogen and chlorophyll status - SPAD, anthocyanin and flavonoids – Duolex. Growth

rates by non-invasive techniques like NDVI, Concept of Net assimilation rate and DM/LAD; surrogates for photosynthetic traits; stomatal characteristic.

Unit 4: Identifying Photo-insensitive Genotypes-options and Approaches Exposing to longer and shorter photoperiod by staggered sowing; extending the day length- light interception by red light; days to heading/ anthesis, approaches forsynchronization of flowering.

Unit 5: Identifying Thermo-insensitive Genotypes-options and Approaches Altering total degree days- staggered sowing at lower latitudes or by growth chambers; quantifying heading, anthesis, maturity and grain filling days, grainnumber and weight, grain filling rate.

Unit 6: Yield Structure Analysis- Relevant Yield Attributes

Pollen biology, stigma receptivity, spikelet sterility (cereals), floral abscission (other crops), fruiting points / productive tillers, number of grains/ fruits per panicle/ inflorescence and grain characteristic. Phenotyping for lodging- culm traits, intermodal length, lignification, Phenylalanine ammonia lyase (PAL) and Tyrosine ammonia lyase(TAL). Approaches to identify genetic resources with traits to improve yield potential.

Unit 7: Source-sink Relationship- Assessment of Limitation

Phenotyping for source-sink size, Concept of sink-source limitation-defloration and defoliation. Remobilization of stored metabolites and concept of stay green; estimation of water soluble carbohydrates; partitioning coefficient and harvest index.

Unit 8: Identify Genetic Resources for Abiotic Stress Constraints Approaches for precise stress imposition to diverse stresses, Identify trait donor lines for different stresses: approaches by Stress Susceptibility Index (SSI), StressInduction Response (SIR), Capturing variability for adaptive traits: root traits,Flowering response, Spikelet fertility, Abscission and Senescence, Screening high density response-based on SSI – root adaptation and Shade Avoidance Response (SAR).

Teaching methods/activities

- Lecture
- Assignment (Reading/Writing)

– Student presentation

Learning outcome

After completion of this course students are expected to develop clear concept and insight into phenotyping technologies associated with plant growth, development and productivity.

References

- KUMARJ, PRATAPA AND KUMARS. 2015. *Plant Phenomics: An Overview*.10.1007/978-81-322-2226-2_1.
- PRATAPA, GUPTAS, NAIRRM, GUPTASK, SCHAFLEITNERR, BASUPS, SINGHCM, PRAJAPATIU, GUPTAAK, NAYYARH, MISHRAAK, BAEKKH.2019. *Using Plant Phenomics to Exploitthe Gains of Genomics .Agronomy* 9,126.
- AOSA. 2009. *Seed Vigor Testing Handbook. Contribution No. 32 to the Hand book on Seed Testing*.
- FINCH-SAVAGE WE AND BASSELGW.2015. *Seed vigour and crop establishment: extending performance beyond adaptation*. *Journal of experimental botany*,*67*(3),567-591.
- MUÑOZ-HUERTAR, GUEVARA- GONZALEZR, CONTRERAS- MEDINAL, TORRES-PACHECOI, PRADO-OLIVAREZJ AND OCAMPO-VELAZQUEZR.2013. *Are view of methods for sensing the nitrogen status in plants: advantages, disadvantages and recent advances*. *sensors*,13(8),10823-10843.
- XUE, JANDSUB. 2017. *Significant Remote Sensing Vegetation Indices: A Review of Developments and Applications, Journal of Sensors*, 2017: 17 https://doi.org/10.1155 /2017/1353691.
- OUZOUNIS, T., ROSENQVIST, E., AND OTTOSEN, C., 2015. *Spectral Effects of Artificial Light on Plant Physiology and Secondary Metabolism: A Review American Society Horticulture Science*. 50(8); 1128–1135doi.org/10.21273/HORTSCI.50.8.1128
- *The Flowering Response of the Rice Plantto Photoperiod: A Review of The Literature* Fourth Edition.
- SEHGAL A, SITA K, SIDDIQUE K H ,KUMAR R, BHOGIREDDY S, VARSHNEY R K AND NAYYAR H. 2018.

Droughtor/andHeat-Stress Effectson Seed Filling in Food Crops: Impactson Functional Biochemistry, Seed Yields, and Nutritional Quality. Frontiersin Plant Science, 9.

- PRASAD, P.V.,BHEEMANAHALLI, R.,AND JAGADISH, S.K. 2017. *Field crops and the fear of heat stress — Opportunities, challenges and future directions*. *Field Crops Research* 200, 114-121.
- GÓMEZJF, TALLEB AND WILSONZA.2015. Another and pollend evelopment: acon served developmental pathway. *Journal of Integrative Plant Biology* 57(11), 876-891.
- KHOBRAR, SAREENS, MEENABK, KUMARA,TIWARI VAND SINGH GP.2019. *Exploringthetraits for lodging tolerance in wheat genotypes: A review*. *Physiology and Molecular Biology of Plants*, 1-12.
- HIRANO K, ORDONIO RL AND MATSUOKA M. 2017. *Engineering the lodging resistance mechanism of post-Green Revolution rice to meet future demands*. *Proceedings of the Japan Academy,SeriesB*, 93(4),220-233.
- WHITE, A.C., ROGERS, A., REES, M AND OSBORNE, C.P., 2016. *How can we make plants growfaster? A source–sink perspective on growth rate Journal of Experimental Botany*, 67(1): 31–45.
- RAGHEBA,A., EL-SHIMYB, HANDRAGHEBB, G.2016. *Green architecture: a concept of sustainability, Procedia – Social and Behavioral Sciences* 216:778–787. *controlling early shade avoidance response inmaize seedlings*, *BMC Genomics* **17**:269, https://doi.org/ 10.1186/s12864-016-2593-6
- CARRIEDO, L., MALOOF, J AND BRADY, S. 2016. *Molecular control of crop shade avoidance. Current Opinion in Plant Biology*. 30.151-158.10.1016 / j.pbi.2016.03.005.

PPH 512 CROP GROWTH REGULATION AND MANAGEMENT 2+0

Objectives

Besides crop improvement, the approach to regulate physiological processes for improving crop production made very good leads in recent years. The focus is to employ the basic knowledge of several physiological processes to manipulate the plant growth and specific processes like ripening, flowering to achieve higher economic yields. This dynamic course will address many of these technologies that are being developed for crop production based on principles of plant physiological processes. Training the students in this student ready coursewill provide the required practical knowledge which will be of immense relevance to contribute private agricultural sectors and foragri-based industries.

Aim of the Course

A comprehensive information needs to be provided in this course like light regulation in polyhouse cultivation, photoperiod responses by red/far red light for synchronizing flowering, techniques for soil less culture like aeroponics, pollen biology and hybrid production, chemical regulation of plant growth processes like flower initiation, flowersex, flower drop, fruit maturity, ripening and shelf-life, etc.

The course is organized as follows

No.	Blocks		Units
1	Propagation - Crop Establishment	1.	Seed as a Propogule
		2.	Vegetative Propogule
2	Regulation of Plant Growth Processes	1.	Regulation of Plant Growth and Flowering
		2.	Fruit Ripening and its Regulation
		3.	Concept of Senescence and its Retardation
3	Protective Cultivation– Stress Mitigation	1.	Protective Cultivation Interventions to Alter
		2.	Physiological Processes and Growth Drought Mitigation Options and Approaches
		3.	Specific Plant Processes Regulated by Chemicals and Growth Hormones

Theory

Block 1: Propagation - Crop Establishment

Unit 1: Seed as a Propogule

Concept of improving seed characteristics for crop establishment. Mechanisms of regulating seed dormancy, precocious germination, ways to control pre-harvest sprouting in crop plants. Seed viability and its regulation, factors to minimize loss of viability and improve seedling vigour. Concept of seed priming, techniques ofPGPR's on seedling vigour and subsequent crop establishment.

Unit 2: Vegetative Propogule

Chemical and hormonal regulation of vegetative propagation. Regulation of rooting, bud sprouting, Bulb/tuber dormancy. Chemical regulation of graft union. Concept of *in vitro* micropropogation.

Block 2: Regulation of Plant Growth Processes

Unit 1: Regulation of Plant Growth and Flowering

Chemical and hormonal regulation of plant architecture, tillering, branching, bud breaking, Regulation of flowering by photo and thermoperiod, nutrients, chemicals and hormones, concept of speed

breeding, Flowering synchrony in hybrid seed production, Sex ratio alteration, flower and fruit thinning, Pollen viability in relation to environment, harvesting, storage and transportation, Prevention of abscission, flower and fruit drop, seed and fruit growth regulation- role of hormones.

Unit 2: Fruit Ripening and its Regulation

Approaches to improve shelf life – storage environment, water loss, respiration, Modified atmosphere, gaseous environment for storage, storage disorders, chilling injury.

Unit 3: Concept of Senescence and its Retardation

Physiology of senescence and options to regulate, Chemical regulation of senescence, maintenance of chlorophyll during storage, role of hormones/micronutrients in reducing senescence, Concept of stay green, advantages and limitations. Relevance of stay green traits in plant breeding for crop improvement.

Block 3: Protective Cultivation–Stress Mitigation

Unit 1: Protective Cultivation Interventions to Alter Physiological Processes and Growth

Spectral characteristics of light in polyhouse, light regulation to optimize plant photosynthetic and photomorphogenic processes and plant growth, LED sources of monochromatic light to regulate growth, etiolating and flowering, High temperature induced thermos-morphogenic processes, Artificial growing media, soilless cultures,aeroponics, fogoponics, Concept of CO_2 fertilization. Effect of humidity on leaf expansion and growth.

Unit 2: Drought Mitigation Options and Approaches

Moisture conservation options at soil and plant level, Concept of increasing water holding capacity, role of Hydrogels – water and mineral nutrients release pattern. Approaches to improve transpiration over evapo-transpiration, stomatal and non- stomatal regulation of water loss, antitranspirants, Osmoprotectants, ROS scavengers, plant nutrients, Root stocks in improving tolerance, Chemical regulation of flower drop due

to temperature, Chemicals to improve pollen viability during abiotic stress.

Unit 3: Specific Plant Processes Regulated by Chemicals and Growth Hormones

Rooting of cuttings, Wine brewing industry, Promotion of gynoecious flower, Hybrid rice production, Induction of flowering in pine apple, cucurbits, Delaying ofReduction in flower and fruit drop, Increase in berry size in grapes.

Teaching methods/activities

- Lecture
- Assignment (Reading/Writing)
- Student presentation

References

- WU X, NING F, HU X AND WANG W. 2017. *Genetic Modification for Improving Seed Vigor Is Transitioning from Model Plants to Crop Plants. Front.PlantSci*.8:8 .doi:10.3389/fpls. 2017.00008
- WILLIAME.FINCH-SAVAGE AND STEVEN FOOTITT. 2017. *Seed dormancy cycling and the regulation of dormancy mechanisms to time germination in variable field environments Journal of Experimental Botany*,68, (4), 843856, https://doi.org/10.1093/jxb/erw477
- AFZALI, URREHMANH, NAVEEDM AND SHAHZADMAQSOOD, BASRAA.2016. *Recent Advances in Seed Enhancements* Intech.
- *Techniques and Experiments Plant Tissue Culture Techniques and Experiments* ElsevierInc. 2013.
- NANDA AK AND MELNYK CW. 2018. *The role of plant hormones during grafting*. *Plant Res*.131(1):49–58.doi:10.1007 /s10265-017-0994-5PMCID: PMC 57 62790
- CASA JJ AND BALASUBRAMANIAN. SK2019. *The rmomor phogenesis, Annual Review of Plant Biology*,70:321-346https://doi.org/10.1146/annurev-arplant- 050718-095919

- HALEVY AH.2018. *Handbook of Flowering*. V*CRCpress*
- WATSON A, GHOSHS, LEET. HICKEY. 2018. *Speed breeding is a powerful tool to accelerate crop research hand breeding*. *NaturePlants* 4,23–29.
- KUSUMANINGRUM D, LEESH, LEEWH, MOC., AND CHO, B.K.2015. *Are view of technologies to prolong the shelf life of fresh tropical fruits in Southeast Asia. Journal of Biosystems Engineering* 40(4), 345-358.
- SANDARANI, MDJC, DASANAYAKA DCMCK AND JAYASINGHE CVL. 2018. *Strategies Used to Prolong the Shelf Life of Fresh Commodities. J Agri Sci Food Res*9:206.
- FALAGÁN, N AND TERRY LA. 2018. *Recent advances in controlled and modified atmosphere of fresh produce. Johnson Mat they Technology Review* 62(1), 107-117.
- KIM,J., KIM,J. H., LYU,J.I., WOO, H.R., AND LIM, P.O. 2017. *New insights in to the regulation of leaf senescence in Arabidopsis*. *Journal of experimental botany* 69(4), 787-799.
- LUCHE, H.D.S., SILVA, J.A.G.D., MAIA, L.C.D., AND OLIVEIRA, A.C.D. 2015. *Stay-green: apotentiality in plant breeding*. *Ciência Rural*, *45*(10), 1755-1760.
- BIAN, Z., JIANG, N., GRUNDY, S. AND LU, C., 2017.*Uncovering LED light effects onplant growth: new angles and perspectives-LED light for improving plant growth, nutrition andenergy-use efficiency*. In *International Symposium on New Technologies for Environment Control, Energy-Saving and Crop Production in Green house and Plant*1227.491-498.
- BARRETT, G.E., ALEXANDER, P.D., ROBINSON, J.S AND BRAGG, N.C., 2016. *Achieving environmentally sustainable growing media for soilless plant cultivation systems–A review*. *Scientia horticulturae*, 212:220-234.
- RAVIV, M., LIETH, J.H. AND BAR - TAL, A. (EDS), 2019. *Soilless Culture: Theory and Practice: Theory and Practice*. Elsevier.

- WANG, P.,DENG, Y., LI, X.Y., WEI, Z., HU, X., TIAN, F., WU, X., HUANG,Y., MA, Y.J., ZHANG,C.AND WANG,Y.2019. *Dynamical effects of plastic mulch one vapo transpiration partitioning in a mulched agriculture ecosystem: Measurement with numerical modeling. Agricultural and Forest Meteorology*, 268:98-108.
- GERNOT BODNER, ALIREZA, HANS- PETER *Management of crop water under drought: A review. Agronomy for sustainable development*.2:401-442

M.Sc. (Agri.) in Seed Science and Technology

Course Code	Course Title	Credit Hours
SST 501	Seed Developmental Biology	2 (1+1)
SST 502	Seed Dormancy and Germination	2 (1+1)
SST 503	Seed Production Principles and Techniques in Field Crops	3 (2+1)
SST 504	Seed Production Principles and Techniques in Vegetable Crops	3 (2+1)
SST 505	Seed Production Techniques in Fruits, Flowers, Spices, Plantation and Medicinal Crops	3 (2+1)
SST 506	Seed production Techniques in Forage, Pasture and Green Manure Crops	2 (1+1)
SST 507	Seed Legislation and Certification	3 (2+1)
SST 508	Post-Harvest Handling and Storage of Seeds	3 (2+1)
SST 509	Seed Quality Testing and Enhancement	2 (1+1)
SST 510	Seed Technology of Tree Species	2 (1+1)
SST 511	Seed Industry and Marketing Management	2 (1+1)
SST 512	Seed Health Testing and Management	2 (1+1)
SST 515	Germplasm Collection, Exchange and Quarantine	2 (1+1)
	Total	**31(19+12)**
SST 580	Qualifying Examination	2(0+2)
SST 581	Seminar - I	1 (0+1)
SST 582	Seminar - II	1 (0+1)
SST 591	Research - I	13 (0+13)
SST 592	Research - II	14 (0+14)

SST 501 SEED DEVELOPMENTAL BIOLOGY (1+1)

Objective

To acquire knowledge on development and maturation of essential structures of seed and their influence on seed quality.

Theory

Block-I: Floral biology

Unit 1: Floral biology - Types of pollination, mechanisms; sporogenesis - micro and mega sporogenesis; gametogenesis - development of male and female gametes and their structures; pollination and fertilization - mode of pollination, double fertilization, factors affecting pollination, fertilization; self-incompatibility and male sterility.

Unit 2: Embryogenesis - Development of monocot and dicot embryos - embryo plane formation - development of endosperm, cotyledons and seed coat - hard seed; apomixis - identification, classification, significance and its utilization; poly-embryony - types and significance; haplontic and diplontic sterility system, causes of embryo abortion, embryo rescue technique; somatic embryogenesis.

Block-2 : Seed development

Unit 1: Seed Development - Source of assimilates - mechanism of translocation; chemical composition - synthesis and deposition of storage reserves - starch, protein, fat and secondary metabolites - hormonal regulation.

Unit 2: Maturation drying - orthodox and recalcitrant seeds - desiccation tolerance - mechanism - structural changes during desiccation - role of LEA protein.

Block –3: Seed maturation

Unit 1: Seed maturity indices - physiological and harvestable maturity; biotic and abiotic factors influencing seed development - development of hard seeds.

Practicals

- Study on floral biology of monocot
- Study on floral biology of dicot plants
- Study on pollen morphology of different crops
- Pollen germination and viability test in major crops
- Seed embryo and endosperm development in monocots

- Seed embryo and cotyledon development in dicots
- Anatomy and morphology of seed coat during development
- Hard seed coat development
- Study on external and internal structures
- Seed development and maturation in agricultural crops - physical and physiological changes
- Seed development and maturation in horticultural crops - physical and physiological changes
- Study of biochemical changes during seed development and maturation in agricultural crops
- Study of biochemical changes during seed development and maturation in horticultural crops
- Study on physiological and harvestable maturity and maturity indices in different crops
- Study on acquisition of seed dormancy and germination at different stages of maturity
- Preparation of seed album and identification of seeds

References

- ADKINS, S. W., ASHMORE, S. E. AND NAVI, S. C., 2007, *Seeds: Biology, Development and Ecology*. CAB International, Oxford shire, UK.
- BEWLEY, J. D. AND BLACK, M., 1994, *Seeds: Physiology of Development and Germination*. Springer, NewYork.
- BLACK, M., BEWLEY, J. D. AND HALMER, P., 2006, *The Encyclopedia of Seeds: Science, Technology and Uses*. CAB International publications,UK.
- CHHABRA, A. K., 2006, *Practical Manual of Floral Biology of Crop Plants*. Department of Plant Breeding, CCSHAU, Hisar.
- COPELAND, L. O. AND MC DONALD, M. B., 2001, *Principles of Seed Science and Technology*. 4thEd. Kluwer Academic publishers, USA.

- FRANKEL, R. AND GALUN, E., 1977, *Pollination Mechanisms, Reproduction and Plant Breeding*. Springer Verlag, NewYork.
- HESSE, M. H., HAIDEMARIE, R., ZETTLER, M., WEBBER, R., BUCHNER, A. R., RADIVO AND ULRICH, S., 2009, *Pollen Terminology. Anillustratedh and book*. Springer Verlag, NewYork.

SST 502 SEED DORMANCY AND GERMINATION (1+1)

Objective

To impart knowledge on significance, mechanism of dormancy, induction and release of seed dormancy and germination, types and factors influencing germination and their management.

Theory

Block-1: Seed dormancy

Unit 1: Seed Dormancy - Definition, concept and theories - significance - evolution; classification and mechanism of dormancy - ecological significance.

Unit 2: Induction of dormancy during development - hormonal, physiological, molecular and genetic control of dormancy - maternal and paternal contribution; environmental factors influencing dormancy induction and release - seasonal influence - winter and summer annuals - secondary dormancy induction mechanism; artificial induction of dormancy and release; soil seed bank - natural release of dormancy and its mechanism; dormancy breaking - principles and methods.

Block 2 : Seed germination

Unit 1: Seed germination - types and phases of germination; imbibition - pattern and water kinetics - events of germination - physical, physiological, biochemical changes -aerobic and anaerobic respiration quiescent.

Unit 2: Physiological and biochemical changes, enzyme activation - mechanism - factors affecting enzyme activation - breakdown of stored materials - starch, protein and fat - energy generation - mobilization of storage reserves - changes in phenolic compounds.

Block 3 :Molecular and genetic control of seed germination

Unit 1: Molecular and genetic mechanisms, molecular and genetic control of seed germination - auto tropism; factors affecting germination - media - temperature - light - gases; in-situ and viviparous germination - causes and mechanism - pattern of seed germination - tri-phasic curve.

Practicals

- Seed dormancy - identification of dormancy
- Estimation of ABA and GA in dormant and non-dormant seeds
- Study on artificial induction of dormancy
- Dormancy breaking methods - scarification and stratification
- Dormancy breaking methods - hormonal and chemical treatments
- Dormancy breaking methods - after ripening and leaching of inhibitors
- Dormancy breaking methods - combined treatments
- Assessing the period of natural release of seed dormancy
- Seed germination - studying the pattern of imbibition
- Studying the pattern of seed germination in different media
- Study on influence of light and temperature on germination and seedling development
- Estimation of hydrolytic enzyme - á amylase in different species
- Estimation of hydrolytic enzyme - protease
- Estimation of hydrolytic enzyme - lipase
- Estimation of dehydrogenase enzyme and respiratory quotient in seeds
- Estimation of food reserve composition during seed germination

References

- BASKIN, C. AND BASKIN, J. M., 2014, *Seeds: Ecology, Biogeography, and Evolution of Dormancy and Germination*. Academic Press, Cambridge, UK.

- BEWLEY, J. AND BLACK, M., 1994, *Physiology of Development and Germination*. Springer, New York. BewleyJD, BradfordKJ, Hilhorst HWM and NanogakiH. 2013. *Seeds: Physiology of Development, Germination and Dormancy*. Springer, NewYork.
- BEWLEY, J. D. AND BLACK, M., 1982, *Physiology and Biochemistry of Seeds in Relation to Germination*. Volume2: Viability, Dormancy and Environmental Control. Springerlink, New York, USA
- BLACK, M. AND BEWLEY, J. D., 2000, *Seed Technology and its Biological Basis*. CRC Press. Florida, USA.
- BRADBEER, J. W.,1988, *Seed Dormancy and Germination*. Chapmanand Hall, NewYork, USA. DavidR. Murray. 1985.*Seed Physiology*. Vol.2: Germination and Reserve Mobilisation.
- Academic Press, London, UK.
- HEYDECKER, W., 1985, *Seed Ecology*. Pennsylvania State University Press,USA.
- KHAN, A. A., 1977, *The Physiology and Biochemistry of Seed Dormancy and Germination*. North–Holland Publishing Company, USA.
- KOZLOWSKI, T. T., 2012, *Seed Biology: Importance, Development and Germination*. (Vol.I). Academic PressInc., NewYork.
- MAITI, R. K., SARKAR, N. C. AND SINGH, V. P., 2012, *Principles of Post Harvest Seed Physiology and Technology*. Agrobios, Jodhpur.
- MAITI, R. K., SARKAR, N. C. AND SINGH, V. P., 2006, *Principles of Post Harvest Seed Physiology and Technology*. Agrobios, Jodhpur, Rajasthan.
- MAYER, A. M. AND MAYBER, A. P., 1963, *Germination of Seeds*. Pergamon Press, Oxford, NewYork**.** PrakashM. 2011. *Seed Physiology of Crops*. Satish Serial Publishing house. Azadpur. New Delhi.
- ROBERTS, E. H., 1972, *Viability of Seeds*. Springerlink, NewYork, USA**.**

SST 503 SEED PRODUCTION PRINCIPLES AND TECHNIQUES IN FIELD CROPS (2+1)

Objective

To impart knowledge on principles and practices involved in quality seed production of field crops.

Theory

Block-1 : Importance of seed

Unit1: Importance of Seed - Seed quality concept - factors influencing seed production; generation system of seed multiplication - classes of seed, stages of seed multiplication in varieties and hybrids - seed multiplication ratio (SMR) - seed replacement rate (SRR) - seed renewal period (SRP) - varietal replacement rate (VRR).

Block-2 : Seed production principles

Unit 1: Genetic and agronomic principles of variety and hybrid seed production; methods and techniques of seed production in varieties and hybrids of important cereals and millets - wheat, oat, rice, maize, sorghum and pearl millet; varietal seed production in small millets - finger millet, fox tail millet, little millet, kodo millet, proso millet and barnyard millet.

Unit 2: Methods and techniques of varietal seed production in major pulses - black gram, green gram, cowpea, chickpea, horse gram, soybean and lentil - varietal and hybrid seed production in red gram.

Block- 3 :Methods and techniques of seed production

Unit 1: Methods and techniques of seed production in major oil seed crops - groundnut, sesame - varietal and hybrid seed production in sunflower, castor and mustard; varietal seed production in minor oilseed crops (safflower, linseed, niger) - varietal and hybrid seed production in cotton - varietal seed production in jute.

Unit 2: Seed production planning for varieties and hybrids of major crops; participatory seed production - seed hubs, seed village concept and community seed bank.

Practicals

- Seed selection - quality of seed on field establishment
- Sowing and nursery management techniques
- Planting - age of seedling on crop establishment - rice and pearl millet
- Isolation distance and border rows in hybrid seed production field - space and barrier isolation; modifying isolation based on border rows in maize
- Planting design for hybrid seed production - rice, maize, pearl millet, cotton, red gram, sunflower
- Practicing breeding tools for hybrid seed production - detasseling - emasculation and dusting
- Study on methods of achieving synchronization - rice, bajra, sunflower
- Practicing supplementary pollination - rice and sunflower
- Study on foliar nutrition and influence on seed yield
- Practicing roguing operation - identification of off-types, pollen shedders, shedding tassels, partials, selfed bolls
- Pre and post-harvest sanitation operations - cereals, millets and pulses
- Estimation of shattering and shattering loss; study on insitu germination and loss
- Visit to seed production fields
- Visit to seed industry
- Seed production planning and economics of seed production - varieties
- Seed production planning and economics of seed production - hybrids

References

- AGRAWAL, R. L., 2019, *Seed Technology*. Oxford & IBH Publishing Company Pvt. Ltd., New Delhi. HebblethwaitePD. 1980. *Seed Production*. Butter worth Heinemann Ltd., London,UK.

- JOSHI, A. K. AND SINGH, B. D., 2004, *Seed Science and Technology*. Kalyani Publishers, NewDelhi. Kulkarni GN. 2011. *Principles of Seed Technology*. Kalyani Publishers, New Delhi.
- MAITI, R. K., SARKAR, N. C. AND SINGH, V. P., 2006, *Principles of Post Harvest Seed Physiology and Technology*. Agrobios, Jodhpur, Rajasthan.
- MC DONALD, M. B. AND COPEL. L., 1998, *Seed Production Principles and Practices*. CBS Publishers, New Delhi.
- MONDAL, S. S., SAHA, M. AND SENGUPTA, K., 2009, *Seed Production of Field Crops*. New India Publishing Agency, New Delhi.
- SINGHAL, N. C., 2003, *Hybrid Seed Production in Field Crops*. Kalyani Publications, NewDelhi. SenS and GhoshN. 2010. *Seed Science and Technology*. Kalyani Publishers, New Delhi.
- SINGHAL, N. C., 2010, *Seed Science and Technology*. Kalyani Publishers, New Delhi.

SST 504 SEED PRODUCTION PRINCIPLES AND TECHNIQUES IN VEGETABLE CROPS (2+1)

Objective

To impart knowledge on principles and practices involved in quality seed production of vegetable crops.

Theory

Block-1 : Factors influencing the vegetable seed production

Unit 1: Importance and present status of vegetable seed industry - factors influencing vegetable seed production; varietal and hybrid seed production techniques in major solanaceous vegetable crops - tomato, brinjal, chilli; malvaceous vegetable crop - seed production techniques of bhendi.

Block–2 : Seed production in cucurbits, gourds, melons, cole cropsand leguminous vegetables

Unit 1: Varietal and hybrid seed production techniques in important cucurbitaceous vegetables - gourds and melons, cole crops - cauliflower, cabbage, knol-khol, root vegetables - carrot, beetroot, turnip, radish and other temperate / hilly vegetable crops.

Unit 2: Varietal seed production techniques in major leguminous vegetables - peas and beans; seed production techniques in leafy vegetables - amaranthus, palak, spinach, and lettuce.

Block-3: Seed production techniques in tuber crops

Unit 1: Seed production techniques in tuber crops - potato, sweet potato, colocasia, tapioca and yam, seed-plot technique in potato - true potato seed (TPS) production techniques - seed production techniques in bulb crops - onion, garlic.

Unit 2: Vegetative and clonal multiplication - methods, merits and demerits; clonal multiplication - potato, sweet potato, colocasia, tapioca and yam.

Practicals

- Identification of vegetable seeds
- Study on sowing and nursery management
- Study on transplanting and age of seedling on crop establishment
- Studying floral biology of solanceous, malvaceous and cucurbitaceous vegetable crops
- Studying floral biology of other vegetable crops
- Practicing planting design for hybrid seed production
- Modification of sex ratio in cucurbits
- Practicing emasculation and pollination methods
- Practicing roguing operations - identification of off-types - selfed fruits
- Harvesting methods - single and multiple harvesting method

- Practicing seed extraction methods - wet methods - tomato, brinjal, other cucurbitaceous fruits
- Seed extraction - dry methods - chillies, bhendi, cucurbitaceous
- Visit to seed production fields
- Visit to private seed industry
- Planning and economics of varietal seed production
- Planning and economics of hybrid seed production

References

- AGARWAL, R. L., 2012, *Seed Technology*. Oxford & IBH Publishing Company Pvt. Ltd., NewDelhi. ChadhaKL. 1995. *Advances in Horticulture*. Volume 1to13. Malhothra Publishing House, New Delhi.
- GEORGE, R. A. T., 1985, *Vegetable Seed Production*. LonhmanInc., NewYork. Hebblethwaite PD. 1980. *Seed Production*. Butterworth Heinemann Ltd, London, UK. KulkarniGN. 2011. *Principles of Seed Technology*. Kalyani Publishers, NewDelhi.
- MAITI, R. K., SARKAR, N. C. AND SINGH, V. P., 2006, *Principles of Post Harvest Seed Physiology and Technology*. Agrobios, Jodhpur, Rajasthan.
- MC DONALD, M. B. AND COPELAND, L., 1998, *Seed Production: Principles and Practices*. CBS Publishers, NewDelhi.
- SEN, S. AND GHOSH, N., 2010, Seed Science and Technology. Kalyani Publishers, New Delhi. SinghalNC. 2010. *Seed Science and Technology*. Kalyani Publishers, New Delhi.
- VANANGAMUDI, K., NATARAJAN, N., SRIMATHI, P., NATARAJAN, K., SARAVANAN, T., BHASKARAN, M., BHARATHI, A., NATESAN, P. AND MALARKODI, K., 2006, *Advances in Seed Science and Technology*. Vol. 2. *Quality Seed Production in Vegetables*. Agrobios, Jodhpur.

SST 505 SEED PRODUCTION TECHNIQUES IN FRUITS, FLOWERS, SPICES, PLANTATION AND MEDICINAL CROPS (2+1)

Objective

To impart comprehensive knowledge on seed production techniques in fruits, flowers, spices, plantation and medicinal crops.

Theory

Block–1: Scope for seed production in fruits, flowers, spices, plantation and medicinal crops

Unit 1: Scope for seed production in fruits, flowers, spices, plantation and medicinal crops; factors influencing seed production and quality; propagation methods - seed and clonal propagation; seed and seedling standards; propagation and seed production techniques in major tropical, sub-tropical and temperate fruit crops; seed orchards - seed collection, extraction processing and storage techniques.

Block –2 :Seed production in flower crop

Unit 1: Seed production techniques in commercially important flower crops - nursery management, clonal propagation, planting, seed crop management, post-harvest seed handling and storage techniques.

Unit 2: Seed production techniques in commercially important seed spices and other spices - nursery management, sowing, seed crop management and post-harvest seed handling and storage techniques.

Block –3 :Seed production in plantation crop

Unit 1: Seed production in commercially important plantation crops - mother tree selection - criteria - nursery management, elite seedling production, planting, plantation management, post-harvest handling and storage techniques.

Unit 2: Methods of quality seed production in commercially important medicinal plants - nursery management, sowing, seed crop management, post-harvest handling and storage methods.

Practicals

- Study on the floral biology and pollination mechanism
- Identification of seeds of fruits, flowers, spices, plantation and medicinal crops
- Selection of mother plants and trees - phenotypic characters and genotypic characters
- Study on different types of clonal and vegetative propagules
- Seed and clonal standards of vegetatively propagating crops
- Germination improvement treatments for seeds and vegetative propagules
- Study on selection of planting materials and sowing methods
- Nursery management practices for elite seedling production
- Seed extraction methods - wet method and dry method
- Post harvest seed handling - seed grading, upgrading techniques
- Study of seed storage techniques
- Practicing seed germination enhancement techniques in fruits, spices and plantation crops
- Practicing seed germination enhancement techniques in flowers and medicinal crops
- Planning for seed production - economics of seed production in flower crops
- Visit to mother tree orchard
- Visit to plantation and orchard

References

- CHADHA, K. L., 1995, *Advances in Horticulture*. (Volume1to13). Malhotra Publishing House, NewDelhi.
- HARTMAN, H. T. AND KESTER, D. E., 2000, *Plant Propagation: Principles and Practices*. Prentice Hall, New Jersey, USA.
- SINGH, S. P., 2001, *Seed Production of Commercial Vegetables*. Agrotech, NewDelhi.

- VANANGAMUDI, K. AND NATARAJAN, K., 2008, *Advances in Seed Science and Technology. Quality Seed Production in Spices, Plantation, Medicinal and Aromatic crops* (Vol.5). Agrobios. Jodhpur.
- VANANGAMUDI K. M. PRABU. AND LAKSHMI, S., 2012, *Advances in Seed Science and Technology Vol. Flower Seed Production*. Agrobios, Jodhpur.

SST 506 SEED PRODUCTION TECHNIQUES IN FORAGE, PASTURE AND GREEN MANURE CROPS (1+1)

Objective

To impart knowledge on basic principles and methods of quality seed production in forage and green manure crops.

Theory

Block 1: :Scope and importance of seed production in forage, pasture and green manure crops

Unit 1: Scope and importance of seed production in forage, pasture and green manure crops - factors influencing seed production - seasonal influence; problems and constraints in seed production - seed set, shattering and seed dormancy; vegetative and clonal propagules and apomictic seed.

Unit 2: Quality seed production techniques in major fodder crops - lucerne, hedge lucerne, leucaena, fodder sorghum, fodder maize and oats.

Block –2 :Seed production techniques of forage grasses

Unit 1: Seed and planting material production techniques of major forage grasses - bajranapier grass, guinea grass, deenanath grass and *Cenchrus*sp.; forage legumes *Stylosanthus*, cowpea and berseem.

Block-3: Seed production techniques of green manure crops

Unit 1: Seed production techniques in major green manure crops - *Glyricidia, Sesbania* sp., sunhemp, daincha, jute and *Tephrosia* sp.

Unit 2: Post-harvest seed handling - processing, threshing, grading and upgrading; dormancy breaking and germination improvement - quality standards for seed and vegetative propagules.

Practicals

- Seed collection and identification of seeds
- Estimation of seed setting and shattering loss
- Maturity indices - determination of physiological and harvestable maturity
- Seed extraction and threshing methods
- Separation of ill filled seeds - practicing different methods
- Study of seed and clonal materials - standards
- Quality of planting material and vegetative propagules on crop establishment
- Seed quality analysis in forage and fodder crops - tiller wise quality analysis
- Seed quality analysis in determinate and indeterminate crops
- Study on effect of ratooning on seed quality
- Practicing seed quality enhancement techniques
- Practicing different seed extraction and dormancy breaking treatments
- Preparation of vegetative propagules and planting
- Planning for seed production in fodder and green manure crops
- Economics of seed production in fodder, forage crops and green manure crops

References

- FAO., 2007, *Quality Declared Seed System*. FAO Plant Production and Protection Publication, FAO, Rome.
- FARITY, D. T. AND HAMPTON, J. C., 1997, *Forage Seed Production*. Vol.I. *Temperate Species*. CAB International Publications.UK.

- FROMA, J., 1997, *Temperate Forage Legumes*. CAB International Publications. UK. Gutterridge RG. 1997. *Forage Tree Legumes in Tropical Agriculture*. CAB International Publications, UK.
- MASILAMANI, S. AND SIVASUBRAMANIAN, K., 2016, *Seed Production in Green Manures*. Kalyani Publications, New Delhi.

SST 507 SEED LEGISLATION AND CERTIFICATION (2+1)

Objective

To impart knowledge on seed legislation in relation to seed certification and quality control systems.

Block–1: Genesis of seed quality control

Unit 1: Genesis of seed Industry in India; seed quality control - concept and objectives; regulatory mechanisms - Seed Act (1966) - Seed Rules (1968) - statutory bodies - Central Seed Committee - Central Seed Certification Board.

Unit 2: Seed Control Order (1983) - New Policy on Seed Development (1988) - Exim Policy - National Seed Policy (2002) - Plant Quarantine Act.

Unit 3: Introduction to WTO and IPR - UPOV and its role - OECD seed certification schemes - PPV & FR Act (2001) and Rules (2003) - Seed Bill (2004 and 2011): Seed certification system in SAARC countries, Europe, Canada, Australia and USA.

Block –2 :Seed certification

Unit 1: Seed certification - history and objectives; general and specific crop standards, field and seed standards; seed certification agency - role of certification agency / department and seed certification officers, phases of seed certification; field inspection - counting procedures - liable for rejection (LFR) - downgrading and partial rejection - reporting.

Block –3: Post harvest handling

Unit 1: Post-harvest inspection - construction of seed lot number; seed sampling - testing - labeling, sealing and grant of certificate - types and specifications for tags and labels; seed lot validity and revalidation; appellate authority, stop sale order, penalties records and registers to be

maintained by seed processing units and seed dealers - verification procedures, role of seed analyst and seed inspector in quality regulation.

Practicals

- Preparation of sowing report - varieties - transplanted and direct sown crops and hybrids
- Verification of sowing report - seed certification procedures
- Field inspection - estimation of area and isolation distance, stages of inspection for varieties and hybrids - procedures
- Practicing field counting procedures - methods for row planting, broadcasted - varieties
- Practicing field counting procedures - direct sown and transplanted crops - varieties
- Study on field counting procedures - hybrids - planting design, planting ratio and block method and double count
- Identification of contaminants - genetic and physical contaminants, procedure to remove partials, pollen shedders and shedding tassels
- Assessing and calculation of field standards for important crops
- LFR, partial rejection and downgrading - reasons, procedures and preparation of reports
- Yield estimation - single and multiple harvest crops
- Post harvest inspection - groundnut, cotton, pulses

References

- AGARWAL, R. L., 2012, *Seed Technology*. Oxford & IBH Publishing Company Pvt. Ltd., New Delhi. Anon. 2016. *Manual of Seed Certification Procedures*. Directorate of Seed Certification, Coimbatore, Tamil Nadu.
- CHAKRABARTHI, S. K., 2010, *Seed Production and Quality Control*. Kalyani Publishers, New Delhi. MishraDK, KhareD, BhaleMS and Koutu GK.2011. *Handbook of Seed Certification*. Agrobios, Jodhpur, Rajasthan.

- NEEMA, N. P., 1986, *Principles of Seed Certification and Testing*. Allied Publishers, New Delhi Ramamoorthy K, Sivasubramaniam K and KannanM. 2006. *Seed Legislation in India*. Agrobios, Jodhpur, Rajasthan.
- RENUGADEVI, J., SRIMATHI, P., RENGANAYAKI, P. R. AND MANONMANI, V., 2012, *A Handbook of Seed Testing*. Agrobios, Jodhpur, Rajasthan.
- SHARMA, P., 2008, *Seed Legislation*. Gene-tech Book Publishers, NewDelhi.
- TRIVEDI, P. C., 2011, *Seed Technology and Quality Control*. Pointer Publications, Jaipur, Rajasthan. Tunwar NS and SinghSV. 2003. *Indian Minimum Seed Certification Standards*. Central Seed Certification Board, Ministry of Agriculture, GOI, New Delhi.

SST 508 POST HARVEST HANDLING AND STORAGE OF SEEDS (2+1)

Objective

To impart knowledge on principles, techniques and methods of seed processing, treatment and storage.

Theory

Block –1 :Seed processing

Unit 1: Seed processing - objectives and principles; processing sequence - threshing, shelling, ginning, extraction methods; drying - principles and methods; seed cleaning, grading, upgrading - methods - machineries and equipment - scalper, pre-cleaner, cleaner cum grader, specific gravity separator, indented cylinder, disc separator, spiral separator, velvet separator, magnetic separator, electronic colour sorter - working principles and functions.

Unit 2: Online seed processing - elevators and conveyers - processing plant - specifications, design and layout; mechanical injury - causes and detection - management.

Block-2 : Seed treatment

Unit 1: Seed treatment - methods - pre and mid storage seed treatments, seed treating formulations and equipments; packaging materials - types - bagging and labeling; seed blending - principle and methods.

Unit 2: Seed storage - purpose and importance - factors affecting storage, optimum condition for storage of different seeds; storage principles - Harrington's thumb rule - concepts and significance of moisture equilibrium - maintenance of safe seed moisture - physical, physiological, biochemical and molecular changes during seed storage - storage behaviour of orthodox and recalcitrant seeds - prediction of viability - viability nomograph.

Block-3 :Methods of seed storage

Unit 1: Methods of seed storage - modified atmospheric storage - ultra dry storage - vacuum storage - cryopreservation - germplasm storage - gene banks - NBPGR, IPGRI and National seed storage laboratory; seed storage godown - structure - maintenance - sanitation.

Practicals

- Seed extraction - wet and dry methods
- Seed processing sequence for different crops
- Design of processing plant - equipments - estimation of processing efficiency
- Seed drying methods - principle and methods
- Practicing seed grading - upgrading techniques
- Delinting methods - assessment of mechanical damage
- Visit to seed processing unit
- Seed packaging - effect of packaging materials on seed longevity
- Prediction of viability during storage - viability nomograph and accelerated ageing test
- Assessing physical changes during seed storage

- Assessing physiological changes during seed storage
- Assessing biochemical changes during seed storage
- Storage behaviour of recalcitrant seeds
- Pre-storage seed treatments - protectants - antioxidants - halogens
- Practicing seed blending methods
- Seed storage godown - sanitation, fumigation - visit to seed storage godown and cold storage unit
- Inspection and maintenance (licence and renewal) of records in processing unit - float test, preparation of processing report and seed lot number construction
- Visit to seed certification agency / department
- Visit to grow-out test field
- Visit to seed retail shop - procedures followed by Seed Inspector, verification of records and reporting
- Procedure to issue tag, specification, bagging, tagging, labelling and sealing

References

- BARTON, L. V., 1961, *Seed Preservation and Longevity*, (Vol.1). Leonard Hill, London.
- GREGG, B. R., LAW, A. G., VIRDI, S. S. AND BALIS, J. S., 1970, *Seed Processing*. Avion printers, New Delhi.
- GUPTA, D., 2009, *Seeds: their conservation principles and practices*. Sathishserial publishing house. New Delhi.
- JUSTICE, O. L. AND BASS, L. N., 1978, *Principles and Practices of Seed Storage*. Agriculture Hand Book No.506, Castle House Publication Ltd.,Washington.
- KULKARNI, G. N., 2011, *Principles of Seed Technology*. Kalyani Publishers, New Delhi.
- MAITI, R. K., SARKAR, N. C. AND SINGH, V. P., 2006, *Principles of Post Harvest Seed Physiology and Technology*. Agrobios, Jodhpur, Rajasthan.

- PADMAVATHI, S., PRAKASH, M., EZHIL KUMAR, S., SATHIYANARAYANAN, G. AND KAMARAJ, A., 2012, *A Text book of Seed Science and Technology*, New India Publishing Agency, New Delhi.
- SEN, S. AND GHOSH, N., 2010, *Seed Science and Technology*. Kalyani Publishers, NewDelhi. SinghalNC. 2010. *Seed Science and Technology*. Kalyani Publishers, New Delhi.

SST 509 SEED QUALITY TESTING AND ENHANCEMENT (1+1)

Objective

To impart knowledge on principles, techniques and methods of seed testing and seed quality enhancement.

Theory

Block- 1 : Seed testing history and principles

Unit 1: Seed testing - history and development; seed testing in India; ISTA and its role in seed testing; seed lot and size, types of seed and size, samples - sampling - intensity and methods, sampling devices, receipt and registration of submitted samples in the laboratory and sub sampling; purity analysis - components and procedure - determination of other distinguishable varieties (ODV) and test weight determination - application of heterogeneity test - method of testing coated and pelleted seeds; seed moisture estimation - principles and methods, application of tolerances.

Block 2 : Seed testing methods

Unit 1: Seed germination test - requirements, media and methods - seedling evaluation, tolerance and reporting results; viability test (TZ test) - principle, procedure and evaluation; vigour tests - concept of seed vigour and vigour test - types of vigour tests - direct and indirect tests - physical, physiological and biochemical tests - principles and methods; seed health test - principles and methods.

Unit 2: Genetic purity assessment - laboratory methods - physical, chemical, biochemical and molecular tests - growth chamber and field

testing (Grow Out Test) methods; testing of GM seeds; storage of guard sample - referral test; application of tolerance in seed testing; advanced non-destructive techniques of seed quality analysis - soft x-ray imaging - hyper spectral imaging, thermal imaging - spectroscopy - e-nose and machine vision techniques.

Block 3: Seed enhancement techniques

Unit 1: Seed quality enhancement techniques - history and development; classification - physical, physiological and protective seed treatments - special seed treatments; physical seed treatment - liquid floatation, specific gravity separation, irradiation, electric and electromagnetic seed treatments - principles and methods - seed pelleting and coating principles, purpose and methods.

Unit 2: Physiological seed enhancement treatments - seed infusion, seed priming - principles and methods - physiological, biochemical and molecular mechanisms; pre-germination and fluid drilling techniques; biological seed treatments - microbial inoculation; organic seed treatment - integrated seed treatment - concept and methods of designer seed.

Practicals

- Seed testing - sampling and dividing methods
- Determination of seed test weight and heterogeneity test
- Physical purity analysis - components, procedure, reporting results
- Seed moisture estimation - methods and equipments
- Conduct of seed germination test and seedling evaluation
- Conduct of quick viability (tetrazolium) test and evaluation
- Conduct of vigour tests - direct, indirect test and special tests
- Genetic purity assessment - laboratory and conventional methods - image analysis for seed quality
- Conducting different seed health tests to identify bacteria, fungi and insects.
- Visit to seed testing laboratory

- Seed enhancement techniques - practicing physical treatments and water floatation techniques
- Seed coating and pelleting - uses of adhesives and filler materials
- Performing seed priming - hydro, halo and bio-priming - solid matrix priming
- Practicing seed infusion and microbial inoculation treatments
- Practicing pre-germination technique
- Studying integrated seed treatment / designer seed treatment

References

- AGRAWAL, P. K., 1993, *Handbook of Seed Testing*. Ministry of Agriculture, GOI, New Delhi Agrawal R L.1997.*Seed Technology*. Oxford & IBH
- AGRAWAL, P. K. AND DADLANI, M., 1992, *Techniques in Seed Science and Technology*. 2nd Ed. South Asian Publications.
- CHAKRABARTHI, S. K., 2010, *Seed Production and Quality Control*. Kalyani Publishers. New Delhi. Chalam G V Singh A and Douglas J E. 1967. *Seed Testing Manual*. ICAR and United States Agency for International Development, New Delhi.
- COPELAND, L. O. AND MC DONALD, M. B., 2001, *Principles of Seed Science and Technology*. 4th Ed. Kluwer Academic publishers,USA.
- International Seed Testing Association., 2018, *Handbook on Seedling Evaluation*, 4th Edition, Published by ISTA, Zurichstr, Switzerland.
- International Seed Testing Association, 2019, *International Rules for Seed Testing* 2019. Published by ISTA, Zurichstr, Switzerland.
- ISTA.,1999, *Seed Science and Technology*, 27th supplement.
- RENUGADEVI, J., SRIMATHI, P., RENGANAYAKI, P. R. AND MANONMANI, V., 2012, *A Handbook of Seed Testing*. Agrobios. Jodhpur, Rajasthan.
- TRIDEVI, P. C., 2011, *Seed Technology and Quality Control*. Pointer Publication. Jaipur, Rajasthan. VasudevanSN,

Doddagowder SR, Rakesh CM and PatilSB. 2013. *Seed Testing and Quality Control*. Agrotech Publications, Udaipur, Rajasthan.

SST 510 SEED TECHNOLOGY OF TREE SPECIES (1+1)

Objectives

To make the students gain knowledge on seed production and handling techniques of various trees pecies.

Theory

Block 1 : Significance of tree seed technology

Unit 1: Importance of tree seeds - seed quality in plantation establishment - scope of seed production in tree species; seed structure and its significance in natural regeneration of forest species.

Unit 2: Reproductive biology - angiosperms and gymnosperms - reproductive age - seasonal influence on flowering - reproductive efficiency; factors influencing seed set - pollination - pollinating agents - self incompatibility - seed dispersal - mode and mechanism of dispersal.

Block 2 : Tree seed production

Unit 1: Seed stand - selection and delineation - seed production area - seed zone - selection criteria for candidate, plus and elite tree; seed orchards - definition - types - seedling and clonal seed orchard - pollen dilution zone - seed orchard establishment and management; OECD certification programmes for forest reproductive materials and seeds - ISTA certification standards for tree species.

Unit 2: Physiological maturity - maturity indices - determining optimum harvestable maturity; seed collection - methods - factors influencing seed collection - precautions in collection of recalcitrant seeds; seed extraction - methods - wet, dry and cone extraction; drying - critical moisture content - seed processing; dormancy - types of dormancy in tropical, sub-tropical and temperate tree seeds - dormancy breaking treatments; recalcitrant seeds - mechanism.

Block 3 : Techniques of tree seeds handing

Unit 1: Seed production and handling techniques in important tree borne oil seeds (mahua, karanja, neem, simaruba, Callophyllum), timber (teak, sandal, pine, cedar, red sanders, Dalbergia), fuel wood (Acacias), pulp wood (bamboo, Ailanthus, *Casuarina, Melia, Eucalyptus*), fodder (*Leucaena, Albizzia*) and ornamental (*Cassia, Delonix*) tree species.

Practicals

- Study of tree seed structure - internal and external structures
- Study on phenology of different tree species
- Selection procedure of candidate and plus trees
- Assessment of seed set, physiological and harvestable maturity
- Assessing natural regeneration in different tree species
- Study on seed dispersal methods and dispersal distance in different species
- Seed collection techniques in important tree species - seed collection - orthodox and recalcitrant seeds - safety measures during collection
- Seed extraction methods - wet and dry extractions - fruits, pods, cones *etc.*,
- Study on different seed drying methods and precautions
- Practicing seed grading and upgrading techniques
- Practicing seed dormancy breaking methods
- Germination improvement treatments for elite seedling production
- Study on storage of recalcitrant seed
- Estimation of critical moisture content for safe storage
- Visit to seed production area and seed orchard

References

- DENNIS, A. J., SCHEPP, E. N., GREEN, R. J. AND WESTCOTT, D. A., 2007, *Seed Dispersal*. Agrobios, Jodhpur. Khanna, L. S., 1993, *Principles and Practices of Silviculture*. Khanna Bandhu, Dehradun, India. Lars Schmidt 2000. *Guide to Handling of Tropical and Sub Tropical Forest Seed*. Danida Forest Seed Centre, Denmark.

- NEGI, S. S., 1998, *Forest Tree Seed*. International Book Distributors, Dehradun, India.
- RAM PRASAD. AND KHANDYA, A. K., 1992, *Handling of Forestry Seeds in India*. Associated Publishers, New Delhi.
- SIVASUBRAMANIAM, K., RAJA, K. AND GEETHA, R., 2012, *Recalcitrant Seeds–Causes and Effects*. Sathish Serial Publishing House. Azadpur, New Delhi.
- UMARANI, R. AND VANANGAMUDI, K., 2004, *An Introduction to Tree Seed Technology*. International Book Distributors, Dehradun.
- VANANGAMUDI, K., NATARAJAN, K., SARAVANAN, J., NATARAJAN, N., UMARANI, R., BHARATHI, A. AND SRIMATHI, P., 2007, *Advances in Seed Science and Technology: Forest Tree Seed Production* (Vol.4). Agrobios, Jodhpur
- WILLAN, R. L., 1985, *Aguide to Forest Seed Handling*. FAO, Rome
- ZOEBEL, B. AND TALBERT, T. T., 1984, *Applied Forest Tree Improvement*. Johwilley and Sons, NewYark.

SST 511 SEED INDUSTRY AND MARKETING MANAGEMENT (1+1)

Objective

To empower the students to become seed entrepreneurs by imparting knowledge on seed industry management and marketing strategies.

Theory

Block 1 : Current seed industry

Unit 1: Introduction to seed industry - genesis, growth and structure of seed industry - mission and objectives - present status of Indian and global seed industry - role of seed industry in Indian agriculture; government initiatives - seed hubs, seed villages and community seed production system.

Unit 2: Seed industry - organization set up and functions - public, private, MNC's, seed corporations; structure of small, medium and large seed industries, components of seed industry - public private partnership

- custom seed production - risk management - human resource - infrastructure - processing unit - storage go down.

Block 2 : Seed distribution system

Unit 1: Seed production and distribution systems in state and central government; seed supply chain systems - seed production and distribution - planning, organization and coordination, staffing, assembling of resources; cost of seed production - overhead charges.

Unit 2: Seed marketing - definition - importance - role of marketing; type of markets - domestic and global market - problems and perspectives; marketing policies - seed marketing schemes - marketing channels, responsibilities of dealers - marketing mix.

Block 3 : Pricing policies

Unit 1: Seed demand forecasting - purpose - methods and techniques; indenting and seed dispatch procedures and forms - seed store records - maintenance - missing link in seed supply chain; market intelligence - SWOT analysis; seed cost analysis; seed pricing - policy - components of seed pricing - factors - local market rate (LMR) - fixation of procurement and sale price of seed.

Practicals

- Data collection on status of Indian and global seed industry
- Assessing the factors influencing farmers preference and assessment of seed demand and supply
- Planning for establishment of small, medium and large seed industry
- Planning for establishment of seed production and processing unit
- Economics of seed production - varieties and hybrids
- Seed pricings and cost analysis
- Exercise on fixing seed procurement and sale price
- Study of marketing channels - domestic and international
- Maintenance of carryover seeds - Assessing risk factors in seed industry and their management
- Survey and interaction with seed dealers and distributors
- Visit to state seed corporations

- Visit to MNCs and expert discussion
- Case studies and SWOT analysis
- Visit to modern seed processing unit and advanced seed storage complex
- Custom seed production, contract farming and procurement - procedures
- Planning and preparation of project proposal for setup of a seed industry Final practical examination

References

- ACHARYA, S. S. AND AGARWAL, N. L., 2004, *Agricultural Marketing in India*. 4thEd. Oxford and IBH. Broadway AC and BroadwayA. 2003. *A TextBook of Agri-business Management*.
- KALYANI SINGH, A. K. AND PANDEY, S., 2005, *Rural Marketing*. New Age Publications. KugbeiS. 2008. *Seed Economics*. Scientific Publishers, Jodhpur, Rajasthan.
- SHARMA, P., 2008, *Marketing of Seeds*, Green-Tech Book Publishers, NewDelhi
- SINGH, G. AND ASOKAN, S. R., 1991, *Seed Industry in India: A Management Perspective* Oxford & IBH Publishing Co Pvt. Ltd., New Delhi.
- SINGH, S., 2004, *Rural Marketing–Focus on agricultural Inputs*. Vikas Publishing House.

SST 512 SEED HEALTH TESTING AND MANAGEMENT (1+1)

Objective

To acquaint the students with principle and practices of seed health testing and management of seed borne pathogens and storage insects.

Theory

Block 1 : Importance of seed health

Unit 1: History and economic importance of seed health in seed industry and plant quarantine - important seed borne and seed transmitted

pathogens - role of microorganisms in seed quality deterioration - storage and field fungi - effect of storage fungi on seeds - factors influencing storage fungi and management.

Unit 2: Transmission of pathogens - mode and mechanism - seed certification standards; mycotoxins - types and its impact on plant, animal and human health; seed health testing methods - direct examination, incubation, serological and molecular methods.

Block 2 : Management of seed borne pathogens

Unit 1: Production of disease free seeds in agricultural and horticultural crops; management of seed borne pathogens - plant quarantine - Indian system and networking, post-entry quarantine and international systems - Pest Risk Analysis (PRA); sanitary and phytosanitary system (SPS) - certificates; International seed health initiative (ISHI) on seed health standards.

Unit 2: Storage pests - insects, mites, rodents and their development - economic importance; insect infestation - factors influencing, sources and kinds, biochemical changes in stored seeds due to insect infestation; detection methods and estimation of storage losses; types of seed storage structures - domestic and commercial.

Block 3: Seed health management

Unit 1: Fumigation - principles and techniques - type of fumigants; preservatives and seed protectants on seed quality - non-chemical methods for managing seed storage pests - controlled and modified atmospheric storage - trapping devices - IPM for seed storage.

Practicals

- Detection of seed borne pathogens - direct examination
- Detection of seed borne pathogens - Incubation methods
- Detection of seed borne pathogens- serological methods
- Detection of seed borne pathogens - molecular methods
- Study on seed transmission of seed borne fungi, bacteria and viruses
- Identification of storage fungi

- Management of seed borne pathogens - seed treatment methods
- Identification of storage insects - internal and external feeders influencing insects
- Study on the effect of pre harvest spray on field carryover storage pests
- Estimation of storage losses due to pests
- Methods of detection of insect infestation
- Management of storage pests - pesticides, dose determination, preparation of solution and application
- Management of storage pests - non-chemical management methods
- Demonstration of controlled atmospheric storage Safe handling and use of fumigants and insecticides
- Visit to seed storage go downs.
- Visit to tree seed processing unit
- Visit to forage and fodder seed production farms

References

- AGARWAL, V. K. AND SINCLAIR, J. B., 1996, *Principles of Seed Pathology*. Edition, CRC Press Inc. Boca Raton,FL.
- ATHANASSIOU, C. G. AND ARTHUR, F. H., 2018, *Recent advances in stored product protection*. Springer-Verlag, Germany
- COTTON, R. T., 2007, *Insect Pests of Stored grain and Grain products*. Burgess Publ.Co., Minneopolis, Minn.,USA
- KARUNA, V., 2007, *Seed Health Testing*. Kalyani Publishers, NewDelhi.
- KARUNA, V., 2009, *Fundamentals of Seed Pathology*. Kalyani Publishers, New Delhi. Neergaard P. 1979. *Seed Pathology*. Vol.1. The Macmillan Press Ltd.
- RANJEET, K., 2017, *Insect Pests of Stored grain–Biology, Behaviour and Management Strategies*.
- Apple Academic Press, New York, USA.

SST 515 GERMPLASM COLLECTION, EXCHANGE AND QUARANTINE (1+1)

Objective

To acquaint the students with principle and practices of germ plasm collection, exchange of germ plasm and quarantine procedures.

Theory

Block 1 : Importance of germ plasm

Unit 1: History and importance of germplasm exploration; Distribution and extent of prevalent genetic diverisity; Phyto-geographical regions/ ecological zones and associated diversity; Mapping eco-geographic distribution of diversity, threatened habitats, use of flora.

Unit 2: Concept of population and gene pool; variations in population and their classification; Gene frequencies in populations, rare and common alleles; Gene pool sampling in self and cross pollinated and vegetatively propagated species; Non-selective, random and selective sampling strategies; Strategies and logistics of plant exploration and collection; Coarse and fine grid surveys; Practical problems in plant exploration; Use of *in vitro* methods in germplasm collection. Ethno botanical aspects of PGR; Crop botany, farming systems, collecting wil relatives of crop plants; Collection and preservation of specimens; Importance and use of herbaria and preparation of herbarium specimens. Post exploration handling of germplasm collections; Present status and future strategies in collection of major crops of Indian origin such as rice, maize, sorghum, sesame, *Brassica*, okra, eggplant, cotton, mango etc.; approaches for collection including indigenous knowledge.

Block 2: History and importance of plant introduction

Unit 1: History, principles, objectives and importance of plant introduction; Prerequisites, conventions, national and international legislations and policies on germplasm collection and exchange; Documentation and information management;

Block 3: Plant Quarantine set up

Unit 1: Plant quarantine- introduction, history, principles, objectives and relevance; Regulations and plant quarantine setup in India;

pest risk analysis, pest and pathogen information database; Quarantine in relation to integrated pest management; Economic significance of seed-borne pests (insects, mites, non-insect pests, nematodes, fungi, bacteria, viruses, phytoplasma *etc.*). Detection and identification of pests including use of recent techniques like ELISA, PCR *etc.*, Symptoms of pest damage, salvaging techniques for infested / infected germplasm, post- entry quarantine operation, seed treatment and other prophylactic treatments and facilities; Domestic quarantine; Seed certification; International linkages in plant quarantine; weaknesses and future thrust.

Unit 2: Genetically modified organisms (GMOs) or genetically engineered plants (GEPs), Concepts of bio-safety, risk analysis and consequences of spread of GE crops on the environment; Treaties and multilateral agreements governing trans-boundary movement of GEPs or GMOs, Indian regulatory system for bio-safety.

Practicals

- Plant exploration and collection, Techniques of coarse and fine grid surveys
- dentification of wild relatives of crop plants- Example of collection, cataloguing and preservation of specimens;
- Sampling techniques of plant materials;
- Visiting ports, airports to study the quarantine regulations;
- Techniques for the detection of insects, mites, nematodes, bacteria, weeds, pathogens and viruses on seed and planting materials and salvaging;
- Use of visual, qualitative, quantitative, microscopic, molecular and plant growth related techniques (controlled green houses / growth chambers) *etc.*
- Detection of GMOs and GEPs;
- Study of post entry quarantine operation, seed treatment and other prophylactic treatments

References

- AGARWAL, V. K. AND SINCLAIR, J. B., 1996., *Principles of Seed Pathology*. Edition, CRC Press Inc. BocaRaton,FL.
- KARUNA, V., 2007, *Seed Health Testing*. Kalyani Publishers, NewDelhi
- AGRAWAL, P. K. AND DADLANI, M., 1992, *Techniques in Seed Science and Technology*. 2nd Ed. South Asian Publications.
- Chakrabarthi, S. K., 2010, *Seed Production and Quality Control*. Kalyani Publishers. New Delhi. Chalam GV Singh A and Douglas JE. 1967. *Seed Testing Manual*. ICAR and United States Agency for International Development, New Delhi.
- COPELAND, L. O. AND MCDONALD, M. B., 2001, *Principles of Seed Science and Technology*. 4thEd. Kluwer Academic publishers, USA.
- BEWLEY, J. D., BRADFORD, K. J., HILHORST, H. W. M. AND NANOGAKI, H., 2013, *Seeds: Physiology of Development, Germination and Dormancy*. Springer, NewYork.
- MAITI, R. K,, SARKAR, N. C. AND SINGH, V. P., 2006, *Principles of Post Harvest Seed Physiology and Technology*. Agrobios, Jodhpur, Rajasthan.
- AGRAWAL, R. L., 2019, *Seed Technology*. Oxford & IBH Publishing Company Pvt. Ltd., NewDelhi. Hebblethwaite PD. 1980. *Seed Production*. Butterworth Heinemann Ltd., London,UK.
- JOSHI, A. K. AND SINGH, B. D., 2004, *SeedScienceand Technology*. Kalyani Publishers, NewDelhi. KulkarniGN. 2011. *Principles of Seed Technology*. Kalyani Publishers, NewDelhi.
- MAITI, R. K., SARKAR, N. C. AND SINGH, V. P., 2006, *Principles of Post Harvest Seed Physiology and Technology*. Agrobios, Jodhpur, Rajasthan.
- ROBERTS, E. H., 1972, *Viability of Seeds*. Springerlink, New York, USA

- VANANGAMUDI, K., NATARAJAN, N., SRIMATHI, P., NATARAJAN, K., SARAVANAN, T., BHASKARAN, M., BHARATHI, A., NATESAN, P. AND MALARKODI, K., 2006, *Advances in Seed Science and Technology*. Vol. 2. *Quality Seed Production in Vegetables*. Agrobios, Jodhpur.
- SINGH, B. D., Plant Breeding. Kalyani Publishers
- ANON., 2016, *Manual of Seed Certification Procedures*. Directorate of Seed Certification, Coimbatore, Tamil Nadu.
- CHOUDHARY, D. R., 2009, *Guidelines for Storage and Maintenance of Registered Plant Varieties in the National Gene Bank*. Published by Protection of Plant Varieties and Farmer's Rights Authority. Ministry of Agriculture, GoI, NewDelhi, India.
- MISHRA, D. K., KHARE, D., BHALE, M. S. AND KOUTU, G. K., 2011, *Handbook of Seed Certification*. Agrobios, Jodhpur, Rajasthan.
- RAMAMOORTHY, K., SIVASUBRAMANIAM, K. AND KANNAN, M., 2006, *Seed Legislation in India*. Agrobios, Jodhpur, Rajasthan.
- ANON., 2016, *Manual of Seed Certification Procedures*. Directorate of Seed Certification, Coimbatore, Tamil Nadu.
- CHAKRABARTHI, S. K., 2010, *Seed Production and Quality Control*. Kalyani Publishers, New Delhi.
- Choudhary, D. R., 2009, *Guidelines for Storage and Maintenance of Registered Plant Varieties in the National Gene Bank*. Published by Protection of Plant Varieties and Farmer's Rights Authority. Ministry of Agriculture, GoI, New Delhi, India.
- ISTA., 2010, *Handbook of Variety Testing*. International Seed Testing Association, Switzerland. Joshi AK and Singh BD. 2004. *Seed Science and Technology*, Kalyani Publishers, New Delhi, India.
- MISHRA, D. K., KHARE, D., BHALE, M. S. AND KOUTU, G. K., 2011, *Handbook of Seed Certification*. Agrobios, Jodhpur, Rajasthan.

- RAMAMOORTHY, K., SIVASUBRAMANIAM, K. AND KANNAN, M., 2006, *Seed Legislation in India*. Agrobios, Jodhpur, Rajasthan.
- TRIVEDI, P. C., 2011, *Seed Technology and Quality Control*. Publications, Jaipur, Rajasthan.
- BRUSH, S. B., 1999, *Genes in the field: On-farm Conservation of Crop Diversity*. Lewis Publishers, Boca Raton, Florida, USA.
- CHOUDHARY, D. R., 2009, *Guidelines for Storage and Maintenance of Registered Plant Varieties inthe National Gene Bank*. Published by Protection of Plant Varieties and Farmer's Rights Authority. Ministry of Agriculture and Farmers Welfare, GoI, New Delhi.
- GUPTA, D., 2009, *Seeds: Their Conservation Principles and Practices*. Sathish Serial Publishing House. New Delhi.

M.Sc. (Agri.) in Sericulture

Course Code	Course Title	Credit Hours
SER 501	Mulberry Production Technology	2 (1+1)
SER 502	Genetics and Breeding of Mulberry	2 (1+1)
SER 503	Nutrition of Host Plants of Silkworms	2 (1+1)
SER 504	Mulberry Pests and Diseases	2 (1+1)
SER 505	Biotechnology of Mulberry	2 (1+1)
SER 506	Systematics and Morphology of Sericigenous Insects	2 (1+1)
SER 507	Anatomy and Physiology of Sericigenous Insects	2 (1+1)
SER 508	Silkworm Biochemistry and Nutrition	2 (1+1)
SER 509	Silkworm Egg Production Technology	2 (1+1)
SER 510	Silkworm Rearing Technology	2 (1+1)
SER 511	Genetics and Breeding of Silkworms	2 (1+1)
SER 512	Diseases and Pests of Silkworms	2 (1+1)
SER 513	Biotechnology of Silkworm	2 (1+1)
SER 514	Silk Technology	2 (1+1)
SER 515	Vanya Sericulture	2 (1+1)
SER 516	Sericulture By-product Utilization and Value addition	2 (1+1)
	Total	**32 (16+16)**
SER 580	Qualifying Examination	2 (0+2)
SER 581	Seminar-I	1 (0+1)
SER 582	Seminar-II	1 (0+1)
SER 591	Research-I	13 (0+13)
SER 592	Research-II	14 (0+14)

SER 501 MULBERRY PRODUCTION TECHNOLOGY (1+1)

Objective

- The course is designed to provide knowledge on production technology of mulberry saplings, rainfed and irrigated mulberry cultivation, maintenance of separate chawki garden.
- Use of growth hormones and growth regulators on mulberry.
- To know about economics of mulberry production.

Theory

Block 1: Introduction, scope and varieties of mulberry

Unit 1: Introduction and scope of mulberry production

Overview and scope of mulberry sericulture, an overview of sericulture industry in the world and India. Leaf quality requirements, factors influencing mulberry leaf yield and quality. Scope for mechanization in mulberry cultivation.

Unit 2: Varieties of mulberry

Mulberry varieties, traditional mulberry varieties, popular mulberry varieties for different climatic zones, high yielding varieties, varieties for rainfed condition, varieties for specific conditions.

Block 2: Mulberry production

Unit 1: Raising of mulberry saplings and planting

Techniques for raising of mulberry saplings. Preparation of bed, planting material, transportation, storage, preparation of cuttings, planting, weeding, fertilizer application, disease and pest management, uprooting, transportation and planting in main field. Raising mulberry saplings in poly bags.

Unit 2: Establishment of mulberry garden

Package of practices for rainfed and irrigated mulberry cultivation, separate chawki garden, tree mulberry, mulberry cultivation in hilly areas. Selection of land, land preparation, planting, initial care and maintenance of rainfed and irrigated mulberry garden. Pruning practices, Manure

and fertilizer schedule, irrigation schedule, use of biofertilizers for enhanced yield, use of growth hormones and growth regulators, leaf harvesting and preservation. Intercropping, organic farming and mechanization in mulberry cultivation.

Block 3: Mulberry protection

Unit 1:Mulberry pests and their management

Mulberry pest status, occurrence, type of damage and symptoms, crop loss and life-cycle of different pests, methods of management. Integrated Pest Management (IPM) in mulberry.

Unit 2: Mulberry diseases and their management

Mulberry diseases, occurrence, damage, symptoms, crop loss and methods of management. Integrated Disease Management (IDM) in mulberry.

Block 4: Economics

Unit 1: Economics of mulberry production

Maintenance of farm records, monetary and non-monetary inputs in mulberry production, economics of mulberry production.

Practical

- Analysis of area, production and productivity of mulberry and sericulture in Karnataka, India and world;
- Study of Agronomic features of different mulberry varieties;
- Study of different mulberry planting systems;
- Study of rooting and sprouting behaviour of mulberry varieties;
- Raising saplings through soft, semi soft and apical tender shoots;
- Mulberry nursery establishment and management;
- Study of mulberry as an intercrop in plantations;
- Selection of fruits and preparation of mulberry seeds for raising mulberry seedlings;
- Study of different planting systems of tree mulberry;
- Study of Intercropping in mulberry garden;

- Study of organic mulberry farming;
- Study of Mulberry as IFS component;
- Effect of different pruning systems on mulberry yield;
- Estimation of leaf area by non-destructive and destructive methods;
- Study of different leaf preservation techniques and different methods of leaf harvest with special reference to chawki and grown up silkworms;
- Study of different schedules of operation in mulberry garden and fertilizer application, methods of application and irrigation schedules;
- Study of weed flora in mulberry garden;
- Study of Farm records and Economics of mulberry cultivation;
- Institutional/ Farmers field visits.

References

- ANONYMOUS, 1975, *Textbook of Tropical Sericulture.* Japan Overseas Co-operation volunteers, Japan, p.594.
- ARUGA, H., 1994, *Principles of Sericulture*. Oxford & IBH, New Delhi, p. 376.
- DANDIN, S. B., JAISWAL AND GIRIDHAR., 2003, *Handbook of Sericulture Technologies.* CSB, Bangalore, p.287.
- GANGA, G. AND SULOCHANA CHETTY, J., 1991, *An Introduction to Sericulture*. Oxford & IBH, New Delhi, p.176.
- GANGA, G., 2003, *Comprehensive Sericulture.* Volume 2. *Silkworm Rearing and Silk Reeling.* Oxford & IBH, New Delhi, p.429.
- GOVINDAIAH, GUPTA, V. P., SHARMA, D. D., Rajadurai S and Nishitha Naik V. 2005. *Textbook on Mulberry Crop Protection,* p 247.
- JOLLY, M. S., 1987, *Appropriate Sericulture Techniques.* Central Sericultural Research and Training Institute, CSB, Mysore, p.215.
- KAMAL JAISWAL, SUNIL P. TRIVEDI, PANDEY, B. N. AND KHATRI, R. K., 2009. *Moriculture,* pp. 130-147.

- Kichisaburo Minamizawa., 1984, *Moriculture: Science of Mulberry Cultivation,* pp. 372-402.
- RANGASWAMY, G., NARASIMHANNA, M. N., KASIVISWANATHAN, K., SASTRY, C. R. AND JOLLY, M. S., 1976, *Manual on Sericulture-I. Mulberry Cultivation*, FAO, Rome, P.150.
- SAVITHRI, G., SUJATHAMMA, P. AND NEERAJA, P., 2016, *Sericulture Industry: An Overview,* pp. 28-35.
- ULLAL, S. R. AND NARASIMHANNA, M. N. 1981, *Handbook of Practical Sericulture,* CSB, P.209.

Journals

- *Bulletin of Indian Academy of Sericulture*, CSTRI, Berhampore
- *Indian silk,* CSB, Bangalore
- *Journal of Sericultural Science of Japan,* Japan
- *Seridoc*, CSRTI (CSB), Mysore
- *Sericologia*, ISC, Bangalore
- *Korean Journal of Sericulture*, Korea
- *Indian Journal of Sericulture*, CSRTI (CSB), Mysore
- And other Periodicals, Journals, Reports, Brochures, etc.

Websites

- www.csb.gov.in/
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- www.tnau.ac.in/
- www.csrtimys.res.in/

SER 502 GENETICS AND BREEDING OF MULBERRY (1+1)

Objective

- The course is designed to provide both basic and applied knowledge on the subjects of mulberry origin and diversity, floral structure, biology and pollination, genetic basis and general concept of breeding

- Establishment of germplasm and genetic improvement of mulberry by conventional and non-conventional methods of breeding

Theory:

Block 1: Taxonomy and botanical description and classification of mulberry

Unit 1: Origin and diversity studies of mulberry

Centre of origin and diversity studies of mulberry, mulberry species and their distribution in India and other countries. Taxonomy of the genus *Morus*, Botanical description of *Morus* spp.

Unit 2: Study of floral structure, biology and pollination

Reproduction and genetic constitutions in mulberry –asexual reproduction- characteristics of mulberry florets- sexual behaviour-anthesis-reproductive variability. Pollination in mulberry. Cytology of mulberry, cell division- mitosis and meiosis and their significance. Karyomorphological studies. Microsporogenesis and Megasporogenesis in mulberry. Embryological studies of mulberry.

Unit 3: Genetic basis and general concept of mulberry breeding

Expression of gene: Segregation of genes, linkage, homozygosis, quantitative inheritance, features of polygenic inheritance, population structure, selection of parents for hybridization. Procedure of hybridization: pruning and synchronization of flowering, bagging, tagging, pollination. Harvesting and storing of F_1 seeds, raising F_1 generation. Seedling selection criteria. Difficulties in hybridization, consequences of hybridization. Combining ability: general combining ability and specific combining ability, Heritability, genetic advance and genetic divergence.

Block 2: Mulberry germplasm and breeding methods

Unit 1: Mulberry germplasm

Establishment of mulberry, objectives and need, exploration, collection and introduction of mulberry germplasm, acclimatization and utilization. Introductions, world collection of mulberry germplasm, plant quarantine, conservation and maintenance of mulberry germplasm,

characterization and evaluation of mulberry germplasm, role of mulberry germplasm study in mulberry improvement.

Unit 2: Conventional methods of breeding

Objectives and pre-requisites of mulberry breeding. Genetics of important traits. Early work of mulberry breeding, problems associated with mulberry breeding, conditions favouring mulberry breeding. Reproductive systems and plant breeding methods, pollination in mulberry and crossing techniques. Mulberry varieties developed through direct selection, selection without controlled pollination and controlled pollination methods, handling of segregating progenies. Conventional methods of breeding- introduction, clonal selection, backcross method. Intervarietal and distant hybridization. Heterosis breeding. Population improvement. Polycross hybrids – Principles involved, advantages and disadvantages, steps in development of polycross hybrids. Multi locational trials and mulberry authorization programme, testing of feed quality. Advanced generation breeding. Improved varietal evaluation, distribution and maintenance. Challenges for future.

Unit 3: Non-conventional methods of breeding

Polyploidy breeding in mulberry: Introduction, origin of polyploids, general features of polyploidy, induction of polyploidy and optimal level, special features of triploids, process of triploid mulberry development, varieties developed by polyploidy breeding in mulberry.

Mutation breeding in mulberry: Induction of mutation, bud mutation and chimeras, mutation breeding achievements in mulberry, usefulness of induced mutation, limitations and achievements of mutation breeding in mulberry. Breeding for leaf quality, resistance against diseases and pests, tolerance for drought, alkalinity and salinity. Evaluation of mulberry genotypes for different growth and yield parameters. Centres involved in mulberry improvement. Statistical approaches for yield test: Field plot techniques in mulberry breeding eXperiments. Different experimental designs- RCBD, ARCBD and LSD. Recent approaches in mulberry improvement: *In-vitro* techniques- achievements and prospects.

Practical

- Floral structure of mulberry;
- Floral biology of mulberry;
- Practising of staggered pruning in mulberry for inducing flowering;
- Sporogenesis: Micro and Megasporogenesis in mulberry;
- Preparation of mitosis slides in mulberry;
- Preparation of meiosis slides in mulberry;
- Study of pollen morphology, pollen fertility and viability;
- Study of stigma receptivity;
- Pollination and crossing techniques in mulberry;
- Characterization of available mulberry germplasm;
- Collection of mulberry fruits, extraction of seeds and raising of seedlings;
- Practising of selection in segregating population/ progenies;
- Study of varietal characteristics of released mulberry varieties;
- Layout of field experiments in mulberry for yield evaluation;
- Techniques for induction of mutations and polyploidy in mulberry;
- Testing for resistance to biotic and abiotic stresses in mulberry;
- Breeding for quality improvement in mulberry;
- Visit to Germplasm research station, CSGRC, Hosur.

References

Text Books

- AMITABH SARKAR, *Mulberry breeding*. Kalyani publication, New Delhi.
- CHAKRABORTI, S. P., ROY CHOWDHURI, S. AND BINDROO, B. B., 2013, *A text book on mulberry breeding and genetics.* Kalyani publications, New Delhi.
- DANDIN, S. B., 1986, Mulberry breeding for tropics. In "*Lectures on Sericulture*" Edt. (G. Boraiah), Suriamya Publishers, Bangalore, pp. 25-28.

- DAS, B. C. AND KRISHNASWAMI, S., 1969, Estimation of components of variation of leaf yield and its traits in mulberry. *Indian J. Seric.,* 9 (1) : 26-30.
- DAS, B. C., 1983, Mulberry taxonomy, cytology and breeding. *National Seminar on Sericulture Research and Development,* CSB, pp.1-9.
- DAS, B. C. AND KATAGIRI, K., 1968, Germination and storage of pollen on its viability. *Indian J. Seri.,* 10(1): 37-41.
- RANGASWAMY, G., NARASIMHANNA, M. N., KASIVISWANATHAN, K., SASTRY, C. R. AND JOLLY, M. S., 1976, *Manual on Sericulture-I. Mulberry Cultivation*, FAO, Rome, P.150.
- GIRIDHAR, K., 1996, Studies on some improved varieties of mulberry and their influence on the silkworm, *Bombyx mori* L. *Ph. D. Thesis,* Mysore University, Mysore, India.
- JALAJA, K. S. AND RAM RAO, D. M., 2008, Characterization of seven mulberry genotypes for their leaf quality and bioassay with silkworm, *Bombyx mori* L. *Sericologia,* 48(1):85-93.
- MACHII, H., KOYAMA, A., YAMANUCHI, H. AND KATAGIRI, K., 1997, Manual for the characterization and evaluation of genetic resources. *Misc. Natl. Inst. Seri. Entomol. Sci.,* 22: 105-124.
- MACHII, M., 1990, Leaf disc transformation of mulberry plant (*Morus alba* L.) by Agrobacterium Ti plasmid. *J. Seric. Sci. Japan,* 59: 105-110.
- MASILAMANI, S., REDDY, A. R., SARKAR, A., SREENIVAS, B. T. AND KAMBLE, C. K., 2000, Heritability and genetic advance of quantitative traits in mulberry (*Morus* spp.). *Indian J. Seric.,* 13(1): 16-20.
- MOGILI, T., SARKAR A. REDDY. AND MUNIRATHNAM., 2002, Effect of saliniy stress on some improved varieties of mulberry, *Morus* spp. *Sericologia,* 42(2): 149-163.

- OKA, S. AND TEWARY, P. K., 2000, Induction of hairy roots from hypocotyls of mulberry (*Morus indica* L.) by Japanese wild strains of Agrobacterium rhizogeiles. *J. Seric. Sci. Japan*, 69:13-19.
- RANGASWAMI, G., NARASIMHANNA, M. N., KASIVISWANATHAN, K., SASTRY, C. R. AND JOLLY, M. S., 1978, *Manual of Sericulture.* Vol. 1 Mulberry Cultivation, FAO, Rome, p.150.
- SARKAR, A. AND FUJITA, H., 1993b, Japanese system of mulberry breeding: First selection. *Indian Silk,* September, 9-14.
- SARKAR, A., JALAJA KUMAR, S. AND DATTA, R. K., 2000, Gradual improvement of mulberry varieties under irrigated condition in South India and the optimal programme for varietal selection in the tropics. *Sericologia,* 12: 142-148.
- SASTRY, C. R., 1984, Mulberry varieties, exploitation and pathology. *Sericologia,*24(3): 333-359.
- SINGH, B. D., *Plant breeding Principles and methods*. Kalyani publication, New Delhi.
- SUSHEELAMMA, B. N., JOLLY, M. S., SHARMA GIRIDHAR, K., DWIVEDI, N. K. AND SURYANARAYANA, N., 1988,. Correlation and path analysis in mulberry under stress and non-stress conditions. *Sericologia,* 28(2): 239-243.

Journals

- *Bulletin of Indian Academy of Sericulture*, CSTRI, Berhampore
- *Indian silk,* CSB, Bangalore
- *Journal of Sericultural Science of Japan,* Japan
- *Seridoc,* CSRTI (CSB), Mysore
- *Sericologia,* ISC, Bangalore
- *Korean Journal of Sericulture,* Korea
- *Indian Journal of Sericulture,* CSRTI (CSB), Mysore
- And other Periodicals, Journals, Reports, Brochures, etc.

Websites

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- https://www.karnataka.gov.in/kssrdi/documents/2019/tender%20KC.pdf
- www.tnau.ac.in/

SER 503 NUTRITION OF HOST PLANTS OF SILKWORMS (1+1)

Objective

- To provide both basic and applied knowledge on nutritional management through different methods and means of application
- To emphasise on the use of chemicals, fertilizers, organic manure and bio-fertilizer and its important to maintain and sustain higher levels of soil fertility and productivity
- To know the effect of toxicity and deficiency symptoms of macro - and micro - nutrients in mulberry

Theory

Block 1: Organic manures

Unit 1: Principles of manure application

Role of mineral nutrition on growth and development of mulberry, Classification of minerals i.e. organic and inorganic, types of organic nutrition –FYM, compost, vermicompost, pressmud, animal manure-poultry manure, piggery manure. Methods of green manuring and composting.

Block 2: Nutrition of non-mulberry host plants

Unit 1: Nutrition of non-mulberry host plants

Nutrient management in Castor, Tapioca, Terminalia, Soalu and Som.

Block 3: Physico-chemical properties of soil and nutrient uptake

Unit 1: Influence of physical and chemical properties of soil

Types of mulberry soils, soil structure, texture, CEC, clay and mineral composition, soil pH, micro and macro fauna, organic matter and their influence on growth and development.

Role of physical and chemical properties on nutrient uptake and growth. Absorption pattern of major and micro nutrients in different soils.

Block 4: Application of major nutrients

Unit 1: Principles of fertilizer application

Role of bio-fertilizers – nitrogen fixing bacteria, phosphate solubilizing fungi, exploitation of K solubilizing organism, VAM application methods, split application based on soil test for both rainfed and irrigated condition.

Unit 2: Role of nitrogen

Sources of nitrogen, types and method of application, effect of nitrogen on growth and development of mulbery.

Unit 3:Role of Phosphorus

Sources of phosphorus, types and methods of application, effect of phosphorus on growth and development.

Unit 4: Role of potash

Sources of potash, types and methods of application, effect of potassium on growth and development.

Unit 5: Role of secondary nutrients

Sources of secondary nutrients, types and methods of application, effect of secondary nutrients on growth and development of mulberry.

Block 5: Nutrient deficiency

Unit 1: Deficiencies of Major nutrients and their toxicity

Deficiency symptoms of N, P and K and toxicity in mulberry plants. Their effect on quality of mulberry and correction.

Unit 2: Deficiencies of secondary nutrients and their toxicity

Deficiency symptoms of S, Mn, Fe, Mo, Mg, Ca, Zn and other micronutrients and their toxicity in mulberry plants and their effect on quality of mulberry and correction.

Practical

- Collection of soil samples in mulberry garden and interpretation of soil test results;
- Study of recommended fertilizer schedule for both rainfed and irrigated mulberry;
- Modern methods of vermi-composting techniques by using sericulture wastes;
- Different methods of green manuring and soil and water conservation practices in mulberry garden;
- Growth and root parameters of mulberry under different moisture regimes;
- Estimation of mulberry yield per unit area in both rainfed and irrigated condition;
- Use of soil amendments on sprouting and rooting pattern in mulberry;
- Studies on the effect of nutrient solution and bacterial inoculants on the growth of mulberry cuttings;
- Enumeration of beneficial microflora (Bacteria, Fungi and Actinomycetes) in mulberry rhizosphere;
- Induction of deficiency symptoms of major nutrients using sand culture techniques;
- Application of conventional fertilizer to mulberry;
- Practising supply of nutrients to mulberry through fertigation;
- Planning and practicing of foliar nutrient application in mulberry;
- Study of the effect of fertilizer use on physico-chemical properties of mulberry soil;
- Supplementation of deficit nutrients for both rainfed and irrigated mulberry as per soil test;
- Enumeration of micro fauna of soils under mulberry cultivation;
- Study of fertilizer use efficiency in mulberry;

- Practising Seri Suvarna Technology (Trenching and Mulching) in mulberry garden.

References

Text Books

- BONGALE, U. D., 2003, ''Nutritional Management and quality improvement in sericulture'', *Proceedings of the national seminar on mulberry sericulture research in India* 26th to 28th November 2001, P-1037.
- DANDIN, S. B. AND GIRIDHAR, K., 2014, *Handbook of Sericuilture Technologies*, CSB, Bengaluru,P-427.
- GANGA, G., 2003, *Comprehensive Sericulture.* Volume 2. *Silkworm Rearing and Silk Reeling.* Oxford & IBH, New Delhi, P.429.
- *Nutritional Management and Quality improvement in Sericulture.* 2003. KSSRDI. Bangalore.
- RAJANNA, L, DAS, P. K., RAVINDRAN, S., BHOGESHA, K., MISHRA, R. K., SINGHVI, N. R., KATIYAR, R. S. AND JAYARAM, H., 2005, *Mulberry cultivation and physiology*, Central Silk Board, Bangalore, p. 367.
- RANGASWAMY, G., NARASIMHANNA, M. N., KASIVISWANATHAN, K. AND SASTRY, C. R., 1976, *Manual on Sericulture-I. Mulberry cultivation,* FAO, Rome, p.150.

Journals

- *Bulletins of Sericultural Experimental Station* – Suginami, Tokyo, Japan.
- *Journal of Sericultural Science of Japan* – Sericultural Experimental Station, Wade, Suginami-ku, Tokyo, Japan.
- *Sericologia* – ISC, Bangalore.
- *Indian Journal of Sericulture* – CSR & TI, Mysore.
- *Journal of Sericulture and Technology* – Published by NASSI, Bangalore.
- *Indian Silk* – Central Silk Board, Bangalore.
- *Bulletin of Indian Academy of Sericulture* – Bhubaneshwar, Orissa.

- *Reshme Krishi (Kannada)* – Department of Sericulture, Government of Karnataka, Bangalore.
- *Current Science* – Indian Institute of Science, Bangalore.

Websites

- www.csb.gov.in/
- www.karnataka.gov.in/kssrdi/documents/2019/tender%20KC.pdf
- www.tnau.ac.in/
- www.csrtimys.res.in/

SER 504 MULBERRY PESTS AND DISEASES (1+1)

Objective

- To provide both basic and applied knowledge in managing diseases and pests in mulberry eco-system
- It helps to equip students to understand different pests infesting and diseases affecting mulberry crop at different stages and seasons, diseases affecting mulberry crop and their management

Theory

Block 1: Mulberry Pests and their Management

Unit 1: Leaf eating pests (Defoliators)

Mulberry leaf roller, Bihar hairy caterpillar, wingless grasshopper, cutworm, rootgrubs -Classification, status, seasonal incidence, damage caused, symptoms, loss, lifecycle and management.

Unit 2: Sap feeders (Sucking pests)

Thrips, jassids, spiraling whitefly, scale insects, mealy bugs, spider mites -Classification, status, seasonal incidence, damage caused, symptoms, loss, lifecycle and management.

Unit 3: Minor pests of mulberry

Stem borer, termites, May–June beetles, stem girdler beetle – Classification, status, seasonal incidence, damage caused, symptoms, loss, lifecycle and management.

Block 2: Mulberry diseases and their management

Unit 1: Fungal diseases

Root rot diseases, powdery mildew, leaf spot and leaf rust diseases. Classification, occurrence, symptoms and damage, extent of crop loss and management.

Unit 2: Bacterial diseases

Leaf blight and rot diseases-Classification, occurrence, symptoms of damage extent of crop loss and management.

Unit 3: Viral diseases

Leaf mosaic and mulberry dwarf diseases classification, occurrence, symptoms extent of crop loss and management.

Unit 4: Nematode disease

Root knot diseases- Classification, occurrence, symptoms, identification of root knots extent of crop loss and management.

Practical

- Collection of insect and non-insect pests from mulberry garden and their preservation;
- Classification of mulberry pests based on taxonomy and nature of feeding;
- Classification of mulberry diseases;
- Collection of diseased specimen from mulberry garden and their preservation;
- Classification of mulberry diseases based on taxonomy and parts of the plants damaged;
- Incidence and estimation of damage to mulberry caused by mulberry leaf webber;
- Incidence and estimation of damage to mulberry caused Bihar Hairy Caterpillar;
- Study of life cycle of mulberry leaf webber;
- Study of life cycle of black headed hairy caterpillar;

- Study of life cycle of mulberry leaf spot;
- Study of life cycle of mulberry leaf rust;
- Study of life cycle of powdery mildew of mulberry;
- Isolation of leaf spot fungus and bacterial blight pathogen in the laboratory and characterization;
- Varietal response of mulberry to root knot nematode disease;
- Incidence, symptoms and damage of tukra disease to different varieties of mulberry;
- Life cycle of wingless grasshopper and cutworm on mulberry;
- Incidence of thrips on the available varieties of mulberry;
- Collection of specific predators and parasites in mulberry garden, preservation and their classification;
- Diseases and pests associated with mulberry nursery and tree mulberry;
- Commonly used insecticides and fungicides in mulberry garden-classification, forms, formulations and their applications.

References

- BILGRAMI, K. S. AND DUBE, H. C., 1997, A Textbook of Modern Plant Pathology. Vikas Psublishing House Pvt. Ltd., New Delhi.
- GAUTAM, R. D., 1994, Biological Pest Suppression. Westvill Publishing House, New Delhi. Ghosh MR. 1989. *Concepts of Insect Control*. New Age International Publishers, New Delhi.
- GOVINDAN, R., RAMAKRISHNA NAIKA. AND SANNAPPA, B., 2004, *Advances in Disease and Pest Management in Sericulture*. Seri Scientific Publishers, Bangalore.
- GOVINDAN, R., RAMAKRISHNA NAIKA. AND SANNAPPA, B, 2004, *Progress of Research on Disease and Pest Management in Sericulture*. Seri Scientific Publishers, Bangalore.
- HUANG, E., 2003, *Protection of Mulberry Plants*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.

- METCALF, C. L., FLINT, W. P. AND METCALF, R. L., 1962, *Destructive and Useful Insects*. MacGraw-Hill Book Co. Inc., New York and London.
- NARAYANASWAMY, K. C. AND DEVAIAH, M. C., 1998, *Silkworm Uzi Fly*. Zen Publishers, Bangalore.
- NATARAJU, B., SATHYAPRASAD, K., MANJUNATH, D. AND ASWANI KUMAR, C., 2005, *Silkworm Crop Protection.* Central Silk Board, Bangalore.
- RANGASWAMI, G., 1996, *Diseases of Crop Plants in India*. Prentice Hall of India Pvt. Ltd., New Delhi.
- REDDY D. N. R. AND NARAYANASWAMY, K. C., 2003, *Pests of Mulberry*. Zen Publishers, Bangalore.
- SENGUPTA, K., KUMAR, P., BAIG, M. AND GOVINDAIAH,. 1990, *Handbook on Pest and Disease Control of Mulberry and Silkworm*. ESCAP, UN, Thailand.
- SINGH, R. N., SAMSON, M. V. AND DATTA, R. K., 2000, *Pest Management in Sericulture*. Indian Publishers, Delhi.
- SUKUMAR, J., DANDIN, S. B. AND BONGALE, U. D., 1994, *Mulberry Disease and Management.* KSSRDI, Bangalore.

Journals

- *Bulletins of Sericultural Experimental Station* – Suginami, Tokyo, Japan.
- *Journal of Sericultural Science of Japan* – Sericultural Experimental Station, Wade, Suginami-ku, Tokyo, Japan.
- *Sericologia* – Jacques Rousseau, 69350, La Mulatiere, France.
- *Indian Journal of Sericulture* – CSR & TI, Mysore.
- *Journal of Sericulture and Technology* – Published by NASSI, Bangalore.

- *Indian Silk* – Central Silk Board, Bangalore.
- *Bulletin of Indian Academy of Sericulture* – Bhubaneshwar, Orissa.
- *Reshme Krishi (Kannada)* – Department of Sericulture, Government of Karnataka, Bangalore.

Websites

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SER 505 BIOTECHNOLOGY OF MULBERRY (1+1)

Objective

- To provide both basic and applied knowledge on the subjects of tissue culture techniques, molecular markers and recombinant DNA technologies to PG students

Theory

Block 1: Mulberry biotechnology, scope and prospects

Unit 1: Mulberry biotechnology, scope and prospects

Scope of breeding for hardier and productive mulberry genotypes. Preservation of genetic material. Development of transgenic mulberry. Molecular linkage map of mulberry. Micropropagation: *In-vitro* propagation in mulberry-production of haploids- induction of haploids, advantages and disadvantages of haploids. Double haploid -induction, advantages and disadvantages of double haploids. Practical achievements of DH method, polyploids- Somaclonal variations, procedures, advantages, disadvantages and their application. Secondary metabolites. Gametoclonal variations – their scope and applications. Cryopreservation: Definition and meaning, Steps in cryopreservation, advantages and disadvantages, Cryopreservation requirements, applications of cryopreservation in mulberry for germplasm preservation.

Unit 2: Mulberry germplasm characterization

Mulberry germplasm characterization by using molecular markers. Introduction, features of ideal DNA markers, types of DNA markers, uses in crop improvement. Application of biotechnological tools in screening for biotic and abiotic stress tolerance in mulberry.

Unit 3: Genotyping and phenotyping

Introduction, definition of genotype and phenotype. Phenotyping-advantages and disadvantages. Methods of genotyping, advantages and disadvantages of genotyping and applications of genotyping. Marker Aided Selection (MAS) for economically important traits in mulberry. Steps involved in MAS, application of MAS, advantages of MAS, limitations of MAS.

Block 2: Recombinant DNA technology

Unit 1: **Genes transfer systems**

Vector mediated gene transfer, microinjection, electroporation, direct DNA uptake, gene gun technique, selectable markers and reporter system; comparison of transgenic technology and traditional breeding methods, detection of transgenic mulberry. Prospects of transgenic mulberry. Procedure of development of transgenic mulberry. Advantages and disadvantages of transgenic mulberry. Risks in transgenic technology. Biosafety and regulatory issues, Achievements.

Unit 2: QTL mapping

Development of maps, advantages and limitations of QTL mapping. Methods of mapping. Requirements and steps involved in QTL mapping. Mapping populations (F2S and back crosses RILs, NILs, DHs). Tagging of economically important traits in mulberry.

Unit 3: Seri bioinformatics

Bioinformatics in crop improvement-introduction, branches of bioinformatics, computer programmes used in biology, applications in crop improvement, varietal information system, PGR data base. Studies on Genomics- genomics in crop improvement, types of genomics: structural, functional and applications, achievements and limitations.

Studies on proteomics. Studies on metabolomics, advantages of bioinformatics, limitations. Intellectual Property Rights. Plant variety protection act (PVPA): introduction, types of protection, basic requirements, organizations involved, procedure of PVP, material to be protected, types of varieties, exemptions under PVPA, advantages and disadvantages of PVPA. Nano- technology: Introduction, main features, Application of nano-technology, application in mulberry improvement.

Practical

- Laboratory safety rules;
- Seri biotechnology lab and its facilities;
- Preparation of MS medium for tissue culture in mulberry;
- Selection, collection and preparation of plant material for mulberry tissue culture;
- Culturing of plant material/explant in culture media;
- Tissue culture techniques for mulberry propagation;
- Hardening of tissue cultured mulberry plants;
- Isolation of genomic DNA- mulberry leaf;
- Amplification of DNA in mulberry by using PCR;
- Study of diversity of mulberry germplasm by using molecular markers;
- Comparative study of diversity of mulberry germplasm through morphological traits and molecular markers;
- Techniques for gene transformation in mulberry;
- Different softwares used in QTL mapping;
- Molecular databases in mulberry;
- Visit to MAS lab in Department of Biotechnolgy, UAS, GKVK, Bengaluru;
- Visit to Seri-Biotechnology Research Laboratory, CSB, Kodathi, Bengaluru.

References

Text Books

- BURRELL, M. M., 1993, *Enzymes of Molecular Biology*. Humana Press Inc., NewYork.
- KENDREW, J., 1994, *The Encyclopedia of Molecular Biology*. Blackwell Scientific Publications, Oxford.
- OLD, R. W. AND PRIMROSE, S. B., 1994, *Principles of gene manipulation: An Introduction to genetic engineering*, 5th Ed. *Blackwell Scientific Publications*, U. S. A.
- HANSEN, G. AND WRIGHT, M. S., 1999, Recent advances in the transformation of plants. *Trends in Biotech.,* **13:** 324-331.
- VIJAYAN, K., 2004, Genetic relationship of Japanese and Indian mulberry (*Morus* spp.) genotypes as revealed by DNA fingerprinting. *Plant Syst. Evol.,***243**: 221-232.

Journals

- *Bulletins of Sericultural Experimental Station* – Suginami, Tokyo, Japan.
- *Journal of Sericultural Science of Japan* – Sericultural Experimental Station, Wade, Suginami-ku, Tokyo, Japan.
- *Sericologia* – ISC, Bangalore.
- *Indian Journal of Sericulture* – Published by CSR & TI, Mysore.
- *Journal of Sericulture and Technology* – NASSI, Bangalore.
- *Indian Silk* – Central Silk Board, Bangalore.
- *Bulletin of Indian Academy of Sericulture* – Bhubaneshwar, Orissa.
- *Reshme Krishi (Kannada)* – Department of Sericulture, Government of Karnataka, Bangalore.

Websites

- www.csb.gov.in/
- www.karnataka.gov.in/kssrdi/documents/2019/tender%20KC.pdf
- www.tnau.ac.in/
- www.csrtimys.res.in/

SER 506 SYSTEMATICS AND MORPHOLOGY OF SERICIGENOUS INSECTS (1+1)

Objective

- To inculcate basic understanding about systematics and to explore fauna among sericigenous group of insects.
- To understand morphological features of different stages of sericigenous insects.

Theory

Block 1: Systematics of sericigenous insects

Unit 1: Introduction, scope and methods

Introduction to systematics: Concept, scope and applications, methods involved in systematics with an emphasis on molecular methods.

Unit 2: Type concepts

Holotype, syntype, erection of type and preservation of type.

Unit 3: Preparation of keys

Key formation for sericigenous insects to identify orders, families, genera, species and tribes/ eco-races.

Unit 4: Zoological nomenclature

Binomial nomenclature; concept, scope and application.

Block 2: Morphological studies

Unit 1: Introduction to morphology

Introduction, general morphology with special reference to the morphology of sericigenous insects.

Unit 2: Morphology of integument

Structure, segmentation and out growths, body regions, appendages and other structures, their modifications in general.

Unit 3: Morphology of body segments and appendages

Morphology of head, thorax, abdomen and their appendages, antennae, mouthparts, setae, legs, cerci, styli and others. Morphology of reproductive organs – modifications.

References

- Study of head of sericigenous insects;
- Study of thorax and abdomen of sericigenous insects;
- Study of integument, their processes, out growths and setal maps;
- Preparation of temporary/ permanent slides to study the integument processes;
- Collection and preservation of specimens – whole specimen, dry/ wet preservation, labelling of the specimens;
- Study of type concept – hollotype, syntype and allotype;
- Preparation of keys to orders, families, genera, species and tribes;
- Study of different sericigenous insects;
- Study of chaetotaxy in sericigenous insects;
- Study of immature stages of silkworm *Bombyx mori* L.;
- Study of immature stages of Tropical Tasar silkworm;
- Study of immature stages of Eri silkworm;
- Study of Polymorphism in silkworm *Bombyx mori* L., tropical tasar and eri silkworm;
- Field visits for collection of non-mulberry silkworms;
- Collection and preservation of sericigenous insects (Dry preservation);
- Collection and preservation of immature stages of sericigenous insects (Wet preservation);
- Visit to Taxonomic section of department of entomology to understand preservation of specimens and their management.

References

- DILIP DE SARKAR., 1998, *The Silkworm – Biology, Genetics and Breeding*. Vikas Publishing House Pvt. Ltd., New Delhi.
- IMMS, A. D., 1961, *General Text Book of Entomology*. 9th Edn., Rev. by O.W. Richards & R.G. Davies, Bombay.
- SAXENA, A. B., 1996, *Development of Behaviour in Insects*. Anmol Publications Pvt. Ltd., New Delhi.

- SAXENA, A. B., 1996, *Principles of Insect Morphology*. Anmol Publications Pvt. Ltd., New Delhi.
- SAXENA, A. B., 1996, *Ecology of Insects.* Anmol Publications Pvt. Ltd., New Delhi.
- CHAPMAN, R. F., 2013, *The Insects: Structure and Function,* Cambridge University Press. NY.

Journals

- *Bulletins of Sericultural Experimental Station* - Suginami, Tokyo, Japan.
- *Journal of Sericultural Science of Japan* - Sericultural Experimental Station, Wade, Suginami-ku, Tokyo, Japan.
- *Sericologia* – ISC, Bangalore.
- *Indian Journal of Sericulture* - CSR & TI, Mysore.
- *Journal of Sericulture and Technology* - Published by NASSI, Bangalore.
- *Indian Silk* - Central Silk Board, Bangalore.
- *Bulletin of Indian Academy of Sericulture* - Bhubaneshwar, Orissa.
- *Reshme Krishi (Kannada)* - Department of Sericulture, Government of Karnataka, Bangalore.

Websites

- www.csb.gov.in/
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- www.tnau.ac.in/
- www.csrtimys.res.in/

SER 507 ANATOMY AND PHYSIOLOGY OF SERICIGENOUS INSECTS (1+1)

Objective

- This course is designed to provide basic knowledge on anatomy-internal organs/systems, and their functions.
- To know about the physiology of sericigenous insects and its importance in crop production.

Theory

Block 1: Anatomy of sericigenous insects

Unit 1: Introduction, scope and importance

Structure of the various internal systems. The scope of the study for their application aspects and its importance for future research work.

Unit 2: Anatomical studies of various systems

Digestive, circulatory, respiratory, excretory, muscular, reproductive and nervous systems (including central, visceral and peripheral) and sense organs of larva, pupa and adult. Endocrine and exocrine glands (including silkglands).

Unit 3: Comparison of anatomical structures among various sericigenous insects

Variation of anatomical structures in different life stages, *viz*., larva, pupa and adult among different sericigenous insects mulberry, tasar, eri and muga.

Block 2: Physiology of silkworms

Unit 1: Introduction, scope and importance

Relation of anatomical structure with function, role in growth and development.

Unit 2: Physiology of different systems

Physiology of digestive, circulatory, respiratory, excretory, muscular, reproductive and nervous systems, endocrine and exocrine glandular systems, hormonal mechanism, enzymes, pheromones, nutritional role of vitamins and other growth factors. Properties of

haemolymph, histology, nerve impulses, sensory physiology. Silkglands and silk sysnthesis.

Unit 3: Silkworm nutrition

Qualitative and quantitative nutritional requirement of silkworms, vitamins, carbohydrates, proteins and role of microbes in nutrition. Preparation of artificial/synthetic diets for silkworms.

Practical

- Study of digestive system of mulberry silkworm and silk moth;
- Study of excretory system of mulberry silkworm and silk moth;
- Study of digestive system of larva of eri silkworm;
- Study of circulatory and reproductive system in mulberry silkworm;
- Study of circulatory and reproductive system in eri silkworm;
- Study of nervous system and endocrine glandular system mulberry silkworm larvae and eri silkworm;
- Study of silk glands in mulberry silkworm, tasar, eri and muga silkworms;
- Study of properties of haemolymph of mulberry, eri and tasar silkworms;
- Study of physiology of digestion and excretion in mulberry silkworm;
- Study of physiology of circulation and nervous system of mulberry silkworm;
- Study of physiology of reproductive system in mulberry silkworm;
- Study of physiology of silk protein synthesis;
- Study of endocrine systems, diapause and hibernation;
- Preparation of artificial diets/synthetic diets;
- Study of comparative anatomy of digestive system of pupa and adult of mulberry silkworm;
- Study of comparative anatomy of digestive system of pupa and adult of Eri silkworm;
- Visit to sericulture institutes.

References

- ATHER, H. SIDDIQI., 1982, *Experimental Physiology*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
- BECK, S. D., 1963, *Animal Photoperiodism.* Holt, Holt Library of Science Series, New York.
- BECK, S. D., 1980, *Insect Photoperiodism.* Academic Press, New York.
- GILMOUR, D., 1961, *Biochemistry of Insects.* Academic Press, New York.
- GOLDSMITH, M. R. AND FRANTISEK MAREC., 2010. *Molecular Biology and Genetics of the Lepidoptera.*CRC Press Taylor & Francis Group, Broken Sound Parkway NW, USA.
- GOVINDAN BHASKARAN, STANLEY FRIEDMAN. AND RODRIGUEZ, J. G., 1981,. *Current Tropics in Insect Endocrinology and Nutrition*. Plenum Press, New York and London.
- MOROHOSHI, S., 2000, *Development Physiology of Silkworms*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
- SAXENA, A. B., 1996,. *Hormones of Insects*. Anmol Publications Pvt. Ltd., New Delhi.
- STURNIKOV, V. A., 1976, *Control of Silkworm Development and Sex*. MIR Publishers, Moscow.
- WIGGLESWORTH, V. B., 1956, *Insect Physiology.* 5th Edn., Rev. Methuen, London.

Journals

Text Books

- *Bulletins of Sericultural Experimental Station* – Suginami, Tokyo, Japan.
- *Journal of Sericultural Science of Japan* – Sericultural Experimental Station, Wade, Suginami-ku, Tokyo, Japan.
- *Sericologia* – ISC, Bangalore.
- *Indian Journal of Sericulture* – CSR & TI, Mysore.

- *Journal of Sericulture and Technology* – Published by NASSI, Bangalore.
- *Indian Silk* – Central Silk Board, Bangalore.
- *Bulletin of Indian Academy of Sericulture* – Bhubaneshwar, Orissa.
- *Reshme Krishi* (*Kannada*) – Department of Sericulture, Government of Karnataka, Bangalore.

Websites

- www.csb.gov.in/
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- www.tnau.ac.in/
- www.csrtimys.res.in/

SER 508 SILKWORM BIOCHEMISTRY AND NUTRITION (1+1)

Objective

- The course on silkworm biochemistry and nutrition will aim at enlightening the students on importance of raising silkworm on suitable mulberry leaves that nourish silkworm so as to undoubtedly infer the impact of treatments imposed during the experimentation.
- They will be competent enough to emphasis on the application of balanced nutrition to mulberry

Theory

Block 1: Nutrients for silkworm

Unit 1: Requirement of nutrients to silkworm

Carbohydrate, protein and fat metabolism, chemical nature of vitamins and hormones. Nutritional requirements of amino acids, lipids, vitamins, minerals. Qualitative and quantitative requirements of nutrients.

Unit 2: Metabolism and Utilization of nutrients

Metabolism of amino acids, lipids, vitamins, minerals, leaf composition affecting silkworm growth, feed efficiency, supplementation of nutrients.

Block 2: Biochemistry of nutrient utilization

Unit 1: Biochemical pathway for survival and cocoon production

Physiology of moulting, egg and pupal diapause in silkworm, biochemical pathways of silk synthesis and biochemistry of haemolymph.

Practical

- Qualitative tests for carbohydrates in silkworm heamolymph;
- Quantitative estimations of total soluble sugars in silkworm heamolymph;
- Qualitative tests for proteins and free amino acids in silkworm heamolymph;
- Quantitative estimations of proteins in silkworm heamolymph;
- Qualitative tests for lipids in silkworm heamolymph;
- Quantitative estimation of lipids in silkworm heamolymph;
- Determination of ascorbic acid level in the mulberry leaves;
- Determination of ascorbic acid level in silkworm heamolymph;
- Study of amylase activity in silkworm digestive juice and haemolymph;
- Study of phosphatase activity in silkworm digestive juice and haemolymph;
- Study of esterase activity in silkworm egg, larval haemolymph and silk glands;
- Qualitative tests for phospholipids and cholesterol in silkworm tissues;
- Quantitative estimation of phospholipids and cholesterol in silkworm tissues;
- Study of food consumption indices in silkworm;
- Estimation of lipid biomass in different silkworm breeds;
- Estimation of silk gland biomass in different silkworm breeds;
- Study of isozymes of different enzymes associated with silk productivity;

- Visit to Seri Bio-technology research laboratory/CSGRC.

References

- HAMAMURA, Y., 2001, *Silkworm rearing on Artificial Diet*. Oxford & IBH Publishing Co. Pvt., New Delhi. p. 287.
- MOROHOSHI, S., 2000, *Development Physiology of Silkworms*. Oxford & IBH Publishing Co. Pvt., New Delhi. p. 287.
- REDDY, D. N. R, NARAYANASWAMY, K. C., MANJUNATH GOWDA. AND JAYARAMAIAH, M., 2005, *Morphology and Anatomy of Silkworms*. CVG Books, Bangalore. p. 133.
- TAZIMA, Y., 1978, *The Silkworm- An Important Laboratory Tool*. Kodansha Ltd., Tokyo. p. 307.

Journals

- *Bulletins of Sericultural Experimental Station* – Suginami, Tokyo, Japan.
- *Journal of Sericultural Science of Japan* – Sericultural Experimental Station, Wade, Suginami-ku, Tokyo, Japan.
- *Sericologia* – ISC, Bangalore.
- *Indian Journal of Sericulture* – CSR & TI, Mysore.
- *Journal of Sericulture and Technology* – Published by NASSI, Bangalore.
- *Indian Silk* – Central Silk Board, Bangalore.
- *Bulletin of Indian Academy of Sericulture* – Bhubaneshwar, Orissa.
- *Reshme Krishi* (*Kannada)* – Department of Sericulture, Government of Karnataka, Bangalore.

Websites

- www.csb.gov.in/
- www.karnataka.gov.in/kssrdi/documents/2019/tender/20KC.pdf
- www.tnau.ac.in/
- www.csrtimys.res.in/

SER 509 SILKWORM EGG PRODUCTION TECHNOLOGY (1+1)

Objective

- The course is formulated with the aim of equipping the PG students with best scientific and practical knowledge on all the activities of egg production
- To emphasis on organizational setup of seed production and silkworm seed acts.

Theory

Block 1: Organization of egg production

Unit 1: Three tier multiplication of silkworm seeds

Organization of egg production, breeder stock, foundation stock and commercial egg production (egg cards and loose egg preparation).

Unit 2: Seed Act

State Seed Acts and Central Seed Act 2010.

Block 2: Grainage

Unit 1: Establishment of grainage

Location of grainage, plan of grainage, grainage equipment and egg production capacity.

Unit 2: Grainage activities

Seed areas, seed cocoon market, selection of parent seed, procurement and transportation of seed cocoons, sorting, storage, handling and processing of seed cocoons. Sex separation in pupal stage, moth emergence, synchronization of moth emergence, pairing, depairing, mother moth examination, laying preparation on egg cards/ loose egg production, rejection of defective eggs, disinfection, washing, refrigeration and incubation of eggs.

Block 3: Hybrid egg production

Unit 1: Production of hybrid eggs

Production of hybrid seeds (Multivoltine × Bivoltine), (Bivoltine × Bivoltine), (Bivoltine × Bivoltine) × (Bivoltine × Bivoltine) (Double

Cross Hybrid). Grainage pests. Economics of egg production.

Unit 2: Artificial methods of hatching

Artificial methods of hatching of bivoltine eggs - cold and hot acid treatments, other physical and chemical methods of breaking hybernation, hybernation schedules.

Practical

- Silkworm breeds and their classification;
- Study of ground plan of model grainage building;
- Study of grainage equipments;
- Preliminary examination of seed cocoons for production of dfls, study of handling and processing of seed cocoons;
- Study of sex separation at pupal and adult stages;
- Study of silkworm egg incubation;
- Study of silkworm egg hibernation schedules;
- Study of grainage pests and their management;
- Preservation of male moths for reuse;
- Preservation of male and female pupae for synchronization;
- Effect of mating duration on egg production and fertility status of eggs;
- Disinfection of grainage equipments;
- Designation of multivoltine and bivoltine seed areas in Karnataka;
- Estimation of cocoon requirement for production of unit number of DFLs;
- Production of non-hibernating eggs of silkworm;
- Production of hibernating eggs of silkworm (on egg cards and loose egg preparation);
- Artificial hatching of silkworm eggs through acid treatment;
- Economics of silkworm egg production.

References

- ANONYMOUS., 1997, *Silkworm Egg Production*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
- DANDIN, S. B. AND GUPTA, V. P., 2002, *Advances in Indian Sericulture Research*. CSR&TI, Mysore.
- DATTA, R. K., 1996, *Global Silk Scenario – 2001. Proceedings of the International Conference on Sericulture – 1994,* Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
- NARASIMHANNA, M. N., 1998, *Manual on Silkworm Egg Production.* CSB, Bangalore.

Journals

- *Bulletin of Sericultural Experimental Station* - Suginami, Tokyo, Japan.
- *Journal of Sericultural Science of Japan* - Sericultural Experimental Station, Wade, Suginami-ku, Tokyo, Japan.
- *Sericologia* – ISC, Bangalore
- *Indian Journal of Sericulture* - CSR & TI, Mysore.
- *Journal of Sericulture and Technology* - NASSI, Bangalore.
- *Indian Silk* - Published by Central Silk Board, Bangalore.
- *Bulletin of Indian Academy of Sericulture* - Bhubaneshwar, Orissa.
- *Reshme Krishi (Kannada)* - Department of Sericulture, Government of Karnataka, Bangalore.
- *Current Science* – Indian Institute of Science, Bangalore.

Websites

- www.csb.gov.in/
- www.karnataka.gov.in/kssrdi/documents/2019/tender%20KC.pdf
- www.tnau.ac.in/
- www.csrtimys.res.in/

SER 510 SILKWORM REARING TECHNOLOGY (1+1)

Objective

- The course is designed with the aim of equipping the PG students with the best scientific knowledge and technical expertise in the field of silkworm rearing technology to achieve successful and quality silkworm cocoon production

Theory

Block 1: Planning for silkworm rearing

Unit 1:Chawki and late age silkworm rearing

Planning for rearing, criteria to be considered for rearing, plan of rearing house for chawki and late age silkworm rearing, rearing equipment, measurement and regulation of environmental factors.

Unit 2: Disinfection and disinfectants

Different types of disinfectants used during silkworm, disinfection of rearing room and equipment.

Unit 3: Mulberry leaf preservation

Harvesting, transportation and preservation of mulberry leaves.

Unit 4: Incubation of silkworm eggs

Different methods of incubation of silkworm eggs, black-boxing, hatching and brushing.

Block 2: Silkworm rearing

Unit 1: Early instar silkworm rearing

Early instar silkworm (Chawki) rearing, different methods, environmental conditions, quality of leaf, feeding, bed cleaning, spacing. Chawki rearing centres – importance and scope.

Unit 2: Late age silkworm rearing

Different methods of late age silkworm rearing, environmental conditions, quality of leaf, feeding, bed cleaning and spacing. Management of silkworm during moulting. Rearing house and equipment for shoot method of rearing. Advantages and dis-advantages of shoot rearing.

Block 3: Mounting, harvesting and marketing of silk cocoon

Unit 1: Mounting of ripe silkworms and cocoon marketing

Identification and mounting of ripe silkworms, different kinds of mountages and mountage sheds, care during mounting. Harvesting, cleaning and grading of cocoons, transportation and marketing of cocoons (e-transaction).

Practical

- Ground plan for model silk worm rearing house for shelf method of rearing;
- Chemical and physical agents used in silkworm rearing and disinfection;
- Rearing equipment for shelf method of rearing;
- Incubation of silk moth eggs and black- boxing;
- Hatching and brushing;
- Early instar silkworm rearing;
- Late age silkworm rearing;
- Regulation of environmental conditions for silkworm rearing;
- Harvesting and preservation of mulberry leaf;
- Management of silkworms during moulting;
- Mounting of ripe silkworms;
- Cocoon harvesting, grading, transportation and marketing;
- Rearing house and equipment for shoot method of rearing;
- Shoot feeding for late age silkworm rearing;
- Harvesting and preservation of mulberry shoots;
- Spacing and bed cleaning in shoot feeding method of silkworm rearing;
- Economics of silkworm rearing;
- Rearing from brushing to mounting for seed and silk production.

References

- ANONYMOUS., 1998, *Illustrated Textbook on Sericulture*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
- BORAIAH, G., 1994, *Lectures on Sericulture*. SBS Publishers, Bangalore.
- DANDIN, S. B. AND GUPTA, V. P., 2002, *Advances in Indian Sericulture Research*. CSR&TI, Mysore.
- DANDIN, S. B., JAYANT JAYASWAL. AND GIRIDHAR, K., (Eds.), 2003, *Handbook of Sericulture Technologies*. CSB, Bangalore.
- DATTA, R. K., 1996, *Global Silk Scenario – 2001. Proceedings of the International Conference on Sericulture – 1994.* Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
- GOVINDAN, R., CHINNASWAMY, K. P., KRISHNAPRASAD, N. K. AND REDDY, D. N. R., 2000, *Advances in Tropical*
- *Sericulture. Vol. 4– Proceedings of NSTS – 1999,* UAS, Bangalore.
- GOVINDAN, R., DEVAIAH, M. V. AND RANGASWAMY, H. R., 1978, *Reshme Vyavasaya (Kannada)*. UAS, Bangalore.
- HIROO AND SIBUYA-KU., 1975, *Textbook of Tropical Sericulture.* Japan Overseas Corporation, Volunteers, Tokyo, Japan.
- KRISHNASWAMI, S., NARASIMHANNA, M. N., SURYANARAYAN, S. K. AND KUMARARAJ, S., 1973, *Sericulture Manual-2 - Silkworm Rearing.* Agriculture Service Bulletin, FAO, Rome.
- RAJAN, R. K. AND HIMANTHARAJ, H. T., 2005, *Silkworm Rearing Technology.* Central Silk Board, Bangalore.
- RAMAKRISHNA NAIKA., GOVINDAN, R. AND SANNAPPA, B., 2002, *Organic Sericulture*. Seri Scientific Publishers, Bangalore.
- TANAKA, Y., 1964, *Sericology*. Central Silk Board, Bangalore.
- TAZIMA, Y., 1972, *Handbook of Silkworm Rearing.* Fuji Pub.Co. Ltd., Tokyo, Japan.
- ULLAL, S. R. AND NARASIMHANNA, M. N., 1981, *Handbook of Practical Sericulture*. CSB, Bangalore.

- YASUJI HAMAMURA., 2001, *Silkworm Rearing on Artificial Diet.* Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
- YONEMURA, M. AND RAMA RAO, N., 1925, *Handook of Sericulture*. Mysore Government Branch Press.

Journals

- *Bulletin of Sericultural Experimental Station* - Suginami, Tokyo, Japan.
- *Journal of Sericultural Science of Japan* - Sericultural Experimental Station, Wade, Suginami-ku, Tokyo, Japan.
- *Sericologia* – ISC, Bangalore.
- *Indian Journal of Sericulture* - CSR & TI, Mysore**.**
- *Journal of Sericulture and Technology* - NASSI, Bangalore.
- *Indian Silk* - Central Silk Board, Bangalore.
- *Bulletin of Indian Academy of Sericulture* - Bhubaneshwar, Orissa.

Websites

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SER 511: GENETICS AND BREEDING OF SILKWORMS (1+1)

Objective

- The course is designed to provide both basic and applied knowledge on the subjects of silkworm genetics and principles of silkworm breeding
- The subject is addressed to understand reproductive biology, hereditary traits and principles of silk worm breeding and accomplishments

Theory

Block 1: Genetics of silkworm

Unit 1: Cytology

Ancestor and cytological basis of origin of silkworms. Cytological aspects of silkgland and achievements in deciphering molecular biology of silk gene. Hormonal control mechanisms.

Unit 2: Reproductive biology

Phenomena of spermatogenesis and oogenesis with relevance to crossing over, cell division types in silkworms, synaptonemal complex, fertilization, chromosomes in silkworms. Sex determination, parthenogenesis, polyploidy, mosaics.

Unit 3: Inheritance of characters,

Hereditary traits of importance in egg, larva, pupa-cocoon and adult. E- Group as a tool in genetics and significance. Linkage groups in silkworms. Sex-linked inheritance, Quantitative and Qualitative Characters in silkworm breeding. Genetics of cocoon colours. *Bombyx mori* L. genome and latest genome sequence, Translocation of characters in metamorphic stages.

Block 2: Breeding of silkworm

Unit 1: Silkworm breeding resources

Multivoltine and bivoltine races and hybrids. Silkworm germplasm and resource potential.

Unit 2: Methods of silkworm breeding

Methods of silkworm breeding and their importance with relevance to Indian scenario. Breeding for thermotolerance, disease resistance and special characters required for the domestic market and also for silk export. Sex linked and sex-limited races- their importance and need of the hour, Authorization and release of silkworm races.

Practical

- Study of mitosis and meiosis in silkworm;
- Study of oogenesis in silkworm;
- Study of spermatogenesis and fertilization in silkworm;
- Study of important hereditary traits in egg and larva of silkworm *Bombyx mori* L.;

- Study of important hereditary traits of pupa and cocoons of silkworm *Bombyx mori* L.;
- Study of important hereditary traits of adult *Bombyx mori* L.;
- Study of Marker genes and linkage groups in silkworm;
- Study of heterosis - working out heterosis, heterobeltiosis and standard heterosis for economic characters;
- Study of silkworm germplasam;
- Study of biometrical methods in silkworm breeding;
- Study of modern methods of silkworm breeding;
- Study of induction of parthenogenesis in silkworm breeds;
- Study of induction of polyploidy in silkworm breeds;
- Study of conventional methods of silkworm breeding;
- Study of breeding of newly evolved silkworm breeds;
- Study of breeding of non-mulberry silkworms;
- Study of silkworm breeding plans;
- Visit to CSGRC,CSB, Hosur.

References

- ANONYMOUS., 1993, *Principles and Techniques of Silkworm Breeding*. ESCAP, UN, New York. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi. p.111.
- GARDNER, E. J, SIMMONS, M. J. AND SNUSTAD, D. P., 1991, *Principles of Genetics,* John Willey& Sons Inc., New York. p. 649.
- HIRATSUKA, E., 1999, *Silkworm Breeding*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi. p. 500.
- JOLLY, M. S, SEN, S. K, SONWALKER, T. N. AND PRASAD, G. K., 1979, *Non-mulberry Silks*. FAO – Agricultural Service Bulletin, Rome. p. 178.
- KOVALEV, P. A., 1970, *Silkworm Breeding Stocks*. Central Silk Board, Bombay. p. 233.
- SARKER, D. D., 1998, *The Silkworm Biology, Genetics and Breeding.* Vikas Publishing House Pvt. Ltd., New Delhi. p. 338.

- SARIN, C., 1990, *Genetics.* Tata McGraw – Hill Publishing Co. Ltd., New Delhi. p. 528.
- SINGH, B. D., 1997, *Plant Breeding: Principles and Methods.*Kalyani Publishers, New Delhi. p. 702.
- SINGH, R. K. AND CHAUDHARY, B. D., 1996, *Biometrical Methods in Quantitative Genetic Analysis*.
- KALYANI PUBLISHERS, New Delhi. p. 318.
- SREERAMAREDDY, G., 1998, *Silkworm Breeding*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
- TAZIMA, Y., 1964, *The Genetics of Silkworm*. Logos Press Ltd., London. p. 253.

Journals

- *Bulletins of Sericultural Experimental Stat*ion - Suginami, Tokyo, Japan.
- *Journal of Sericultural Science of Japan* - Sericultural Experimental Station, Wade, Suginami-ku, Tokyo, Japan.
- *Sericologia* – ISC, Bangalore.
- *Indian Journal of Sericulture* - CSR & TI, Mysore.
- *Journal of Sericulture and Technology* - NASSI, Bangalore.
- *Indian Silk* - Published by Central Silk Board, Bangalore.
- *Bulletin of Indian Academy of Sericulture* - Bhubaneshwar, Orissa.
- *Reshme Krishi (Kannada*) - Department of Sericulture, Government of Karnataka, Bangalore.
- *Current Science* – Indian Institute of Science, Bangalore.

Websites

- www.csb.gov.in/
- www.karnataka.gov.in/kssrdi/documents/2019/tender%20KC.pdf
- www.tnau.ac.in/
- www.csrtimys.res.in/

SER 512 DISEASES AND PESTS OF SILKWORM (1+1)

Objective

- The course will address disease causing pathogen, etiology, symptoms, sources of infection, predisposing factors, transmission, diagnosis of different pathogens, regulation of environmental factors, prevention and control of diseases
- To know about pests of mulberry and non-mulberry silkworms, nature and extent of damage, life-cycle and management, other pests and predators effecting silkworm crop and their management

Theory

Block 1: Silkworm diseases and their management

Unit 1: Importance and classification

Taxonomic position of silkworm disease causing organisms including viruses, bacteria, fungi, protozoans and pests causing economic loss to silkworms, and their importance**.**

Unit 2: Silkworm pathogens, disease development and diagnosis

Occurrence, causative agent, symptoms and infection, source of infection, predisposing factors, seasonal incidence, transmission and management of the pathogens individually including viral, fungal, bacterial, protozoan and mixed infections. Diagnosis of different pathogens based on symptoms (external and internal), patho-physiology and histopathology.

Unit 3: Management of silkworm diseases

Comparative etiology of silkworm pathogens. Management, prevention and control of diseases of silkworms, regulation of predisposing and environmental factors contributing to diseases, rearing disease resistant breeds of silkworm. Management of alternative hosts of silkworm disease causing pathogens (lepidopteran crop pests and pests of mulberry). Intergrated disease management.

Block 2: Silkworm pests and their management

Unit 1: Ujifly, *Exorista bombycis* Louis - a major pest of silkworms

History and taxonomy, bio-ecology, life cycle - egg, maggot, pupa, adult, oviposition, damage and extent of damage caused, prevention and control, biological control and IPM.

Unit 2: Other pests and predators affecting silkworm crop and their management

Pests and predators causing loss to silkworms and cocoons, type of damage, management. Straw itch mite, life cycle, kind of damage, management. Dermestid beetles, classification, life cycle, nature of damage, management. Rats, squirrels, lizards, earwigs, etc.,

Unit 3: Pesticide toxicity

Poisoning by agricultural chemicals to silkworms, acute and chronic symptoms of poisoning by different agricultural chemicals. Residual toxicity of chemicals on mulberry and damage caused, prevention and control.

Practical

- Sterilization techniques for isolation of silkworm pathogens;
- Isolation and purification of *Bm*NPV;
- Isolation and purification of *Bm*CPV;
- Isolation and purification of *Bm*IFV and *Bm*DNV;
- Isolation and purification of white muscardine fungus *Beauveria bassiana* from silkworm *Bombyx mori;*
- Isolation and purification of brown muscardine fungus *Aspergillus tamarii* from silkworm *Bombyx mori;*
- Isolation and purification of bacteria from the gut and haemolymph of silkworm *Bombyx mori;*
- Study of life cycle, symptoms and diagnosis of *Bm*NPV;
- Study of life cycle, symptoms and diagnosis of *Bm*CPV;
- Study of life cycle, symptoms and diagnosis of *Bm*IFV and *Bm*DNV;
- Study of life cycle, symptoms and diagnosis of silkworm microsporidiosis;

- Study of life cycle, symptoms and diagnosis of white and green muscardines;
- Study of bacteria invading the digestive system and haemolymph;
- Study of bacterial toxicosis in mulberry silkworm;
- Intergrated management for prevention of silkworm diseases;
- Study of life-cycle of silkworm ujifly and its management;
- Study of life cycle and management of dermestid beetles;
- Visit to sericulture farmer's fields.

References

Text Books

- Dandin, S. B. and Giridhar, K., 2014, *Handbook of Sericulture Technologies*; Central Silk Board, Ed., Dr., pp 247.
- GOVINDAN, R., NARAYANASWAMY, T. K. AND DEVAIAH, M. C. 1998. *Principles of Silkworm Pathology,* p.420.
- NATARAJU, B., SATHYAPRASAD, K., MANJUNATH, D. AND ASWANI KUMAR, C., 200, *Silkworm Crop Protection*. Central Silk Board, Bangalore, pp. 1-285.
- PRINGLE JAMESON, A., 1984, *Report on the Diseases of Silkworms in India*, IBS, New Delhi, pp.1-64.

Journals

- *Bulletins of Sericultural Experimental Station* - Suginami, Tokyo, Japan.
- *Journal of Sericultural Science of Japan* - Sericultural Experimental Station, Wade, Suginami-ku, Tokyo, Japan.
- *Sericologia* – ISC, Bangalore.
- *Indian Journal of Sericulture* - CSR & TI, Mysore.
- *Journal of Sericulture and Technology* - NASSI, Bangalore.
- *Indian Silk* - Published by Central Silk Board, Bangalore.
- *Bulletin of Indian Academy of Sericulture* - Bhubaneshwar, Orissa.

- *Reshme Krishi (Kannada)* - Department of Sericulture, Government of Karnataka, Bangalore.

Websites

- www.karnataka.gov.in/kssrdi/documents/2019/tender%20KC.pdf
- www.tnau.ac.in/
- www.csrtimys.res.in/

SER 513 BIOTECHNOLOGY OF SILKWORM (1+1)

Objective

- The course is aimed to provide knowledge on biotechnological methods and their application in silkworm crop improvement
- The course will address the available biotechnological methods and approaches that can be applied in the field of sericulture

Theory

Block 1: Biotechnological tools Unit

Unit 1: Tissue culture techniques

Development of polyploids, gametoclonal variations - their scope and applications. Cryopreservation.

Unit 2: Biotechnological methods

Biotechnology and its scope in silkworm, recombinant DNA technology, gene transfer systems-vector mediated gene transfer, microinjection, electroporation, direct DNA uptake, gene gun technique, selectable markers and reporter system. Molecular markers.

Block 2: Application of biotechnology in silkworm

Unit 1: Molecular characterization and mapping

Mulberry silkworm germplasm characterization by using molecular markers, Development of maps, QTL mapping, MAS for economically important traits in silkworm, Mapping populations (F2S and back crosses RILs, NILs, DHs), Molecular mapping and tagging of economically important traits.

Unit 2: Transgenics, Bioinformatics and biosafety

Transgenic silkworm – prospects and achievements in silkworm. Silkworm as a bioreactor for foreign gene expression, molecular aspects of silk synthesis. Application of biotechnological tools in screening for biotic and abiotic stress resistance. Biosafety and regulatory issues, Intellectual Property Rights. Seri bioinformatics. Genomics-structural, functional and applications.

Practical

- Seri biotechnology lab and its facilities;
- Preparation of insect tissue culture (Grace's) medium for silkworm tissue culture;
- Selection and preparation of organs for silkworm tissue culture;
- Application of tissue culture in physiological and genetical studies;
- Isolation of silkworm genomic DNA;
- Amplification of silkworm DNA in mulberry using PCR;
- Isolation of RNA from silkworm haemolymph and RT-PCR techniques;
- Study of diversity of silkworm germplasm by using molecular markers;
- Comparative study of diversity of silkworm germplasm through morphological traits and molecular markers;
- Techniques for gene transformation in silkworm;
- Molecular databases of silkworm;
- Visit to MAS lab in Department of Biotechnolgy, UAS, GKVK, Bengaluru;
- Visit to Seri-Biotechnology Research Laboratory, CSB, Kodathi, Bengaluru.

References

- DANDIN, S. B. AND NAIK, G., 1970, *Biotechnology in Mulberry* (*Morus* spp.) *Crop Improvement: in Plant Biotechnology and Molecular Markers*: 206-216

• GOPINATHAN, K. P., 1992, Biotechnology in sericulture, *Current Science*, 62(3): 283-287.

Journals

- *Bulletins of Sericultural Experimental Station* – Suginami, Tokyo, Japan.
- *Journal of Sericultural Science of Japan* – Sericultural Experimental Station, Wade, Suginami-ku, Tokyo, Japan.
- *Sericologia* – ISC, Bangalore.
- *Indian Journal of Sericulture* – Published by CSR & TI, Mysore.
- *Journal of Sericulture and Technology* – Published by NASSI, Bangalore.
- *Indian Silk* – Published by Central Silk Board, Bangalore.
- *Bulletin of Indian Academy of Sericulture* – Bhubaneshwar, Orissa.
- *Reshme Krishi* (*Kannada*) – Department of Sericulture, Government of Karnataka, Bangalore.

Websites

- www.csb.gov.in/
- www.karnataka.gov.in/kssrdi/documents/2019/tender%20KC.pdf
- www.tnau.ac.in/
- www.csrtimys.res.in/

SER 514 SILK TECHNOLOGY (1+1)

Objective

- The course is designed to make the students to get acquainted with activities in different reeling units operated both in private and government sectors
- The course will help in learning all techniques of silk reeling for quality raw silk production
- To provide knowledge on management of reeling units and utilization of reeling waste for by-product production

Theory

Block 1: Cocoon as raw material for reeling

Unit 1: Physical characteristics

Introduction; Importance and uses of silk, cocoon quality. Physical characteristics- cocoon colour, shape, size, wrinkles, uniformity and compactness.

Unit 2: Commercial characteristics

Cocoon weight, shell weight, shell percentage, filament length, denier, non-breakable filament length, reelability and raw silk percentage.

Block 2: Transaction of cocoons

Unit 1: Defective cocoons

Types of defective cocoons, reasons for defects in cocoons, cocoon sorting, methods of sorting. Selection of raw material for silk reeling – scientific method of testing and classification of cocoons.

Unit 2: Cocoon marketing

Marketing based on visual observation and based on quantitative parameters, open auction system (Quality based pricing) and E-transaction.

Block 3: Steps in silk reeling

Unit 1: Cocoon stifling

Definition, different methods of stifling of cocoons - sun drying, steam stifling, hot air drying (shelf carrier type, Tunnel type, Band type-hot air circulating, air heating type and one step band type) and other methods. Effect of stifling on storage. Moisture percentage, drying percentage, equilibrium moisture percentage. Effect of cocoon thickness and compactness on cocoon stifling, advanced system of cocoon stifling and machineries.

Unit 2: Cocoon cooking and brushing

Cocoon cooking- objectives of cocoon cooking, effect of pressure and temperature on infiltration of water into cocoon cavity, swelling of sericin layer. Different methods of cooking (open pan, two pan and three pan cooking system). Brushing of cocoons, different methods of brushing. Effect of temperature on solubility of sericin and fibroin layers, dipping period and brushing.

Unit 3: Cocoon reeling

Cocoon reeling- definition, different methods of reeling (Open/ Floating/ Sunken), Importance of croissure, length of the croissure and croissure angle on silk reeling. Reeling machinary – Silk reeling on charaka, cottage basin, multiend, semi automatic and automatic reeling machines (ARM).

Unit 4: Re-reeling

Re-reeling, reel permeation, different methods of permeation, re-reeling methods, advantages and disadvantages of open re-reeling and closed type of re-reeling.

Unit 5: Reeling water

Reeling water: Different sources of water used in reeling, characteristics/ properties of water (Impurities of water), physical and chemical properties of water, importance of reeling water, water qualities suggested by Kim and amelioration of water, different methods of amelioration (aeration, filtration, sedimentation and ion exchange method), amelioration of reeled water and reuse of water after treatment.

Block 4: Silk testing and examination

Unit 1: Different methods of silk examination

Different silk examination methods, lacing, book and bale making.

Unit 2: Silk testing and grading

Grading of raw silk based on I.S.A., silk testing tools for physical (visual inspection) and mechanical properties of silk. Procedure adopted for conducting physical and mechanical properties of silk and equipment used for testing of raw silk.

BLOCK 5: Post reeling technology

Unit 1: Doubling, twisting and weaving

Silk throwing, weaving, warping and pern winding (wefting), silk doubling and twisting, by-products of reeling units, types of reeling waste (brushing waste, reeling waste, cooking waste, re-reeling waste, throwing waste and pelade layer) as raw material for spun silk industry.

Unit 2: Marketing of raw silk

Factors influencing the assessment of raw silk quality. Role of silk exchange, auctioning of raw silk based on physical and mechanical properties and economics of silk reeling.

Practical

- Classification of cocoons of different silkworm breeds;
- Study of physical and commercial characters of cocoons;
- Study of mode and time of cocoon transportation and marketing;
- Cocoon sorting, methods and estimation of defective cocoons;
- Cocoon stifling methods and estimation of drying and moisture percentage;
- Practicing of cocoon cooking and brushing methods;
- Estimation of reeling and cooking waste percentage;
- Reeling appliances and practising reeling on Charaka and improved Charaka;
- Study of reeling appliances and practising reeling on Cottage basin and Domestic basin;
- Visit to government filature to acquaint with large scale reeling on Multiend reeling machine;
- Visit to Automatic reeling machine unit at Ramanagara;
- Silk examination, skein making and book making;
- Study of reeling water and its quality;
- Amelioration of silk reeling water and its importance;
- Study of physical properties of mulberry raw silk;
- Study of Microscopic examination of silk bave;
- Study of quality tests of raw silk and by-products of silk reeling;
- Visit to Central silk technological research institute, Bengaluru.

References

- BHASKAR, R. N. AND GOVINDAN, R., 2005, *Techniques in Silk Reeling*, Department of Sericulture, UAS,GKVK, p.50.

- GANGA, G., 2003, *Comprehensive Sericulture.* Volume 2. *Silkworm Rearing and Silk Reeling.* Oxford & IBH, New Delhi, p.429.
- KAMAL JAISWAL, SUNIL P. TRIVEDI., PANDEY, B. N. AND TRIPATHI, A. K., *Mulberry sericulture problems and prospects*, A P H publishing corporation, New Delhi.
- KIM, B. H., 1978, *Raw Silk Reeling*, Korean edition Seoul Publishing Company, P 275.
- KRISHNASWAMI, S., MADHAVA RAO, N. R., SURYANARAYAN, S. K. AND SUNDARAMURTHY, T. S., 1972, *Manual on Sericulture-III.Silk Reeling,* FAO, Rome, p.112.
- MAHADEVAPPA, D., HALLIYAL, V. G., SHANKAR, A. G. AND BHANDIWAD, R., *Mulberry silk reeling technology*, Oxford & IBH publishing Co. Pvt. Ltd.
- Manual on Bivoltine silk Reeling Technology. 2003. Published by JICA, PPP BST Project, p.122
- SAVITHRI, SUJATHAMMA AND NEERAJA., *Sericulture industry: An overview*.
- TRIPURARI, S., *Sericulture and silk industry, Consortium on rural technology*, Madhuvan, Delhi.

Journals

- *Bulletins of Sericultural Experimental Station* - Suginami, Tokyo, Japan.
- *Journal of Sericultural Science of Japan* - Sericultural Experimental Station, Wade, Suginami-ku, Tokyo, Japan.
- *Sericologia* - Jacques Rousseau, 69350, La Mulatiere, France.
- *Indian Journal of Sericulture* - CSR & TI, Mysore.
- *Journal of Sericulture and Technology* - NASSI, Bangalore.
- *Indian Silk* - Central Silk Board, Bangalore.
- *Bulletin of Indian Academy of Sericulture* - Bhubaneshwar, Orissa.
- *Reshme Krishi (Kannada)* - Department of Sericulture, Government of Karnataka, Bangalore.

Websites

- www.csb.gov.in/
- www.karnataka.gov.in/kssrdi/documents/2019/tender%20KC.pdf
- www.tnau.ac.in/
- www.csrtimys.res.in/

SER 515 VANYA SERICULTURE (1+1)

Objective

- This course will provide multi-disciplinary perspective in equiping students to identify and explore species of sericigenous insects
- Rearing technology of commercially exploited non mulberry silkworms

Theory

Block 1: Under exploited less known non-mulberry silks

Unit 1: Scope, importance and distribution in the World

Uses of less known sericigenous species for commercial exploitation, distribution pattern on different host plants and their statistics.

Unit 2: Introduction to Anaphe, Coan and Fagara silks

Systematics, morphology and cocoon characteristics of anaphe, fagara, coan silks and possibilities of their exploitation.

Block 2: Commercially exploited non-mulberry silks

Unit 1: Scope, importance and their distribution in the world

Scope, importance, distribution in the country and the world of eri, tropical tasar, temperate tasar and muga silk worms and their primary and secondary host plants.

Unit 2: Rearing of Eri silkworm

Host plant distribution and their classification, agronomic practices and their protection, grainage techniques, rearing of eri using improved techniques and crop protection.

Unit 3: Rearing of Tasar (tropical/ temperate)

Host plant distribution and their classification, agronomic practices and their protection, grainage techniques, rearing of tropical/ temperate tasar using improved techniques and crop protection.

Unit 4: Rearing of Muga silkworms

Host plant distribution and their classification, agronomic practices and their protection, grainage techniques, rearing of muga silkworms using improved techniques and crop protection.

Unit 5: Economics of non-mulberry silkworm rearing

Economics of non-mulberry silkworm rearing, viz., eri, tasar and muga silkworm rearing and their cost benefit ratio.

Practical

- Study of primary and secondary host plants of eri silkworm;
- Study of primary and secondary host plants of tasar silkworm;
- Study of primary and secondary host plants of muga silkworm;
- Cultivation of popular castor genotypes for eri silkworm rearing;
- Preparation of rearing house for eri silkworm rearing;
- Rearing of eri silkworm on different castor genotypes;
- Calculation of consumption indices in eri silkworm using leaves of different castor genotypes;
- Collection and dry preservation of different primary and secondary host plants of non-mulberry silkworms;
- Preparation of disease free layings of eri silkworm;
- Morphology of eggs and larvae of eri silkworm;
- Morphology of pupa and moth of eri silkworm;
- Morphology of eggs and larvae of tasar and muga silkworms;
- Morphology of pupa and moth of tasar and muga silkworms;
- Effect of different mating durations on fecundity and fertility of eri silk moths;

- Study of different natural enemies of eri silkworm;
- Study of different diseases of eri silkworm;
- Practising of tasar egg production;
- Economics of eri silkworm rearing;
- Visit

References

- JOLLY, M. S, SEN, S. K. AND AHSAN, M. M., 1974, *Tasar culture*. Ambika Publishers, Bombay.
- JOLLY, M. S., SEN, S. K. SONWALKAR, T. N. AND PRASAD, G. K., 1979, *Sericulture Manual - 4 – Non-MulberrySilks*. Agriculture Service Bulletin, FAO, Rome.
- SANNAPPA, B., JAYARAMAIAH, M., GOVINDAN, R. AND CHINNASWAMY, K. P., 2002, *Advances in Ericulture*.Seri Scientific Publishers, Bangalore.
- SARKAR, D. C., 1980, *Ericulture in India*. Central Silk Board, Bangalore.

Journals

- *Bulletins of Sericultural Experimental Station* - Suginami, Tokyo, Japan.
- *Journal of Sericultural Science of Japan* - Sericultural Experimental Station, Wade, Suginami-ku, Tokyo, Japan.
- *Sericologia* - Jacques Rousseau, 69350, La Mulatiere, France.
- *Indian Journal of Sericulture* - CSR & TI, Mysore.
- *Journal of Sericulture and Technology* - NASSI, Bangalore.
- *Indian Silk* - Published by Central Silk Board, Bangalore.
- *Bulletin of Indian Academy of Sericulture* - Bhubaneshwar, Orissa.
- *Reshme Krishi (Kannada)* - Department of Sericulture, Government of Karnataka, Bangalore.

Websites

- www.karnataka.gov.in/kssrdi/documents/2019/tender%20KC.pdf
- www.tnau.ac.in/
- www.csrtimys.res.in/

SER 516 SERICULTURE BY-PRODUCT UTILIZATION AND VALUE ADDITION (1+1)

Objective

- To understand the best utilization of by-products generated at each stage of sericultural activity
- To know the value addition of each byproduct for generating additional income making them good entrepreneurial managers in sericulture.

Theory

Block 1: Entrepreneurship in sericulture

Unit 1: Entrepreneurship in sericulture- prospects and problems

Concept, need, scope, prospects and problems of entrepreneurship in sericulture.

Unit 2: Sericultural entrepreneurship development in different countries

Sericultural entrepreneurial development in India, China, Japan, Korea, Thailand and Brazil.

Block 2: Entrepreneurship development in different areas of Sericulture

Unit 1: Entrepreneurship development in mulberry cultivation

Entrepreneurship development in mulberry cultivation- kisan nursery, composting, vermicomposting, bio-digester, bio-gas production, livestock production, fisheries, mushroom cultivation and silage production.

Unit 2: Entrepreneurship development in egg production and silkworm rearing

Entrepreneurial development in silkworm-egg production, Chawki rearing and cocoon production.

Unit 3: Entrepreneurship development in silk reeling and post reeling activities

Entrepreneurship development in silk reeling – establishment of reeling units, twisting and dying units, weaving units. Entrepreneurship development in seri-inputs, manufacture/ production, marketing/ custom hiring of sericulture material/equipment.

Block 3: Value addition to by-products in sericulture

Unit 1: Value addition to mulberry products

Value addition to mulberry- mulberry as fuel, green manure, fodder, live fencing material, wind breaks. Mulberry fruits and their use in pickle, jam, jelly, beverage/wine preparation. Mulberry as medicine, mulberry in agriculture and sports industry, mulberry in biogas production, mulberry as shade and avenue tree. Processing of mulberry leaves for tea preparation and food products. Medicinal value of mulberry.

Unit 2: Value addition during silkworm rearing

Value addition during silkworm rearing –silkworm litter as livestock feed; as an organic manure, raw material for biogas production, mushroom raising, poultry feed, fish feed, silkworm excreta in cosmetic industry. Silkworm in human consumption.

Unit 3: Value addition to byproducts of silk reeling

Pupal oil extraction and its uses, pupal powder as animal feed and manure. Flimsy cocoons and waste cocoons used as raw material in spun silk industry and quilting purpose. Silkworm pupa in human consumption-commercialized products and locally prepared dishes. Preparation of handicrafts, toys, wall plates, garlands, greeting cards, etc., from waste cocoons. Sericin in medicine, cosmetics, artificial membranes and plastic industry and other uses of silk.

Practical

- Visit to grainage for collection of waste cocoons including pierced cocoons;

- Visit to Chawki rearing centres and cocoon production centres for collection of different by-products;
- Visit to Silk reeling, twisting, dying and weaving units for collection of different by-products;
- Preparation of compost, vermi-compost and bio-digester from mulberry waste;
- Value addition to byproducts of mulberry products-mulberry as fuel, green manure, fodder, live fencing material, wind breaks;
- Estimation of calorific value of mulberry wood as fuel;
- Mulberry fruits for table purpose and preparation of pickles, juice, jam, jelly, beverage/wine;
- Raising of mulberry saplings from desired genotypes for social forestry, avenue tree and eco-friendly flora;
- Processing of mulberry leaf for the tea preparation;
- Preparation of different food products with mulberry leaf as ingredient;
- Mushroom cultivation using silkworm litter as substrate;
- Value addition to silkworm rearing waste – silkworm litter as cattle, sheep and goat feed;
- Preparation of mulberry silage along with popular fodders;
- Quantification of biogas production using silkworm waste;
- Pupal oil extraction and pupal powder preparation and nutrient status estimation;
- Preparation of handicrafts, toys, wall plates, garlands, greeting cards, etc. using waste cocoons;
- Estimation of manurial value of compost and vermi-compost derived from mulberry waste;
- Silkworm pupae as animal, fishery and poultry feed.

References

Text Books

- ANONYMOUS., 2002, *Silk Weaving*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.

- ANONYMOUS, 2002, *Colours from Nature – Silk Dyeing Using Natural Dyes.* Vol. I and II, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
- BERNARD P. CORBMAN., 1983, *Textiles: Fiber to Fabric*. 6th Edition, Mc. Graw – Hill International Editions, Home Economic Series, Singapore, p. 594.
- CHARLES J. HUBER., 1929, *The Raw Silk Industry of Japan*. The Silk Association of America, Inc., New York.
- DANDIN, S. B. AND GUPTA, V. P., 2002, *Advances in Indian Sericulture Research*. CSR&TI, Mysore.
- DANDIN, S. B, JAYASWAL, J. AND GIRIDHAR, K., (Eds.)., 2003, *Handbook of Sericulture Technologies*. CSB, Bangalore.
- DATTA, R. K., 1996, *Global Silk Scenario – 2001. Proceedings of the International Conference on Sericulture – 1994.* Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
- GOVINDAN, R., CHINNASWAMY, K. P., KRISHNAPRASAD, N. K. AND REDDY, D. N. R., 2000, *Non-Mulberry Sericulture, Silk Technology and Sericulture Economics and Extension. Vol. 3– Proceedings of NSTS* – 1999, UAS, Bangalore.
- SINHA, S., 1990, *The Development of Indian Silk*. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
- TAZIMA, Y., 1978, *The Silkworm: An Important Laboratory Tool.* Kodansha Ltd., Tokyo.
- TRIPURARI SHARAN., 1984, *Sericulture and Silk Industry*. Published by Y.K. Sharma, Consortium on Rural Technology, Delhi.
- Ullal S.R. and Narasimhanna M.N., 1981. *Handbook of Practical Sericulture*. CSB, Bangalore.
- Yasuji Hamamura. 2001. *Silkworm Rearing on Artificial Diet.* Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi and Calcutta.
- Yonemura M. and Rama Rao N. 1925, *Handbook of Sericulture*. Mysore Government Branch Press.

Journals

- *Bulletins of Sericultural Experimental Station* – Suginami, Tokyo, Japan.
- *Journal of Sericultural Science of Japan* – Sericultural Experimental Station, Wade, Suginami-ku, Tokyo, Japan.
- *Sericologia* – ISC, Bangalore.
- *Indian Journal of Sericulture* – CSR & TI, Mysore.
- *Journal of Sericulture and Technology* – NASSI, Bangalore.
- *Indian Silk* – Central Silk Board, Bangalore.
- *Bulletin of Indian Academy of Sericulture* - Bhubaneshwar, Orissa.
- *Reshme Krishi* (*Kannada*) – Department of Sericulture, Government of Karnataka, Bangalore.

Websites

• www.csb.gov.in/

• www.karnataka.gov.in/kssrdi/documents/2019/tender%20KC.pdf

• www.tnau.ac.in/

• www.csrtimys.res.in/

M.Sc. (Agri.) in Soil Science

Course Code	Course Title	Credit Hours
SSC 501	Soil physics	3 (2+1)
SSC 502	Soil fertility and fertilizer use	3 (2+1)
SSC 503	Soil chemistry	3 (2+1)
SSC 504	Soil mineralogy, genesis and classification	3 (2+1)
SSC 505	Soil erosion and conservation	3 (2+1)
SSC 506	Soil Biology and Biochemistry	3 (2+1)
SSC 507	Radioisotopes in soil and plant studies	2 (1+1)
SSC 508	Soil, water and air pollution	3 (2+1)
SSC 509	Remote sensing and GIS technique for soil and crop studies	3 (2+1)
SSC 510	Analytical technique and instrumental methods in soil and plant Analysis	2 (0+2)
SSC 511	Management of problematic soils and water	2 (1+1)
SSC 512	Land degradation and restoration	1 (1+0)
SSC 513	Soil Survey and Land use Planning	2 (2+0)
SSC 514	Introduction to nanotechnology	3 (2+1)
	Total	**36 (23+13)**
SSC 580	Qualifying Examination	2 (0+2)
SSC 581	Seminar-I	1 (0+1)
SSC 582	Seminar-II	1 (0+1)
SSC 591	Research-I	13 (0+13)
SSC 592	Research-II	14 (0+14)

SSC 501 SOIL PHYSICS (2+1)

Objective

To impart basic knowledge about soil physical properties and process in relation to plant growth.

Theory

Block I

Unit 1: Basic principles of physics applied to soils, soil as a three phase system.

Unit 2: Soil texture, textural classes, mechanical analysis, specific surface.

Unit 3: Soil consistence; dispersion and workability of soils; soil compaction and consolidation; soil strength; swelling and shrinkage - basic concepts. Alleviation of soil physical constraints for crop production. Soil erosion and edibility

Unit 4: Soil structure - genesis, types, characterization and management soil structure; soil aggregation, aggregate stability; soil tilth, characteristics of good soil tilth; soil crusting -mechanism, factors affecting and evaluation; soil conditioners; puddling, its effect on soil physical properties; clod formation.

Block II

Unit 1: Soil water: content and potential, soil water retention, soil-water constants, measurement of soil water content, energy state of soil water, soil water potential, soil-moisture characteristic curve; hysteresis, measurement of soil-moisture potential.

Unit 2: Water flow in saturated and unsaturated soils, Poiseuille's law, Darcy's law; hydraulic conductivity, permeability and fluidity, hydraulic diffusivity; measurement of hydraulic conductivity in saturated and unsaturated soils.

Unit 3: Infiltration; internal drainage and redistribution; evaporation; hydrologic cycle, field water balance; soil-plant-atmosphere continuum.

Unit 4: Composition of soil air; renewal of soil air - convective flow and diffusion; measurement of soil aeration; aeration requirement for plant growth; soil air management.

Unit 5: Modes of energy transfer in soils; energy balance; thermal properties of soil; measurement of soil temperature; soil temperature in relation to plant growth; soil temperature management.

Practical

- Determination of B.D, P.D and mass volume relationship of soil, Mechanical analysis by hydrometer and international pipette method,
- Measurement of Atterberg limits, Aggregate analysis - dry and wet, Measurement of soil-water content by different methods, Measurement of soil-water potential by using tensiometer and gypsum Blocks, Determination of soil-moisture characteristics curve and computation of pore-size, distribution, Determination of hydraulic conductivity under saturated and unsaturated conditions, Determination of infiltration rate of soil, Determination of aeration porosity and oxygen diffusion rate, Soil temperature measurements by different methods, Estimation of water balance components in bare and cropped fields.

References

- ARUNA KUMAR SAHA, Text book of Physics
- ISSS, New Delhi, Fundamentals of Soil Science
- K. RAMASWAMY, S. MAHIRAGIRA, SHRINE JUNTA RAJMAHAL, J RAMA CHANDRAN AND ANJITHA, Text book on soil Physics
- MANOJ K. SHUKLA, Soil physics – An Introduction
- RATTANLAL AND MONOJ K. SHUKLA, Principles of Soil physics
- T. J. MARSHALL, J.W HOLMES AND C.W. ROSE, Soil physics

- WILLIAM A. JURY AND ROBERT HORTON, Soil Physics
- KOHUKE, HELMUT, Soil Physics

SSC 502 SOIL FERTILITY AND FERTILIZER USE (2+1)

Objective:

To impart basic knowledge about soil fertility and its importance and to understand the role of fertilizers and manures in supplying nutrients to plants so as to increase fertilizer use efficiency and productivity.

Theory:

Block I

Unit 1: Soil fertility and soil productivity; fertility status of major soils group of India; nutrient sources–fertilizers and manures; Criteria of essentiality, classification, law of minimum and maximum, essential plant nutrients - functions and deficiency symptoms, Nutrient uptake, nutrient interactions in soils and plants; long term effect of manures and fertilizers on soil fertility and crop productivity.

Unit 2: Soil and fertilizer nitrogen–sources, forms, immobilization and mineralization, nitrification, denitrification; biological nitrogen fixation -types, mechanism, microorganisms and factors affecting; nitrogenous fertilizers and their fate in soils; management of fertilizer nitrogen in lowland and upland conditions for high fertilizer use efficiency.

Unit 3: Soil and fertilizer phosphorus - forms, immobilization, mineralization, reactions in acid and alkali soils; factors affecting phosphorus availability in soils; phosphatic fertilizers - behavior in soils and management under field conditions. Potassium -forms, equilibriumin soils and its agricultural significance; mechanism of potassium fixation; management of potassium fertilizers under field conditions.

Unit 4: Sulphur - source, forms, fertilizers and their behavior in soils; role in crops and human health; calcium and magnesium–factors affecting their availability in soils; management of sulphur, calcium and magnesium fertilizers.

Block II

Unit 1: Micronutrients – critical limits in soils and plants; factors affecting their availability and correction of their deficiencies in plants; role of chelates in nutrient availability.

Unit 2: Common soil test methods for fertilizer recommendations; quantity–intensity relationships; soil test crop response correlations and response functions.

Unit 3: Fertilizer use efficiency; site-specific nutrient management; plant need based nutrient management; integrated nutrient management; specialty fertilizers concept, need and category. Current status of specialty fertilizers use in soils and crops of India;

Unit 4: Soil fertility evaluation - biological methods, soil, plant and tissue tests; soil quality in relation to sustainable agriculture, Determination of critical limit, DRIS

Unit 5: Definition and concepts of soil health and soil quality; Long term effects of fertilizers and soil quality.

Practical

- Soil and plant sampling and processing for chemical analysis
- Determination of soil pH, total and organic carbon in soil
- Chemical analysis of soil for total and available nutrients (major and micro)
- Analysis of plants for essential elements (major and micro)

References

- HAVLIN, TISDALE, NELSON AND BEATON - Soil fertility and fertilizers
- ISSS, New Delhi, Fundamentals of Soil Science
- BOYD ELLIS AND HENRY FOTH - Soil fertility
- JADEJA, HIRPARA, VEKARIA AND SAKARVADIA - Soil fertility and nutrient management
- ALFRED VIVIAN Principles of Soil fertility
- RAM LAKHN RAM, Current Research in Soil fertility

SSC 503 SOIL CHEMISTRY (2+1)

Objective

To introduce the basic concepts of soil chemistry and to familiarize students with modern developments in chemistry in relation to soil as a medium for plant growth and development.

Theory

Block I

Unit 1: Chemical (elemental) composition of the earth's crust, soils, rocks and minerals

Unit 2: Elements of equilibrium thermodynamics, chemical equilibria, electro chemistry and chemical kinetics.

Unit 3: Soil colloids: inorganic and organic colloids – origin of charge, concept of point of zero-charge (PZC) and its dependence on variable-charge soil components, surface charge characteristics of soils; diffuse double layer theories of soil colloids, zeta potential, stability, coagulation / flocculation and peptization of soil colloids; electro metric properties of soil colloids; sorption properties of soil colloids; soil organic matter-fractionation of soil organic matter and different fractions, Characterization of OM; clay-organic interactions.

Unit 4: Ion exchange processes in soil; cation exchange- theories based on law of mass action(Kerr-Vanselow, Gapon equations, hysteresis, Jenny's concept), adsorption isotherms, Donnan-membrane equilibrium concept, clay-membrane electrodes and ionic activity measurement, the rmodynamics, statistical mechanics; anionandlig and exchange– inner sphere and outer-sphere surface complexformation, fixation of oxyanions, hysteresis insorption-desorption of oxy-anionsandanions, shift of PZ Conligand exchange, AEC, CEC; experimental methods to study ionexchange phenomena and practical implications in plant nutrition.

Unit 5: Potassium, phosphate and ammonium fixation in soils covering specific and non-specific sorption; precipitation-dissolution equilibria; Concept of quantity/intensity (Q/I) relationship; step and constant- rate K; management aspects.

Block II

Unit 1: Chemistry of acid soils; active and potential acidity; lime potential, chemistry of acid soils; sub-soil acidity.

Unit 2: Chemistry of salt-affected soils and amendments; soil pH, ECe, ESP, SAR and important relations; soil management and amendments

Unit 3: Chemistry and electrochemistry of submerged soils, geochemistry of micronutrients, environmental soil chemistry.

Practical

Preparation of saturation extract, measurement of pH, EC, CO_3, HCO, Ca, Mg, K and Na, Determination of CEC and AEC of soils, Analysis of equilibrium soil solution for pH, EC, Eh by the use of Eh-pH meter and conductivity meter, Determination of point of zero-charge and associated surface charge characteristics by the potentio metric titration method, Extraction of humic substances, Potentiometric and conduct ometric titration of soil humic and fulvic acids, (E4/E6) ratio of soil humic and fulvic acids by visible spectro photometric studies and the D (E4/E6) values at two pH values, Adsorption-desorption of phosphate / sulphate by soil using simple adsorption isotherm, Construction of adsorption envelope of soils by using phosphate / fluoride / sulphate and ascertaining the mechanism of the ligand exchange process involved, Determination of titratable acidity of an acid soil by $BaCl_2$-TEA method, Determination of Q/I relationship of potassium, Determination of lime requirement of an acid soil by buffer method, Determination of gypsum requirement of an alkali soil.

References

- KIM. H. TAN – Principles of Soil Chemistry
- SAROJ KUMAR SANYAL - Text Book of Soil Chemistry
- L. BHATTACHARYA - Text Book of Soil Chemistry
- ISSS, New Delhi - Fundamentals of Soil Science
- PREMASIS SUKUL - Soil Chemistry and Plant Nutrients

- R. B. MEHRA - Text Book of Soil Science
- DILIP KUMAR DAS - Introductory Soil Science

SSC 504 SOIL MINERALOGY, GENESIS AND CLASSIFICATION (2+1)

Objective

To impart and acquaint students with basic structure of clay minerals, genesis terms of factors and processes of soil formation, and to enable the students to classify soils into different land use systems.

Theory

Block I

Unit 1: Fundamentals of crystallography, space lattice, coordination theory, isomorphism and polymorphism.

Unit 2: Classification, structure, chemical composition and properties of clay minerals; genesis and transformation of crystalline and non-crystalline clay minerals; identification techniques; amorphous soil constituents and other non-crystalline silicate minerals and their identification; clay minerals in Indian soils, role of clay minerals in plant nutrition, interaction of clay with humus, pesticides and heavy metals.

Block II

Unit 1: Factors of soil formation, soil formation models; soil forming processes; weathering of rocks and mineral transformations; soil profile; weathering sequences of minerals with special reference to Indian soils.

Unit 2: Concept of soil individual; soil classification systems – historical developments and modern systems of soil classification with special emphasis on soil taxonomy; soil classification, soil mineralogy and soil maps–usefulness.

Practical

- Separation of sand, silt and clay fraction from soil
- Determination of specific surface area and CEC of clay
- Identification and quantification of minerals in soil fractions

- Morphological properties of soil profile in different land forms
- Classification of soils using soil taxonomy
- Calculation of weathering indices and its application in soil formation
- Grouping soils using available database in terms of soil quality

References

- GRAHAM AND MCDANIEL - Soil genesis and Classification
- ISSS, New Delhi - Fundamental of Soil Science
- J. SEHGAL - A Text Book of Pedology (Concepts and Application)
- BRADY, N. C. - Nature and Properties of Soil
- T. D, BISWAS AND S. K. MUKHERJEE - Text Book of Soil Science
- BUO L. S. W., HOLE F. D., M. C. GRACKEN R. J. AND SOUTH - Soil genesis and Classification

SSC 505 SOIL EROSION AND CONSERVATION (2+1)

Objective:

To enable students to understand various types of soil erosions and measures to be taken for controlling soil erosion to conserve soil and water.

Theory

Block I

Unit 1: History, distribution, identification and description of soil erosion problems in India.

Unit 2: Forms of soil erosion; effects of soil erosion and factors affecting soil erosion; types and mechanisms of water erosion; raindrops and soil erosion; rainfall erosivity –estimation as EI30 index and kinetic energy; factors affecting water erosion; empirical and quantitative estimation of water erosion; methods of measurement and prediction of run off; soil losses in relation to soil properties and precipitation.

Unit 3: Wind erosion- types, mechanism and factors affecting wind erosion; extent of problem in the country.

Unit 4: Principles of erosion control; erosion control measures– agronomical and engineering; erosion control structures - their design and layout.

Block II

Unit 1: Soil conservation planning; land capability classification; soil conservation in special problem areas such as hilly, arid and semi-arid regions, water logged and wet lands.

Unit 2: Water shed management- concept, objectives and approach; water harvesting and recycling; flood control in water shed management; socio economic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds; use of remote sensing in assessment and planning of watersheds, sediment measurement

Practical

- Determination of different soil erodibility indices-suspension percentage, dispersion ratio, erosion ratio, clay ratio, clay/moisture equivalent ratio, percolation ratio, rain drop erodibility index
- Computation of kinetic energy of falling rain drops
- Computation of rain fall erosivity index (EI30) using rain gauge data
- Land capability classification of a watershed
- Visits to watersheds

References

- MORGAN AND JOHN WILEY - Soil Erosion and Conservation
- ARGOSIAA - Fundamental of Soil Conservation
- GUSTAFSON - Conservation of the Soil
- MADIREDDY V SUBBA RAO - Soil Conservation, Management and analysis

SSC 506 SOIL BIOLOGY AND BIOCHEMISTRY (2+1)

Objective

To impart knowledge to the students about basics of soil biology, biochemistry, biogeochemical cycles, plant growth promoting rhizo bacteria and microbial interactions in the soil.

Theory

Block I

Unit 1: Soil biota, soil microbial ecology, types of organisms indifferent soils; soil microbial biomass; microbial interactions; un-culturable soil biota.

Unit 2: Microbiology and biochemistry of root-soil interface; phyllosphere; soil enzymes, origin, activities and importance; soil characteristics influencing growth and activity of micro flora; Root rhizosphere and PGPR.

Unit 3: Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil; biochemical composition and biodegradation of soil organic matter and crop residues, microbiology and biochemistry of decomposition of carbonaceous and protenaceous materials, cycles of important organic nutrients.

Block II

Unit 1: organic wastes and their use for production of biogas and manures; biotic factors in soil development; microbial toxins in the soil.

Unit 2: Preparation and preservation of farmyard manure, animal manures, rural and urban composts and vermin compost.

Unit 3: Biofertilizers-definition, classification, specifications, method of production and role in crop production; FCO specifications and quality control of bio fertilizers.

Unit 4: Biological indicators of soil quality; bioremediation of contaminated soils; microbial transformations of heavy metals in soil; role of soil organisms in pedogenesis – important mechanisms and controlling factors; soil genomics and bio prospecting; soil sickness due to biological agents; xenobiotics; antibiotic production in soil.

Practical

- Determination of soil microbial population
- Soil microbial biomass carbon
- Elemental composition, fractionation of organic matter and functional groups
- Decomposition of organic matter in soil
- Soil enzymes
- Measurement of important soil microbial processes such as ammonification, nitrification, N_2 fixation, S oxidation, P solubilization and mineralization of other micronutrients

References

- DAR GHULAM HASSAN - Soil Microbiology and Biochemistry
- ELDORA A PAUL - Soil Microbiology. Ecology and Biochemistry
- S. K. VERMA AND MOHIT VERMA - A Text Book of Plant Physiology, Bio Chemistry and Biotechnology
- CHHONKAR, BHADRARAY, PATRA AND PURAKAYASTHA - Soil Biology and Biochemistry
- PRASAD - Text Book of biochemistry

SSC 507 RADIO ISOTOPES IN SOIL AND PLANT STUDIES (1+1)

Objective

To teach and train the students in the field of radioisotopes use in soil and plant research.

Theory

Block I

Unit 1: Atomic structure, radio activity and units; radio isotopes-properties and decay principles; nature and properties of nuclear radiations; interaction of nuclear radiations with matter, artificial radioactivity

Unit 2: Principles and use of radiation monitoring instruments-proportional, Geiger Muller counter, solid and liquids scintillation counters; neutron moisture meter, mass spectrometry, autoradiography.

Block II

Unit 1: Isotopic dilution techniques used in soil and plant research; use of stable isotopes; application of isotopes in studies on organic matter, nutrient transformations, ion transport, rooting pattern and fertilizer use efficiency; carbon dating

Unit 2: Doses of radiation exposure, radiation safety aspects regulatory aspects, collection, storage and disposal of radioactive wastes

Practical

- Storage and handling of radioactive materials
- Determination of half-life and decay constant
- Preparation of soil and plant samples for radioactive measurements
- Setting up of experiment on fertilizer use efficiency and cation exchange equilibria using radio isotopes
- Determination of A, E and L values of soil using 32P/65Zn
- Use of neutron probe for moisture determination
- Sample preparation and measurement of 15N enrichment by mass spectrophotometery/ emission spectrometry

References

- BHUPINDER SINGH - Radioisotopes in Soil and Plant Studies

SSC 508 SOIL, WATER AND AIR POLLUTION (2+1)

Objective:

To sensitize and make aware to the students about the pollution problems occurring in soil, water and air and its effect on crop production and its remedial measures.

Theory

Block I

Unit 1: Soil, water and air pollution problems associated with agriculture, nature and extent.

Unit 2: Nature and sources of pollutants – agricultural, industrial, urban wastes, fertilizers and pesticides, acid rains, oil spills etc.; air, water and soil pollutants- their CPC standards and effect on plants, animals and human beings.

Unit 3: Sewage and industrial effluents–their composition and effect on soil properties/ health, and plant growth and human beings; soil as sink for waste disposal.

Unit 4: Pesticides–their classification, behavior in soil and effect on soil microorganisms.

Block II

Unit 1: Toxic elements-their sources, behavior in soils, effect on nutrients availability, effect on plant and human health.

Unit 2: Pollution of water resources due to leaching of nutrients and pesticides from soil; emission of green house gases–carbondioxide, methane and nitrous oxide.

Unit 3: Risk assessment of polluted soil, Remediation/ amelioration of contaminated soil and water; remote sensing applications in monitoring and management of soil and water pollution.

Practical

Sampling of sewage waters, sewage sludge, solid/ liquid industrial wastes, polluted soils and plants and their processing, Estimation of dissolved and suspended solids, chemical oxygen demand (COD), biological demand (BOD), measurement of coliform (MPN), nitrate and ammonical nitrogen and phosphorus, heavy metal content in effluents, Heavy metals in contaminated soils and plants, Management of contaminants in soil and plants to safe guard food safety, Air sampling and determination of particulate matter and oxides of sulphur, NO_2 and O_2 conc. Visit to various industrial sites to study the impact of pollutants on soil and plants.

References

- VIJENDRA SINGH - Environmental Chemistry (Water and soil Pollution) -
- CHEE KONG YAP - Soil Pollution
- K. K. SINGH, ASHA JUWARKAR, A. K. SINGH AND ALKATOMAR - Air, Water and Soil Pollution
- PAUL PETRUCIS - Air, Water and Soil Pollution
- PRADYOT PATNAIK - Hand Book of Environmental analysis
- WILEY - Sustainable Solutions For Environmental Pollution

SSC 509 REMOTE SENSING AND GIS TECHNIQUE FOR SOIL, WATER AND CROP STUDIES (2+1)

Objective

To impart knowledge about the basic concepts of remote sensing, aerial photographs, imageries, their interpretation, application of remote sensing in general and with special reference to soils, plants and yield forecasting, to upgrade knowledge about geo statistical techniques with special reference to krigging and GIS and applications in Agriculture.

Theory

Block I

Unit 1: Introduction and history of remote sensing; sources, propagation of radiations in atmosphere; interactions with matter, basic concepts and principles; hardware and software requirements; common terminologies of geographic information system (GIS)

Unit 2: Sensor systems-camera, microwave radio meters and scanners; fundamentals of aerial photographs and multispectral imaging, hyper spectral imaging, thermal imaging; image processing and interpretations.

Unit 3: Application of remote sensing techniques-land use soil surveys, crop stress and yield forecasting, prioritization in watershed and drought management, waste land identification and management.

Block II

Unit 1: Significance and sources of the spatial and temporal variability in soils; variability in relation to size of sampling; classical and geo-statistical techniques of evolution of soil variability.

Unit 2: Applications of GIS for water resources, agriculture, precision farming, disaster management, e-governance, Agricultural Research Information System (ARIS).

Practical

Familiarization with different remote sensing equipments and data products, Interpretation of aerial photo graphs and satellite data for mapping of land resources, Analysis of variability of different soil properties with classical and geo statistical techniques, Creation of data files in a database programme, Use of GIS for soil spatial simulation and analysis, To enable the students to conduct soil survey and interpret soil survey reports in terms of land use planning.

References:

- A. K. KOLAY - Remote Sensing and Assessment of Soil Resources
- M. ANJI REDDY - Text Book of Remote Sensing and Geographical information Systems
- KALI CHANDRA SAHU - Text Book of Remote Sensing and Geographical information Systems
- G. S. SRIVASTAVA - An Information to Geo informatics
- AJAY PRAKASH - Remote Sensing and Geographical Information Systems
- JOHN R. JENSEN - Remote Sensing of the Environment

SSC 510 ANALYTICAL TECHNIQUE AND INSTRUMENTAL METHODS IN SOIL AND PLANT ANALYSIS (0+2)

Objective

To train and familiarize the students with commonly used

instruments – their working principle, preparation of common analytical reagents for qualitative and quantitative analysis of both soil as well as plant samples.

Theory

Block I

Unit 1: Preparation of solutions for standard curves, indicators and standard solutions for acid-base, oxidation reduction and complexometric titration; soil, water and plant sampling techniques, their processing and handling.

Unit 2: Determination of nutrient potentials and potential buffering capacities of soils for phosphorus and potassium; estimation of phosphorus, ammonium and potassium fixation capacities of soils.

Unit 3: Principles of visible, ultra violet and infrared spectrophotometery, atomic absorption, flame-photometry, inductively coupled plasma spectrometry; chromatographic techniques, mass spectrometry and X-ray defractrometery; identification of minerals by X-ray by different methods, CHNS analyzer.

Block II

Unit 1: Electrochemical titration of clays; estimation of exchangeable cations (Na, Ca, Mg, K); estimation of root cation exchange capacity.

Unit 2: Wet digestion/fusion/extraction of soil with aquaregia with soil for elemental analysis; tri acid/di-acid digestion of plant samples; determination of available and total nutrients (N, P, K, S, Ca, Mg, Zn, Cu, Fe, Mn, B, Mo) in soils; determination of total nutrients (N, P, K, S, Ca, Mg, Zn, Cu, Fe, Mn, B, Mo) in plants

Unit 3: Drawing normalized exchange isotherms; measurement of redox potential.

References

- A. S. MAILAPPA - Analytical Techniques and Instrumental methods in Soil plant analysis
- DEO KUMAR, ARBIND KUMAR GUPTA AND ATIK

AHAMAD - Analytical Technique and Instrumental methods in Soil, Plant and water analysis

- SUSANTA KUMAR PAL - Methods of Soil and Plant analysis
- SHASHIKALA AND BASKAR RANI REDDY - Practical hand book an Soil, Plant and Fertilizers analysis
- C. S. PIPER - Soil and Plant analysis
- M. L. JACKSON - Soil Chemicals analysis

SSC 511 MANAGEMENT OF PROBLEM SOILS AND WATER (1+1)

Objective

To study the formation, characteristics of problematic soils and their management including quality of irrigation water.

Theory

Block I

Unit 1: Area and distribution of problem soils–acidic, saline, sodic and physically degraded soils; origin and basic concept of problematic soils, and factors responsible.

Unit 2: Morphological features of saline, sodic and saline-sodic soils; characterization of salt-affected soils-soluble salts, ESP, pH; physical, chemical and microbiological properties.

Unit 3: Management of salt-affected soils; salt tolerance of crops-mechanism and ratings; salt stress meaning and its effect on crop growth, monitoring of soil salinity in the field; management principles for sandy, clayey, red lateritic and dry land soils.

Block II

Unit 1: Acid soils-nature of soil acidity, sources of soil acidity; effect on plant growth, lime requirement of acid soils; management of acid soils; biological sickness of soils and its management.

Unit 2: Quality of irrigation water; management of brackish water for irrigation; salt balance under irrigation; characterization of brackish waters, area and extent; relationship in water use and quality.

Unit 3: Agronomic practices in relation to problematic soils; cropping pattern for utilizing poor quality ground waters.

Practical

Characterization of acid, acid sulfate, salt-affected and calcareous soils, Determination of cations (Na+, K+, Ca++ and Mg++) in groundwater and soil samples, Determination of an ions (Cl-, SO_4-, CO_3- and HCO_3-) in ground waters and soil samples, Lime and gypsum requirements of acid and sodic soils.

References

- BISHWAJIT SINHA - A Text book on problematic Soil and their Management
- RAJNI RANI - Problematic soil and their Management
- ABHAY KUMAR, ASHA KUMAR AND SWATI SHABANA - Problematic soil and their Management
- SPRINGER - Management of Soil Problems
- HIRPARA, JADEJA, VEKARIA AND SAKARVADIA - Text book of Problematic Soil

SSC 512 LAND DEGRADATION AND RESTORATION (1+0)

Objective

To impart knowledge on various factors, processes for land degradation and their restoration techniques.

Theory

Block I

Unit 1: Type, factors and processes of soil/land degradation and its impact on soil productivity including soil fauna, biodegradation and environment.

Unit 2: Land restoration and conservation techniques-erosion control, reclamation of salt- affected soils; mine land reclamation, afforestation, organic products.

Unit 3: Extent, diagnosis and mapping of land degradation by conventional and modern RS-GIS tools; monitoring land degradation by fast assessment, modern tools, land use policy, incentives and

participatory approach for reversing land degradation; global issues for twenty first century.

References

- VIJAY SINGH MEENA - Agricultural Soil degradation and restoration
- SHIVA KUMAR AND SHIVA RAM - Soil Degradation
- LAL AND STEWART - Soil Degradation
- JHA - Land Degradation and Desertification
- SPRINGER - Soil Degradation, Conservation and Remediation

SSC 513 SOIL SURVEY AND LAND USE PLANNING (2+0)

Objective

To strengthen the skills of students in different types and methods of soil survey and classifying them in to various land use patterns.

Theory

Block I

Unit 1: Soil survey and its types; soil survey techniques-conventional and modern; soil series–characterization and procedure for establishing soil series; benchmark soils and soil correlations; soil survey interpretations; thematic soil maps, cartography, mapping units, techniques for generation of soil maps, application of remote sensing and GIS in soil survey and mapping of major soil group of India

Unit 2: Landform–soil relationship; major soil groups of India with special reference to respective states; land capability classification and land irrigability classification; land evaluation and land use type (LUT)–concept and application; approaches for managing soils and landscapes in the framework of agro-ecosystem.

BlockII

Unit 1: Concept and techniques of land use planning; factors governing present land use; Land evaluation methods and soil-site suitability evaluation for different crops; land capability classification and constraints in application.

Unit 2: Agro-ecological regions/sub-regions of India and their characteristics in relation to crop production. Status of LUP in India.

Practical

- Aerial photo and satellite data interpretation for soil and land use
- Cartographic techniques for preparation of base maps and thematic maps, processing of field sheets, compilation and obstruction of maps in different scales
- Land use planning exercises using conventional and RS tools

References

1. Agricultural Soil degradation and restoration – Vijay Singh Meena
2. Soil Degradation – Shiva Kumar and Shiva ram
3. Soil Degradation – Lal and Stewart
4. Land Degradation and Desertification –Jha
5. Soil Degradation, Conservation and Remediation- Springer

SSC 514 INTRODUCTION TO NANO TECHNOLOGY (2+1)

Objective

To create awareness on importance of nano technology, nano structures, mechanical property and nano biology and its application in agriculture research.

Theory

Block I

Unit 1: General introduction: Basics of quantum mechanics, harmonic oscillator, magnetic phenomena, band structure in solids, Mössbauer effect and spectroscopy, optical phenomena, bond in solids, an isotropy.

Unit 2: Nanostructures: growth of compound semiconductors, super lattices, self-assembled quantum dots, nano-particles, nano tubes and nano wires, fullerenes (buckballs, graphene). Nanofabrication and nano-patterning: Optical, X-ray, and electron beam lithography, self-

assembled organic layers, process of synthesis of nano powders, electrode position, and important nano materials.

Block II

Unit 1: Mechanical properties, magnetic properties, electrical properties, electronic conduction with nano particles, investigating and manipulating materials in the nano scale: Electron microscopy

Unit 2: Nano-biology: Interaction between biomolecules and nano-particle surface, different types of in organic materials used for the synthesis of hybrid nano-bio assemblies, application of nano – in agriculture, current status of nano-biotechnology, future perspectives of nano-biology, nano-sensors.

Practical

- Sources of nano particles and its preparation by different approaches
- Electro spinning and its use in agriculture and allied sector.
- Equipments used in Nanotechnology: its principle and uses
- Acquaintances with different equipments used in nanotechnology.
- Synthesis and characterization of Ag and ZnO nano particles.
- Mode of action of ZnO nano particles against soil borne diseases
- Study on efficacy of ZnO nano particles as seed treating agent on plant growth parameters.

References

- THOMAS VARGHESO AND BALAKRISHNA - Nano technology
- PALE AND OWNS - Introduction to Nano Science and Nano technology
- CHATTOPADHAYAY AND BANERJEE - Introduction to Nano Science and Nano technology
- MURTHY, SHANKAR, RATH AND MURDAY - Text book of Nano Science and Nano technology

M. Tech. in Farm Machinery and Power Engineering

Course Code	Course Title	Credit Hours
FMP 501	Soil Dynamics in Tillage and Traction	3(2+1)
FMP 502	Testing and Evaluation of Agricultural Equipment	3(2+1)
FMP503	Ergonomics and Safety in Farm Operations	3(2+1)
FMP 504	Design of Tractor systems	3(2+1)
FMP 505	Design of Farm Machinery-I	3(2+1)
FMP 506	Design of Farm Machinery-II	2(1+1)
FMP 507	Management of Farm Power and Machinery System	3(2+1)
FMP 511	Principles of Automation and Control	3(2+1)
FMP 512	Principles of Hydraulic and Pneumatic Systems	3(2+1)
FMP 513	Applied Instrumentation in Farm Machinery	3(2+1)
FMP 514	Systems Simulation and Computer Aided Problem Solving in Engineering	2(1+1)
FMP 515	Computer Aided Design of Machinery	2(0+2)
FMP 516	Advance Manufacturing Technologies	2(2+0)
FMP 517	Machinery for Precision Agriculture	3(2+1)
FMP 518	Machinery for Horticulture and Protected Agriculture	2 (2+0)
	Total	**40 (26+14)**
FMP 580	Qualifying Examination	2(0+2)
FMP 581	Seminar - I	1(0+1)
FMP 582	Seminar - II	1(0+1)
FMP 591	Research - I	13 (0+13)
FMP 592	Research - II	14 (0+14)

FMP 501 SOIL DYNAMICS IN TILLAGE AND TRACTION (2+1)

Objective

To have an understanding of the principles of soil mechanics as applied to interaction of tillage tools and traction devices with soil in terms of soil forces and deformation during for soil cutting and generation of traction.

Theory

Block 1: Introduction and Dynamic Properties of Soil

Unit I: Characterization of state of stress in a point: Derivation, representation by Mohr's Circle. Coulomb's law of friction and cohesion. Measurement of soil resistance properties: Direct shear box, torsion shear apparatus, tri-axial apparatus. Soil behaviour considerations: Soil water pressure and movement. Critical state soil mechanics: Soil stress –strain behaviour, shear rate effects.

Block 2: Mechanics of Tillage Tools

Unit 1: Soil cutting forces: The universal earthmoving equation, two dimensional cases, smooth vertical blade, smooth and rough raked blades in cohesive soil, unconstrained tool to soil adhesion. The shape of failure surfaces. Hettiaratchi's calculations, effect of soil weight. Soil cutting force by method of trial wedges.

Block 3: Design and Performance of Tillage tools

Unit 1: Extension of theory to three dimensions: Hettiaratchi, Reece-Godwin and Spoor. Three dimensional wedges: McKyes and Ali, Grisso models. Dynamic effect: Inertial forces, change in soil strength. Concept of critical depth. Complex tool shapes: Curved tools-shank and foot tools-mould board plough. Soil Loosening and manipulation: Measurement of soil loosening and its efficiency. Draft force efficiency: Loosening and pulverization efficiency. Soil mixing and inversion: Soil properties, tool shape, tool speed and tool spacing.

Block 4: Mechanics of Traction and Transport

Unit 1: Traction devices: Tyres, type, size, selection mechanics of traction devices. Maximum traction force: Soil deformation and slip, estimation of contact areas. Sinkage in soil: Rolling resistance, Bekker's formulae, McKyes formulae. Soil compaction by agricultural vehicles and machines.

Practicals

- Measurements of soils hear strength by *in-situ* shear box Apparatus and soil friction by friction plate.
- Measuring conepenetrometer resistance and working out tractive coefficients fortyres.
- Measurement of *in-situ* shears strength of soil by torsional vanes hear apparatus
- Solving problems on stress in soil
- Solving problems on soil properties
- Solving problems of tillage tool forces
- Problems on wheel slippage and tyred eflection
- Problems on design and performance of traction devices
- Practical examination

References

- GILL, W. R. AND VANDEN BERG, G. E., 1968, Soil Dynamics in Tillage and Traction.
- HANDBOOK, 316, Agricultural Research Service, US Department of Agriculture, Washington DC, 1968.
- JOHN, B. L., PAUL, K. T., DAVID, W. S. AND MAKOTO, H., 2012, Tractors and their Power Units. 4th Edition. Springer Science & Business Media, ISBN : 81-2390501-7, A SAEISBN:0-929355-72-5.
- KOOLEN, A. J. AND KUIPERS, H., 1983, Agricultural Soil Mechanics. Springer-Verlag ISBN13:978-3-642-69012-9.

• MCKYESE., 1989, Agricultural Engineering Soil Mechanics, Elsevier science publishers B.V., P.O. Box 211,1000 A E Amsterdam, the Netherlands.

·• MCKYES, E., 2016, Soil Cutting and Tillage: Vol7. Developments in Agricultural Engineering Elsevier R Science Publisher S B V.

FMP 502 TESTING AND EVALUATION OF AGRICULTURE EQUIPMENT (2+1)

Objectives

To enable the student to learn the procedure for testing of different farm machinery and the concept behind evaluation of different performance parameters of Farm machinery and the standard sad opted there in.

Theory

Block 1: Introduction to Testing and Evaluation

Unit 1: Importance and significance of testing and types of testing. Test equipment, usage and limitations .Test procedures and various test codes: National and International.

Block 2: Testing and Evaluation of Land Preparation, Sowing and Planting, Intercultural and Plant Protection Equipments

Unit 1: Laboratory and field testing of tillage and sowing machinery: Sub-soiler, laser land leveler, mould board Plough, disc plough, rotavator, cultivator, disc harrow, seed cum fertilizer drill and planter Laboratory and field testing of manual and power operated intercultural machinery and plant protection machine.

Block 3: Testing and Evaluation of Thresher, Chaff cutter and Combine Harvester

Unit 1: Laboratory and field testing of reaper, thresher and chaff cutter.

Unit 2: Laboratory and field testing of straw combine and combine harvester. Review and interpretation of test reports. Importance and need of standardization of components of agricultural equipment.

Practicals

- Lab testing of Stationary diesel engine for full load, variable load and governor test
- Lab Testing and evaluation of seed-cum- fertilizers drills
- Lab Testing and evaluation of seed-cum-fertilizers planters
- Lab Testing and evaluation of knap sack Sprayers
- Lab Testing and evaluation of nozzles
- Field testing of rotavators
- Lab testing of rotavators for soil sample analysis
- Testing and evaluation of reapers
- Testing and evaluation of combine harvester and thresher
- Testing and evaluation of chaff cutters
- Testing and evaluation of laser land leveler
- Case study of test reports of different agricultural implements

References

- BARGER, E. L., LILJEDAHL, J. B. AND MCKIBBEN, E. C., 1967, *Tractors and their Power Units*. Eastern Wiley 4thEdition.
- *Indian Standard Codes for Agricultural Implements*. Published by BIS, New Delhi.
- INNS, F. M., 1986, *Selection, Testing and Evaluation of Agricultural Machines and Equipment.*
- FAO, Service Bull. No.115.
- MEHTA, M. L., VERMA, S. R., RAJAN, P. AND SINGH, S. K., 2019, *Testing and Evaluation of Agricultural Machinery*. Daya Publishing House, Delhi.
- *Nebraska Tractor Test Code for Testing Tractor*, Nebraska, USA.
- SMITH, D. W., SIMS, B. G. AND O' NEILL, D. H., 2001, *Testing and Evaluation of Agricultural Machinery and Equipment-Principle and Practice*. FAO Agricultural Services Bull.110.

FMP 503 ERGONOMICS AND SAFETY IN FARM OPERATIONS (2+1)

Objective

To understand the principles of the science of Ergonomics and its application to farm machinery in order to reduce drudgery in the use of tools and equipment and also make them safe and comfortable to operate.

Theory

Block 1: Introduction

Unit 1: Description of human-machine systems. Ergonomics and its areas of application in the work System. History of ergonomics. Modern ergonomics.

Block 2: Anthropometry

Unit 1: Anthropometry: Its role in daily life, principles in workspace and equipment design, design of Manual handling tasks and application in equipment design. Human postures: Postural stress and its role in design of farm machinery.

Block 3: Ergonomics and Design of Tractor Seat

Unit 1: Human factors in tractor seat design: Entry system, controls, shape, colour coding, dialand in dicators. Modern technology for comfort in driving places.

Block 4: Physiological Parameters and Calibration

Unit 1: Physiological parameters: Psychological and mental stresses and their measurement techniques. Human energy expenditure: Calibration of Subjects, human workload and its assessment.

Block 5: Safety Considerations

Unit 1: Safety considerations and operators protective gadgets in farm Operations. Standards/codes for Tractors and agricultural machinery Safety.

Practicals

- Identify role of ergonomics in our daily life

- Measurement of anthropometric dimensions of agriculture workers and establishing relation between them
- Measurement of strength parameters
- Determination of human requirements of field operation with manual operated equipment
- Assessment of psychological /general load for agricultural operations
- Assessment of stress on eyes by specific agricultural operation
- Noise measurement in tractors
- Calibration of human subject on bicycle ergo meter
- Calibration of human subject on treadmill
- Measurement of physiological parameter, *viz*. heart /pulse rate
- Measurement of oxygen consumption under laboratory conditions
- Case study of accidents and safety on tractors and trailers
- Case study of accidents and safety on chaff cutters and threshers

References

- BRIDGER, R. S., 2009, *Introduction to Ergonomics*. CRC Press, Boca Rotan, USA
- SANDERS, M. S. AND MCCORMICK, E. J., 2000, *Human Factors in Engineering and Design*. Mc Graw Hill.7th edition
- ASTRAND, P., RODAHL, K., DAHL, H. A. AND STROMME, S. B., 2003, *Textbook of Work Physiology –Physiological Basis of Exercise*. Mc Graw Hill.
- GITE, L. P., 2009, *Anthropometric and Strength Data of Indian Agricultural Workers for Farm*
- *Equipment Design*. Central Institute of Agricultural Engineering, Bhopal.
- GITE, L. P., AGRAWAL, K. N., MEHTA, C. R., POTDAR, R. R. AND NARWARIYA, B. S., 2019, *Handbook of Ergonomical Design of Agricultural Tools, Equipment and work Places*. Jain Brothers, New Delhi.

FMP 504 DESIGN OF TRACTOR SYSTEMS (2+1)

Objective

To introduce the student to the principles that direct the design of a tractor and its subsystems and enable the student to apply the concept of machine design in designing the sub systems and critical components.

Theory

Block 1: Types of Tractors

Unit I: Design and types, research, development, design procedure, technicals specifications of tractors, modern trends in tractor design and development, special design features of tractors in relation to Indian agriculture.

Block 2: Engine Terminologies

Unit 1: Engine related terminology. Selection of stroke- bore ratio. Design of engine components; Piston, connecting rod, cylinder, cylinder head, crankshaft *etc*.

Block 3: Design of Tractor Systems

Unit 1: Design of tractor systems like clutch, gearbox, steering, steering geometry, turning force, hydraulic system & hitching, chassis, operator's seat, work-place area and controls. Tire selection, as pectratio *etc*.

Block 4: Computer Aided Design of Farm Tractors

Unit 1: Mechanics of tractor stability. Computer aided design and its application in farm tractors.

Practicals

- Engine design calculations – Stroke – bore ratio determination – Design of radiator-Balancing of crankshaft
- Engine design calculations-Calculation of volumetric/thermal efficiencies
- Transmission component design calculations-Design of clutch
- Transmission component design calculations-Design of gearbox and calculation of speed ratios

- Design of Ackerman steering. Calculation of turning radius
- Design of brakes (mechanical and hydraulic)
- Design of hydraulic system
- Calculation for determination of center of gravity of tractor, moment of inertia and stability
- Practice on the Computer Aided Design (CAD) packages for design of various components

References

- BARGER, E. L., LILJEDAHL, J. B. AND MC KIBBEN, E. C., 1967, Tractors and their Power Units. Wiley Eastern Pvt. Ltd.
- MACMILLAN, R. H., 2002, The Mechanics of Tractor–Implement Performance and Worked Example. University of Melbourne, Australia.
- SHARMA, P. C. AND AGARWAL, D. K., 2000, Machine Design. SKK ataria and Sons, Delhi.

FMP 505 DESIGN OF FARM MACHINERY I (2+1)

Objective

To understand the interaction of tillage tools with soil and design the components of the tillage tools based on their requirement and also to learn how the systems of planting machinery are designed.

Theory

Block 1: Introduction to Soil Properties

Unit 1: Farm machinery design: Modern trends, tasks and requirements, economic considerations of durability, reliability and rigidity. Physico - mechanical properties of soils. Technological process of ploughing. Wedge. Working process of mould board plough, determination of basic parameters. Design of coulters, shares, mould boards.

Block 2: Design of Primary tillage implements

Unit 1: Constructing of mould board working surface. Design of landside, frog, jointer. Forces acting on plough bottom and their effect on plough balance: Trailed, semi mounted and mounted plough. Draft on ploughs, resistance during ploughing. Design disk ploughs: Concave disk working tools, forces acting.

Block 3: Design of Secondary Tillage Implements

Unit 1: Machines and implements for surface and interrow tillage; Peg Toothed harrow, disk harrows, rotary hoes, graders, rollers, cultivators. Design of V shaped sweeps. Rigidity of working tools. Rotary machines: Trajectory of motion of rotary tiller tynes, forces acting, power requirement. Machines with working tools executing an oscillatory motion.

Block 4: Methods of Sowing and Planting

Unit 1

Methods of sowing and planting: Machines, agronomic specifications. Sowing inter-tilled crop. Grain hoppers: Seed metering mechanism, furrow openers and seed tubes. Machines for fertilizer application: Discs type broad casters. Organic fertilizer application: Properties of organic manure, spreading machines. Liquid fertilizer distributors. Planting and transplanting: Paddy transplanters, potato planters.

Practicals

- Design of mould board : Coulter, frog, share
- Design of mould board : mould board plough working surface, jointer
- Trailed, semi mounted and mounted ploughs
- Design of disc plough
- Design of disc harrow
- Design of peg tooth harrow
- Design of cultivators and sweep

- Design of rotary tiller
- Design of traction and transport devices
- Design of seed drills : Metering mechanisms
- Design of seed drills: hopper and furrow opener
- Design of Fertilizer application equipment : fertilizer spreaders
- Design of Fertilizer application equipment : liquid fertilizer
- Applicators and design of its sub systems
- Design of paddy trans planters
- Design of potato planters

References

- BERNACKI, C., HAMAN, J. AND KANAFAJSKI, C. Z., 1972, *Agricultural Machines Theory and Construction.* Vol. I. U.S. Dept. of Commerce, National Technical Information Service ,Spring field, Virginia 22151.
- BOSOI, E. S., VERNIAEV, O. V., SMIRNOV II AND SULTAN-SHAKH, E. G., 1990, *Theory, Construction and*
- *Calculations of Agricultural Machinery - Vol. I.* Oxonian Press Pvt. Ltd. No.56,Connaught
- Circle, New Delhi.
- GILL, R. AND VANDEN BERG, G. E., 2013, *Soil Dynamics in Tillage and Traction*. Scientific Publishers (India) ISBN-10:8172338031.
- YATSUK, E. P., 1981, *Rotary Soil Working Machines Construction, Calculation and Design.*
- American Publishing Co. Pvt. Ltd, NewDelhi.

FMP 506 DESIGN OF FARM MACHINERY-II (1+1)

Objective

To learn the engineering principles behind application of pesticides and the systems that implements the same. To learn the concepts behind design of crop harvesting and threshing equipment.

Theory

Block 1: Integrated Pest Management

Unit 1: Pesticide calculation examples. Multidisciplinary nature of pesticide application. Overview of chemical control integrated pest management. Targets for pesticide deposition. Formulation of pesticides.

Block 2: Design of Sprayers and Uses of Drones

Unit 1: Spray droplets, Hydraulic nozzles, Power operated hydraulics prayer design principles. Air assisted hydraulics prayer design principles. Controlled droplet application. Electro statically charged sprayers. Spray drift and its mitigation. Aerial spraying systems. Use of drones for spraying: Design of spray generation and application issues.

Block 3: Introduction to Combine Harvesters

Unit 1: Introduction to combine harvesters : Construction, equipment subsystems, power sub systems. Crop harvesting: Plant properties, physical and mechanical properties of plant system, plant bending modelling. Properties of plant grain: Physical, mechanical, grain damage. Properties of MOG; Mechanical and aero dynamics.

Block 4: Design of grain Header

Unit 1: Design of grain header; Orienting and supporting reel. Plant cutting cutter bar: Working process, cutter bar drive. Knife cutting speed pattern area. Design of auger for plant collection. Corn header: Working elements, snapping roll design, stalk grasping and drawing process. Cornear detachment: Stalk cutting and chopping.

Block 5: Design of Threshing Units

Unit 1: Cereal threshing and separation; Design of tangential and axial threshing units. Performance indices of threshing units. Modelling material kinematics in different threshing units. Factors influencing the threshing process and power requirement. Separation process and design of straw walker. Cleaning Unit process and operation. Grain pan; Chaffer and bottom sieve. Blower design and flow orientation. Design of conveying system for grain. Straw choppers and shredders.

Practicals

- Measurement of spray characters for different nozzles
- Problems on sizing of sprayer components
- Design of spraying units–manual
- Design of spraying units – powered
- Design of sprayer for special purpose: Orchard and tall trees
- Design of agitation units –mechanical and hydraulic
- Harvesting machines: Problems on design of shear type cutting mechanism
- Harvesting machines: Problems on design of impact type harvesting mechanics
- Harvesting machines: Problems on design of plot for mauger and conveyors
- Harvesting machines : Problems on design of reels
- Design of threshing drum: Radial flow type.
- Design of threshing drum: Axial flow type.
- Design of cleaning systems.
- Design of grading systems
- Design of blowers

References

- BERNACKI, C., HAMAN, J. AND KANAFAJSKI, C. Z., 1972, *Agricultural Machines Theory and Construction.* Vol-I.U.S. Department of Commerce, National Technical Information Service, Spring field, Virginia 22151.
- BINDRA, O. S. AND SINGH, H., 1971, *Pesticides Application Equipments.* Oxford & IBH Publishing Co., NewDelhi.
- BOSOI, E. S., VERNIAEV, O. V., SMIRNOV, II AND SULTAN-SHAKH, E. G. 1987, C*onstruction and Calculations of Agricultural Machinery -Vol.II*. Oxonian Press Pvt.Ltd. NewDelhi.
- MIU, P., 2016, *Combine Harvesters Modeling and Design.* CRC Press, Boca Raton, USA ISBN13:978-1-4822-8237-5

• THORN HILL, E. W. AND MATTHEWS, G. A., 1995, *Pesticide Application Equipment for Usein Agriculture* Vol II. Mechanically powered equipment FAOR ome.

FMP 507 MANAGEMENT OF FARM POWER AND MACHINERY SYSTEM (2+1)

Objective

To understand how principles of management are applied to farm machinery systems to make them more effective and profitable.

Theory

Block 1: Introduction of Farm Mechanization and Economic Performance of Machinery

Unit 1: Importance and objectives of farm mechanization in Indian agriculture, its impact, strategies, myths and future needs. Estimation of operating cost of tractors and farm machinery. Management and performance of power, operator, labour. Economic performance of machinery, field capacity, field efficiency and factors affecting field efficiency.

Block 2: Tractor Power Analysis

Unit 1: Tractor power performance in terms of PTO, drawbar and fuel consumption. Power requirement problems to PTO, DBHP.

Unit 2: Selection of farm machinery, size selection, timeliness of operation, optimum width and problem related to its power selection. Reliability of agricultural machinery. Replacement of farm machinery and inventry control of spare parts.

Block 3: Programming Techniques and Networking Analysis in Farm Machinery

Unit 1: Systems approach to farm machinery management and application of programming techniques to farm machinery selection and scheduling. Network Analysis: Transportation, CPM and PERT, dynamic programming, Markov chain.

Practicals

- Introduction to latest development of advanced agricultural
- Equipment's in India
- Experiment al determination of field capacity of different
- Farm machines
- Case studies on optimum size selection of agricultural machinery
- Determination of inventory of different farm machines for a farm of size 50 has per regional crop rotations
- To develop computer program regarding selection of farm machinery size and power requirement for a 10, 50 and 100 ha farm size.

References

- CARVEILLE, L. A., 1980, Selecting Farm Machinery .Louisiana Cooperative Extn. Services Publication.
- CULPIN, C., 1996, Profitable Farm Mechanization. Lock Wood and Sons, London.
- FAO., 1990, Agricultural Engineering in Development: Selection of Mechanization Inputs.
- FAO, Agri service Bulletin.
- HUNT, D., 1979, Farm Power and Machinery Management. Iowa State University Press, USA.
- KAPOOR, V. K., 2012, Operation Research: Concepts, Problems and Solutions. Sultan Chand
- AND SONS, India. KAB-I, New Delhi.

FMPE 511 PRINCIPLES OF AUTOMATIONAL CONTROL (2+1)

Objective

To learn the principles behind systems for industrial automation and control especially with respect to electronically implemented systems.

Theory

Block 1: Introduction to Industrial Automation

Unit 1: Introduction to industrial automation and control: Architecture of industrial automation systems, review of sensors and measurement systems. Introduction to process control: PID control, controller tuning, implementation of PID controllers, special control structures, feed forward and ratio control, predictive control, control of systems with inverse response, cascade control, overriding control, selective control and split range control.

Block 2: Introduction to PLC Circuits

Unit 1: Introduction to sequence control: PLCs and relay ladder logic, sequence control, scan cycle, RLL syntax, sequence control structured design approach, advanced RLL programming, the hard ware environment, Introduction to CNC machines.

Unit 2: Control of machine tools: Analysis of a control loop, introduction to actuators. Flow control valves, hydraulic actuator systems, principles, components and symbols, pumps and motors. Proportional and servo valves. Pneumatic control systems, system components, controllers and integrated control.

Block 3: Drives and Motors

Unit 1: Control systems: Electric drives, introduction, energy saving with adjustable speed drives step per motors, principles, construction and drives. DC motor drives: Introduction to DC-DC converters, adjustable speed drives. Induction motor drives: Introduction, characteristics, adjustable speed drives. Synchronous motor drive-motor principles, adjustable speed and servo drives.

Unit 2: Networking of sensors, actuators and controllers, the field bus, the field bus communication protocol, introduction to production control systems.

Practicals

- Control system including characteristics of DC servomotor
- AC / DC position control system
- Temperature control system

- Step response of second order system
- Temperature control system using PID level control system
- Introduction to ladder logic, writing logic and implementation in ladder.
- PLC programming
- Water level controller using programmable logic controller
- Batch process reactor using programmable logic controller
- Speed control of AC servo motor using programmable logic controller.

References

- https://nptel.ac.in/downloads/108105063/
- MANE SIS, S. AND NIKOLAKOPOULOS, G., 2018, *Introduction to Industrial Automation. 1st Edition*, CRC Press. Textbook-ISBN9781498705400 -CAT#K24766

FMPE 512 PRINCIPLES OF HYDRAULIC AND PNEUMATIC SYSTEMS (2+1)

Objective

To understand the principles behind operation of hydraulic and pneumatic systems and their components and design of simple hydraulic and pneumatic circuits and select components for the same.

Theory

Block 1: Hydraulic Power and properties of Hydraulic Fluids

Unit 1: Hydraulic power, its advantages, applications, properties of hydraulic fluids, viscosity, bulk modulus, density. Concepts of energy of hydraulic systems, laws of fluid flow.

Block 2: Design of Hydraulic Pump, Motors and Actuators

Unit 1: Hydraulic pump and motors, principle, capacity, classifications, working, performance. Design of various types of pump sand motors.

Unit 2: Actuators, types, design of line actvator and rotary actuators. Hydraulic rams, gear motors, piston motors and their performance characteristics. Hose, filters, reservoirs, types of circuits, intensifier, accumulator, valves. Valve types: Direction control, deceleration, flow, pressure control, check valve and their working etc.

Block 3: Hydraulic circuit Design

Unit 1: Hydraulic circuit design. Applications in farm power and machinery: Tractor, combine, farm machinery systems, hydrostatic system *etc.*

Block 4: Design of Pneumatic Circuits

Unit 1: Power pack, pneumatic circuits, properties of air. Compressors, types. Design of pneumatic circuits.

Practicals

- Study of various hydraulic pumps
- Study of various hydraulic motors
- Study of various hydraulic valves
- Study of various hydraulic directional control valves
- Study of various hydraulic cylinder piston arrangements
- Engineering properties of hydraulic fluids
- Study of hydraulic system of tractor
- Study of power steering system
- Study of power pack, pneumatic circuits, components of pneumatic systems

References

- ANTHONY, E., 2003, *Fluid Power with Applications*. Pearsons Education (Singapore) Pvt. Ltd.
- KRUTZ, G., 1984, *Design of Agricultural Machines*. John Wiley and Sons.
- MAJUMDAR, S. R., 2003, *Oil Hydraulics Systems :Principles and Maintenance*. Tata Mc Graw Hill Co.

• MERRITT, H. E., 1991, *Hydraulic Control System*. John Wiley and Sons Inc.

FMP 513 APPLIED INSTRUMENTTATION (2+1)
FARM MACHINERY

Objective

To understand the operation of instrument that is used in design and evaluation of farm machinery and their application.

Theory

Block 1: Design, Selection and analysis of Strain gauges

Unit 1: Strain gauges, types and applications in two and three dimensional force measurement in farm machinery. Various methods of determining strain/stresses experimentally. Design, selection and analysis of strain gauges.

Block 2: Transducers

Unit 1: Introduction to transducers (sensors). Active and passive transducers, analog and digital modes, null and deflection methods. Performance characteristics of instruments including static and dynamic characteristics.

Block 3: Load Cells

Unit 1: Load cells, torque meters, flow meters, types and principles of working. Devices for measurement of temperature, relative humidity, pressure, sound, vibration, displacement (LVDT) etc. Recording devices and their types. Measuring instruments for calorific value of solid, liquid, and gaseous fuels.

Block 4: Data Acquisition Systems

Unit 1: Basic signal conditioning devices, data acquisition system. Micro computers for measurement and data acquisition. Data storage and their application including wireless communication. Application of sensors in farm machinery and power: Tractor and selected farm machinery.

Practicals

- Calibration of Load Cells
- Calibration of Torque Meters
- Calibration of Flow Meters
- Experiment on LVDT
- Experiment on Strain Gauge
- Speed measurement using optical devices
- Vibration Measurement
- Making of Thermocouples
- Application of Sensors in Farm Machinery like wheel hand hoe *etc.*

References

- AMBROSIUS, E. E., 1966, *Mechanical Measurement and Instruments*. The Ronald Press Company.
- DOEBLIN, E. O., 2004, *Measurement System – Application and Design*. Tata M c Graw Hill
- NAKRA, B. C. AND CHOUDHARY, K. K., 1985, *Instrumentation, Measurement and Analysis.* 2nd Edition Tata Mc Graw Hill.
- NACHTIGAL, C. L. (Editor)., 1990, *Instrumentation and Control. Fundamentals and Application*. Wiley Series in Mechanical Engineering.
- OLIVER, F. J., 1971, *Practical Instrumentation Transducers*. Hayden book company Inc.

FMP 514 SYSTEMS SIMULATION AND COMPUTER AIDED PROBLEM SOLVING IN ENGINEERING (1+1)

Objectives

To give the student orientation in simulation of continuous and discrete systems especially using computer programme and software.

Theory

Block 1: Introduction to Mathematical Modeling and approximation

Unit 1: Mathematical modeling and engineering problem solving: Conservation laws and engineering. Computers and software: Software development, structured programming, logical representation. Modular programming. Approximation: Round off errors, truncation errors, significant figures, accuracy and precision.

Block 2: Simulation

Unit 1: Nature of simulation: Systems models and simulation, discreet event simulation, time advance mechanisms, components of discrete event simulation model, simulation of single server queuing system. Program organization and logic, development of algorithm. Simulation of an inventory system.

Block 3: Computer Aided Programming Methods

Unit 1: Solving roots of equation using computers. Application in: Ideal and non-ideal gas laws, open channel flows, design of an electric circuit, vibration analysis. Solving linear algebraic equation on computers: Naïve Gauss Elimination, techniques for improving solutions, LU decomposition and matrix inversion. Application in: Steady state analysis of chemical reactors, statically determinate truss, current and voltage in circuits, spring mass systems.

Block 4: Optimization Techniques

Unit 1: Optimization techniques. Search techniques: Golden Sections, quadratic interpolation. Application: Optimum design of tank, least cost treatment of waste water, power transfer for circuits. Solving ordinary differential equation on computers: Modeling engineering systems with ordinary differential equation, solution techniques using computers.

Practicals

- Exercises in developing imple programmes in C.
- Demonstration of solutions using analytical and numerical methods for simple problems

- Development of programmes for generation of random variables
- Writing programme for generating random variates
- Writing programme for event advance mechanism of single server queuing system
- Writing programme for arrival module of single server queuing system.
- Writing programme for departure module of single server queuing system and statistical performance
- Writing programme for solution of roots of equation.
- Solving simple engineering problems using roots of equation.
- Development of algorithm for Gaussian elimination
- Application of Gaussian elimination to mass balance problems and Statically determinate truss.
- Application of Gaussian elimination to analysis of electrical circuits
- Development of algorithm for Golden Sections and application
- Application of optimization technique to design of tank
- Application of optimization technique to waste water treatment
- Predat or prey models and chaos.

Reference

- BALAGURUSAMY, E., 2000, *Numerical Methods.* Tata Mc Graw Hill Publishing Company limited, New Delhi.
- CHAPRA, S. C. AND CANALE, R. P., 1994, *Introduction to Computing for Engineers*. 2nd Edition Mc Graw Hill International Edition, New York.
- DENT, J. B. AND BLACKIE, M. J., 1979, *System Simulation in Agriculture.* Applied Science Publishers Ltd., London.
- LAW, A. M., 2015, *Simulation Modeling and Analysis.* Mc Graw Hill International Edition, New York.
- SCHILLING, R. J. AND HARRIES, S. L., 2002, *Applied Numerical Methods for Engineers Using MATLAB and C*.Thomson Asia Pvt. Ltd. Singapore.

- VEERARAJAN,T. AND RAMACHNADRAN, T., 2004, *Numerical Methods with Programmes in Cand*
- *C++*. Tata Mc Graw Hill Publishing company limited, New Delhi.

FMP 515 COMPUTER AIDED DESIGN OF MACHINERY (0+2)

Objective

To learn the practice of designing components and assemblies based on computer aided drafting technique.

Practicals

- Learning 2 D drafting: Controlling display settings, setting up units, drawing limits and dimension styles
- Drawing and dimensioning simple 2 D drawings, key board shortcuts
- Working with blocks, block commands. Exercise in simple assembly in or thographic
- Exercise in measuring and drawing simple farm machinery parts.
- Learning3D Drafting: Advantages of virtual prototyping-starting the 3 D drafting environment, self-learning tools, help and tutorials. Familiarizing with user interface, creating files and file organization, structuring and streamlining. Features of document window.
- Concept of coordinate system: Working coordinate system, model coordinate system, screen coordinate system, graphics exchange standards and database management system.
- Working with feature manager and customizing the environment. Planning and capturing design intent.
- Documentation of design. Using design journal and design binder. Preliminary design review and layout
- Practice in drawing 2 D sketches with sketcher and modifying sketch entries.
- Adding Reference geometry: Planes and axes. Adding relations and working with relations. Dimensioning sketch. Exercises.

- Parts and features: Sketched features and applied features, pattern and mirror features. Documenting design.
- Assembly: Creating and organizing assemblies, connecting parts and subassemblies with mates
- Organizing the assembly by using layouts.
- Exercise in creating drawing: Setting up and working with drawing formats, creating drawing views from the 3 D model,
- Case studies: Measuring and drawing assemblies of farm implements

Reference

- JANKOWSKI, G. AND DOYLE, R., 2007, Solid Works® For Dummies®, 2nd Edition, Published by Wiley Publishing, Inc. ISBN: 978-0-470-12978-4
- SHIH, R. H., 2014, AutoCAD 2014 Tutorial-First Level: 2D Fundamentals. SDC Publications.

FMP 516 ADVANCED MANUFACTURING TECHNOLOGIES (2+1)

Objective

To learn the modern manufacturing techniques and their application to manufacture of different components and assemblies.

Theory

Block 1: Properties of Materials, Materials Selection and Metallurgy

Unit 1: Material and their characteristics, structure and properties of materials, wood, ferrous, Non-ferrous, alloys, plastic, elastomers, ceramics and composites. Material selection and metallurgy: Equilibrium diagram, time temperature transformation curves, heat treatments, surface treatment: Roughness and finishing.

Block 2: Measurement of Quality Assurance, Fundamental of Farming Process

Unit 1: Measurement and quality assurance: Quality control, tolerance, limits and clearance. Automated 3-D coordinate measurements.

Advance casting processes and powder metallurgy. Forming process: Fundamentals of metal forming, hot and cold rolling, forging processes, extrusion and drawing.

Block 3: Machining Process

Unit 1: Workshop practices applied in prototype production, jigs and fixtures. Traditional machining processes: Cutting tools, turning, boring, drilling, milling and related processes. Non-traditional machining processes fuzzyc-mean (FCM), electric discharge machining (EDM), laser beam machining (LBM), Abrasive jet machining (AJM), and Wire-electro-discharge machining (EDM).

Unit 2: Joining processes: Gas flame processes, arc processes, brazing and soldering, adhesive and bonding.

Block 4: Numerical Control, Automation, Robotics and 3D Printing

Unit 1: Numerical control: Command system codes, programme, cutter position X and Y, incremental movements, linear contouring, Z movements and commands. Manufacturing systems and automation. Robotics and robot arms. 3-D printing. Integrated manufacturing production system.

Practicals

- Identification of material and their application
- Study of heat treatment processes and their suitability with respect to materials.
- Tool and equipments for measurements: Tolerance limits, clearance and surface finish
- Site visits for study of advanced manufacturing techniques
- Case studies.

Reference

- BEGEMAN, M. L., OSTWALD, P. F. AND AMSTEAD, B. H., 1979, *Manufacturing Processes: SI Version*. John Wiley and Sons. 7th Edition.
- CHAPMAN, PAJ., 1996, *Workshop Technology*, Part III.CBS Publisher and distributors Pvt Ltd.3rd Edition international Edition.

- GUPTA, R. B., 2017, *Production Technology*, VolI-Production Process. Satya Prakashan, New Delhi.
- HOYOS, L., 2010, *Fundamentals of Tool Design*. American Society of Tool and Manufacturer Engineers. Sixth Edition.
- JAIN, R. K., 1994, *Production Technology: A Textbook for Engineering Students*. Khanna Publishers, New Delhi.
- POLUKIN, P., GRINGERG, B., KANTENIK, S., ZHADAN, V. AND VASILYE, D. *Metal Process Engineering*, MIR Publishers Moscow.

FMP 517 MACHINERY FOR PRECISION AGRICULTURE (2+1)

Objective

To learn the principles behind precision agriculture and the systems for implanting the same.

Theory

Block 1: Importance of Precision Agriculture

Unit 1: Importance of precision agriculture. Mapping in farming for decision making. Geographical concepts of PA. Understanding and identifying variability

Block 2: Application of GPS and GIS in Agriculture

Unit 1: Geographical Position System (GPS) Basics (Space Segment, Receiver Segment, Control Segment), Error and correction, Function and usage of GPS. Introduction to Geographic Information system (GIS), function of GIS, use of GIS for decisions. IDI devices usage in Precision Agriculture Yield monitor, variable rate applicator for fertilizers, seed, chemicals etc. Remote sensing Aerial and satellite imagery. Above ground (non-contact) sensors.

Block 3: Data Analysis and Surface Analysis Techniques

Unit 1: Data analysis, concepts of data analysis, resolution, Surface analysis. Analysis application interpretive products (map, charts, application map etc).

Block 4: Precision Variable Equipments

Unit 1: Electronics and Control Systems for Variable rate applications, Precision Variable Equipment, Tractor-Implement interface technology, Environmental Implications of Precision Agriculture.

Block 5: Cost Benefit of Precision Agriculture

Unit 1: Goals based on end results of Precision Agriculture, Recordkeeping, Spatial Analysis, Variable Rate Application, Reducing of negative environmental impact, Crop / technology cost optimization. Economic of precision agriculture and determining equipment and software, review of Cost / Benefit of Precision Agriculture, System v/s. Parcels. Making a selection.

Practicals

- Calculation of the benefits of data and mapping
- Determining Latitude / Longitude, UTM or State Plane Position
- Navigation with Way points
- Configuring a GPS System
- Defining area of field for prescriptive treatment
- Making the grid and grid sampling process
- Collection of tractor-implement interface data
- Generation of yield maps
- Example of spatial and temporal variability and resolution
- Surface Analysis using software like Arc-View
- Economic of precision agriculture and determining equipment
- Cost / Benefit of Precision Agriculture for making a optimized selection.

Reference

- CLAY, S. A., CLAY, D. E. AND BRUGGEMAN, S. A., 2017, *Practical Mathematics for Precision Farming* American Society of Agronomy, Crop Science Society and Soil Science Society of America,5585Gulford Rd, Madison,WI53711

- HENTEN, E. J. V., GOENSE, D. AND LOKHORST, C., 2009, *Precision Agriculture*. Wageningen Academic Publishers.
- RAM,T., LOHAN, S. K., SINGH, R. AND SINGH, P., 2014, *Precision Farming: A new Approach*. Astral International Pvt. Ltd., New Delhi, ISBN: ISBN 978-81-7035-827-5 (Hardbound) ISBN
- 978-93-5130-258-2(International Edition).
- SHANNON, D. K., CLAY, D. E. AND KITCHEN, N. R. (editors)., 2018, *Precision Agriculture Basics* American
- Society of Agronomy, Crop Science Society and Soil Science Society of America, 5585 Gulford Rd, Madison, WI 53711
- SINGH, A. K. AND CHOPRA, U. K., 2007, Geo informatics Applications in Agriculture. New India Publishing Agency, Pritam Pura, New Delhi.

FMP 518 MACHINERY FOR HORTICULTURE AND PROTECTED AGRICULTURE (2+0)

Objectives

To learn about the different machinery used in cultivation of vegetable crops, orchard crops and also in protected agriculture.

Theory

Block 1: Machineries for Harvesting of Crops.

Unit1: Vegetable cultivation, nursery machinery, tray seeders, grafting machines, vegetable trans-planters. Machinery for planting crops on raised beds, mulch laying and planting machines. Harvesting of vegetable crops: Harvesting platforms and pickers.

Block 2: Machinery for Orchard Crop

Unit 1: Machinery for orchard crops: Pit diggers, inter-cultivators and basin forming equipment for orchards. Machinery for transplanting of trees. Harvesters for fruit crops: Shaker harvesters, types and principle of operation. Elevated platforms for orchard management and harvesting. Pruning machines.

Block 3: Machinery for Special Crops, Lawn and garden

Unit 1: Machinery for orchards, vineyard machinery spraying machines, inter-cultivation machines. High clearance machines and special purpose machinery for crops on trellis. Machinery for special crops: Tea leaf harvesters, pruners and secateurs.

Unit 2: Machinery for lawn and garden: Grass cutters, special machinery for turf maintenance. Turf aerators and lime applicators.

Block 4: Protected Agriculture

Unit 1: Protected agriculture: Principles, mechanical systems of greenhouse, ventilation systems, shading system, water fogging system, irrigation system, sensors, electrical and electronic system. Intelligent Control system for green houses. Machinery for processing of growth media, tray filling machines-tray sowing machines, transplanting machines. Robotic grafting machines. Weeding and thinning equipment. Crop protection and harvest under protected agriculture.

Reference

- BELL, B. AND COUSINS, S.,1997, *Machinery for Horticulture*. Old Pond Publishing Ltd ISBN-10:0852363699, ISBN-13:978-0852363690
- *Good Agricultural Practices for Green house Vegetable Production in the South East European countries* FAO Rome 2017.
- PONCE, P., MOLINA, A., CEPEDA, P., LUGO, E. AND MAC CLEERY, B., 2014, *Green house Design and Control.* CRC Press, ISBN 9781138026292-CATK23481,1st

M. Tech. in Food Processing Technology

Course Code	Course Title	Credit Hours
FPT 501	Emerging Technologies in Food Processing	3 (2+1)
FPT 502	Emerging Technologies in Food Packaging	3 (2+1)
FPT 503	Industrial Manufacturing of Food and Beverages	3 (2+1)
FPT 504	Food Material and Product Properties	3 (2+1)
FPT 505	Cocoa and Chocolate Processing Technologies	3 (2+1)
FPT 506	Spices, Herbs and Condiments	2 (2+0)
FPT 507	Meat, Poultry, Fish and Egg Processing	3 (2+1)
FPT 508	Nutraceuticals and Specialty Foods	3 (2+1)
FPT 509	Frozen and Concentrated Foods	2 (1+1)
FPT 510	Aseptic Processing and Packaging	3 (2+1)
FPT 511	Traditional Foods	3 (2+1)
FPT 512	Technologies of Convenience Foods	3 (2+1)
FPT 513	Food Powder and Premixes	3 (2+1)
FPT 514	Food Ingredients and Additives	3 (2+1)
FPT 515	Flavour Chemistry and Technology	3 (2+1)
FPT 516	Bioprocessing and Separation Technology	3 (2+1)
FPT 517	Enzymes in Food Processing	3 (2+1)
FPT 518	Food Process Automation and Modelling	2 (2+0)
FPT 519	Zero Waste Processing	2 (2+0)
FPT 520	Special Problem / Summer Internship	2 (0+2)
	Total	**55 (37+18)**
FPT 580	Qualifying Examination	2 (0+2)
FPT 581	Seminar-I	1 (0+1)
FPT 582	Seminar-II	1 (0+1)
FPT 591	Research-I	13 (0+13)
FPT 592	Research-II	14 (0+14)

FPT 501 EMERGING TECHNOLOGIES IN FOOD PROCESSING (2+1)

Objective

To gain a better understanding of the newer food processing technologies such as membrane processing, high pressure processing and ultrasonic processing and know their applications.

Theory

Block 1: Membrane Technology

Unit 1: Pressure activated membrane processes: Microfiltration, Ultrafiltration, Nanofiltration and Reverse Osmosis and their industrial application. Membrane distillation.

Unit 2: Supercritical fluid extraction (SCFE): Concept, properties of super critical fluids, extraction methods, application in food processing.

Block 2: Microwave and Radio Frequency Processing

Unit 1: Advantages of microwave and radio frequency processing, mechanism of heat generation, application in food processing, microwave blanching, sterilization and finish drying.

Unit 2: Hurdle technology: Concept and principle, preservation techniques as hurdles and their principles, hurdle technology for foods.

Block 3: Recent Technologies in Food Processing

Unit 1: High Pressure Processing: Concept, equipment for HPP treatment, mechanism of microbial and enzyme inactivation and its application in food processing, effect on food constituents.

Unit 2: Ultrasonic processing: Properties, types of equipment, and applications. Cryo-processing of foods. Nanotechnology: Principles and applications in foods.

Unit 3: Principle and application of high intensity light, pulsed electric field, ohmic heating, IR heating, inductive heating, cold plasma, and pulsed X-rays in food processing and preservation.

Practicals

Evaluation of the characteristics of RO treated water. Production and characteristics of treated water using MF, UF, NF and RO systems. Effect of ultrafiltration on fruit juice quality. Effect of microfiltration process on milk quality. Extraction of lycopene from tomato using SCFE system. Microwave blanching of vegetable and determination of blanching efficacy. Nano emulsions and their characteristics. Effect of ohmic heating on the processing of fruit pulp. Effect of different drying techniques/hybrid drying techniques on fruits and vegetables. Visit to food industries utilizing advanced food processing techniques.

References

- GOULD GW, 2000. New Methods of Food Preservation, CRC Press
- BARBOSA-CANOVAS, 2002. Novel Food Processing Technologies, CRC Press
- SUN DW, 2015. Emerging Technologies for Food Processing, Elsevier Ltd.
- NEMA PK, KAUR BP AND MUJUMDAR AS, 2018. Drying Technologies for Foods: Fundamentals and Applications, CRC Press.

FPT 502: EMERGING TECHNOLOGIES IN FOOD PACKAGING (2+1)

Objective

To learn about the newer food packaging technologies such as active and intelligent packaging, antimicrobial packaging and study the recent advances in food packaging materials and systems.

Theory

Block 1: Active and intelligent packaging

Unit 1: Active packaging and intelligent packaging techniques, current use of novel packaging techniques.

Unit 2: Oxygen, ethylene and other scavengers: Oxygen scavenging technology, selecting right types of oxygen scavengers; ethylene, carbon dioxide and other scavengers.

Unit 3: Antimicrobial food packaging: Antimicrobial agents, constructing antimicrobial packaging systems, factors affecting the effectiveness of antimicrobial packaging.

Block 2: Non-migratory Bioactive Polymers (NMBP)

Unit 1: Advantages of NMBP; inherently bioactive synthetic polymers: types and application; polymers with immobilized bioactive compounds and their applications.

Unit 2: Time temperature labels and indicators (TTIs): Defining and classifying TTIs, Application of TTIs to monitor shelflife. Self-heating / rehydrating packages.

Unit 3: Freshness indicator in packaging: Compounds indicating the quality of packaged food products, freshness indicators, pathogen indicators, other methods for spoilage detection.

Block 3: Packaging- Flavour Interactions

Unit 1: Factors affecting flavour absorption, role of food matrix, role of differing packaging materials, flavour modification and sensory quality; packaging materials compatibility with foods.

Unit 2: Developments in modified atmosphere packaging (MAP): Permeability properties of polymer packaging; measurement of permeability of water and gases. Selection criteria of packaging films.

Unit 3: Recycling of packaging materials: Recyclability of packaging plastics, improving the recyclability of plastics packaging, testing safety and quality of recycled materials, uses of recycled plastics in packaging.

Block 4: Green Plastics for Food Packaging

Unit 1: Problems of plastic packaging wastes, range of biopolymers, developing novel biodegradable materials.

Unit 2: Edible Films and Coatings: Properties, types, sources, applications, advantages, disadvantages, theories of plasticization, challenges and opportunities.

Unit 3: Safety and legislative aspects of packaging: Regulatory considerations; plastic, metal, paper and glass packaging.

Practicals

Determination of WVTR and GTR in different packaging materials. Oxygen and ethylene scavengers and their analysis. Application of anti-microbial packaging for moisture sensitive foods. Evaluation of chemical residue migration from package to food. Application of MAP in selected foods. Determination of oxidative changes in packaged foods. Comparative evaluation of flexible and rigid packages for fragile foods. Shelf life evaluation of a packaged food product. Determination of oil and grease resistance for packaging films. Determination of shelf life of fresh fruits and vegetables by using edible coating and films. Visit to food packaging material manufacturing industry.

References

- AHVENAINEN R, 2001. Novel Food Packaging Techniques, CRC Press
- HAN J AND HAN J, 2005. Innovations in Food Packaging, Academic Press
- YAM K AND LEE D, 2012. Emerging Food Packaging Technologies, Woodhead Publishing.

FPT 503 INDUSTRIAL MANUFACTURING OF FOOD AND BEVERAGES (2+1)

Objective

To learn about the commercial scale manufacture of various types of foods and beverages, and to study the processes and equipment used in their manufacture.

Theory

Block 1: Grain Products

Unit 1: Industrial manufacturing of grain based products: formulation, processes, machinery and material balance of baked, puffed, flaked, roasted products.

Unit 2: Extrusion technology: Importance and applications of extrusion in food processing; pre and post extrusion treatments; manufacturing process of extruded products; Breakfast cereals, RTE/ RTC foods, instant premixes, functional foods.

Block 2: Fruit and Vegetable Products

Unit 1 – Industrial manufacturing of fruit and vegetable based products: formulation, process, machinery and material balance of minimally processed and retorted products.

Unit 2 – IMF, high moisture stable foods; IQF; machines and equipment for batch and continuous processing of fruit and vegetable products.

Block 3: Chocolates and candies

Unit 1 – Coating or enrobing of chocolate (including pan-coating); maintenance, safety and hygiene of bakery plants.

Unit 2 – Fats and oil processing: Technology of refined oil, winterized oil, hydrogenated fat, texturized fat; by-products of fat/oil processing industries – oil seed protein isolates; antioxidant and its mechanism of application.

Block 4: Beverages

Unit 1 – Non-alcoholic beverages: Carbonated beverages: carbonation equipment, ingredients, preparation of syrups, filling system, packaging, containers and closures.

Unit 2 – Non-carbonated beverages: Coffee bean preparation, processing, *brewing decaffeination*; instant coffee; Tea: types-black, green; Fruit juices and beverages. Aseptic packaging of beverages. Grain based and malted beverages.

Unit 3 – Alcoholic beverages: Wine and beer - ingredients, preparation, packaging, quality evaluation.

Unit 4 – Packaged drinking water: types, manufacturing processes, quality evaluation and raw and processed water; methods of water

treatment.BIS quality standards of bottled water, mineral water, natural spring water, flavoured water, carbonated water.

Practicals

Preparation of cereal and pulse based ready-to-eat snack food by extrusion cooking. Preparation of cereal grain based puffed and fried products. Instant food premixes. Preparation of flaked rice products. Effect of roasting time and temperature on quality of pop-corn. Shelf-life and packaging requirements of snack food products. Preparation of fruit/vegetable based ready to serve beverages and quality evaluation. Determination of quality of packaged drinking water. Preparation of wine and beer. Preparation of soy milk.

References

- EDMUND WL, 2001. Snack Foods Processing, CRC Press
- FRAME ND, 1994. Technology of Extrusion Cooking, Springer US
- BAMFORTH CW, 2006. Brewing: New Technologies, Woodhead Publishing.

FPT 504 FOOD MATERIAL AND PRODUCT PROPERTIES (2+1)

Objective

To gain a better understanding of the physico-chemical, mechanical, rheological and functional properties of various types of foods and the factors influencing the properties of foods.

Theory

Block 1: Physico-chemical Properties

Unit 1: Biomaterials and their properties in relation to processing and product development.

Unit 2: Physico-chemical characteristics: Shape, sphericity, size, microstructure, volume, density, porosity, surface area, coefficient of friction, angle of repose, influence of constituents on processing.

Block 2: Mechanical and Rheological Properties

Unit 1: Flow behaviour of granular and powdered food materials; rheological models; creep phenomenon, stress-strain-time effects and relationships.

Unit 2: Textural characteristics and textural profile analysis of food products.

Block 3: Thermal, Electrical and Optical Properties

Unit 1: Specific heat, thermal conductivity, phase transition; thermodynamics-basic principles and laws; kinetics of water absorption; heat capacity; thermal diffusivity, electrical resistance and conductance; dielectric constant; reflectivity.

Unit 2: Food microstructure: Methods and systems for food microstructure determination; light microscopy, transmission electron microscopy, scanning electron microscopy; image analysis: image acquisition, image processing.

Block 4: Functional Properties

Unit 1: Dextrinization, gelatinisation, crystallisation, gelation, foaming, coagulation, denaturation, syneresis, foaming, emulsification.

Unit 2: Sensory attributes: Sensory properties and correlation with objective indices; microstructure and its relation to texture.

Practicals

Suitability of physical dimension and shape of food materials for processing and packaging. Bulk density, true density and porosity of samples. Analysis of powder characteristics using powder flow analyser. Mixing and strength characteristics of wheat flour using faringograph. Amylolytic activity using falling number of wheat flour. Stress-strain curve to study viscosity of Newtonian and non-Newtonian fluids. Effect of temperature on viscosity profile of a food sample. Texture profile analysis of food samples. Dielectric constant of foods. Organoleptic evaluation of food materials. Water activity of foods. Determination of colour value of food, viz. LAB, whiteness index, yellow index, browning index.

References

- RAO MA AND RIZVI SSH, 1986. Engineering Properties of Foods, Marcel Dekker
- BOURNE MC, 1981. Food Texture and Viscosity; Concept and Measurement, Academic Press
- STEFFE JF, 1992. Rheological Methods in Food Process Engineering, Freeman Press
- RAHMAN MS, 2009. Food Properties Handbook, CRC Press
- POMERANZ Y, 1991. Functional Properties of Food Components, Academic Press.

FPT 505 COCOA AND CHOCOLATE PROCESSING TECHNOLOGIES (2+1)

Objective

To learn about the processing of cocoa beans and the manufacture of different types of chocolate products. Chocolate is among the most popular foods consumed.

Theory

Block 1: Cocoa Processing

Unit 1: Cocoa, chemistry of the cocoa bean, analysis of cocoa beans, processing of raw bean, changes taking place during fermentation of cocoa beans.

Unit 2: Processing of cocoa beans: cleaning, roasting, alkalization, cracking and fanning; nib grinding for cocoa liquor; cocoa butter and cocoa powder; chemical changes during various stages of processing.

Block 2: Chocolate Manufacture

Unit 1: Types of chocolates, ingredients, chemistry of chocolate manufacture.

Unit 2: Mixing, refining, conching, tempering, moulding, etc. to obtain chocolate slabs and chocolate bars. Dark, milk and white chocolate and their manufacturing processes. Quality evaluation, packaging and storage of chocolates.

Block 3: Enrobed and Other Confectionary Products

Unit 1: Compound coatings and candy bars; tempering technology, chocolate hollow figures, chocolate shells.

Unit 2: Enrobing technology, manufacture of candy bars. Application of vegetable fats for enrobing. Production of chocolate mass.

Practicals

Anatomical structure of cocoa beans. Effect of fermentation on cocoa beans. Effect of roasting on cocoa beans. Effect of packaging on quality of cocoa beans. Production of cocoa liquor and cocoa butter. Effect of tempering on chocolate. Fat expulsion during chocolate storage. Production of milk chocolate. Production of dark chocolate. Effect of packaging on quality of chocolate. Effect of storage temperature on chocolate quality.

References

- MINIFIE, BW, 1999. Chocolate, Cocoa and Confectionery Technology. Springer Science & Business Media.

FPT 506 SPICES, HERBS AND CONDIMENTS (2+0)

Objective

To learn about the different types of spices and herbs commonly used and study the processes involved in the manufacture of various value added products from spices and herbs.

Theory

Block 1: Introduction to Spices and Herbs

Unit 1: Status and scope of spice processing industries in India; spices, herbs and seasonings: classification on the basis of origin and physical characteristics.

Unit 2: Major spices: Post-harvest technology; processed products of following spices: ginger, chilli, turmeric, onion garlic, pepper and cardamom

Unit 3: Minor spices, herbs and leafy vegetables: all spice, sweet basil, caraway seed, cassia, cinnamon, clove, coriander, cumin, dill seed, nutmeg, mint, rose merry, saffron, sage.

Block 2: Processing Technology of Spices

Unit 1: Chemical composition, processing methods, equipment used; recent advances in processing; spice quality evaluation, criteria for assessment of spice quality.

Unit 2: Effect of processing on spice quality, contamination of spices with micro-organisms and insects.

Unit 3: Spice Essential Oils: methods of extraction, isolation, and encapsulation;Spice Oleoresins: method of extraction, isolation, separation equipment.

References

- REINECCIUS G. 2005. Flavour Chemistry and Technology, CRC Press
- HEATH HB, 1986. Flavour chemistry and Technology, AVI Publishers
- PIGGOTT JR, PATERSON A. 1994. Understanding Natural Flavours, Springer US.

FPT 507 MEAT, POULTRY, FISH AND EGG PROCESSING (2+1)

Objective

To learn about the processes involved and the equipment required for the manufacture of various processed products from meat, poultry, fish and eggs. Processing is commonly employed for adding value to the raw meat and poultry.

Theory

Block 1: Meat Industry

Unit 1: Meat and meat products in India. Meat production and trade practices. Prospects and problems in production of fresh meat in India. Research and Development activities on meat and poultry products.

Unit 2: Breeds, pre-slaughter care, ante and post mortem, slaughter, handling of offal (edible and inedible). Cuts of beef, pork and mutton.

Unit 3 – Meat plant sanitation, ante-mortem inspection, post-mortem inspection, condemnation, product inspection, laboratory inspection, labelling. Types of grades, factors used to establish quality grades, conformation, fleshing and finish.

Block 2: Meat Processing

Unit 1: Properties of fresh meat: perception of tenderness, factors affecting tenderness, myofibrillar tenderness, marbling. Methods to improve tenderness (electrical stimulation, aging). Meat colour, pigments associated with colour, methods to improve meat colour. Water holding capacity of meat.

Unit 2: Poultry meat: Kinds of poultry, processing of poultry meat. Special poultry products: smoked turkey, packaged precooked chicken, freeze dried poultry meat.

Unit 3: Egg and egg processing: Egg quality, egg preservation, egg powder production.

Unit 4: Meat analogues and restructured meat products; Textured plant proteins; processes for preparation of meat analogues and restructured meat products.

Block 3: Fish Processing and Fish Products

Unit 1: Chemical/nutritional composition of fish; fish in human diet. Selection of raw material for processing, streaking and filleting of fish; production of fish paste, fish oils, sauce, fish protein concentrates.

Unit 2: Irradiation of fish and fish products; packaging of fish products; quality control and quality assurance. Allergens, toxins and infectious diseases from meat, poultry and fish products.

Practicals

Effect of low and high oxygen atmosphere on meat colour. Action of tenderizing enzymes on meat. Observation of structure of the muscle under compound microscope. Identification of different internal organs

of poultry birds and their utilization for product preparation. Dressing of fish. Determination of buffering capacity of fish muscle. Rapid estimation of hypoxanthine concentration in chill stored fish. Cut out test for canned fish products. Determination of glycogen in fish muscle. Visit to meat industry.

References

- KERRY J, KERRY J. 2002. Meat Processing, Woodhead Publishing
- MEAD G. 2004. Poultry meat processing and quality, Woodhead Publishing
- SAHOO J AND CHATLI MK. 2015. Textbook on Meat, Poultry and Fish Technology, Daya Publishing House
- SAHOO J, SHARMA DK AND CHATLI MK. 2016. Practical Handbook on Meat Science and Technology, Daya Publishing House.

FPT 508 NUTRACEUTICALS AND SPECIALTY FOODS (2+1)

Objective

To study and understand the manufacture and applications of nutraceuticals, functional foods and specialty foods which are gaining importance in recent times.

Theory

Block 1: Nutraceuticals and Functional Foods

Unit 1: Nature, type and scope of nutraceutical and functional foods. Nutraceutical and functional food applications and their health benefits. Nutraceutical compounds and their classification based on chemical and biochemical nature. Innovations in functional foods for health and wellness.

Unit 2: Nutraceuticals/food components for specific diseases such as cancer, heart disease, diabetes, obesity, anti-aging and arthritis; Prebiotics and probiotics; Omega 3 and Omega 6 fatty acids, isoflavones, phenolic compounds, catechins, lycopene, glucosinolates.Delivery system and controlled release of nutraceuticals.

Block 2: Specialty Foods

Unit 1: Design of specialty foods for different age groups. Selection of ingredients, health benefits and production of specialty foods. Non-thermal techniques, bioprocessing techniques, dehydration techniques; effect of processing on bioactive ingredients.

Unit 2: Packaging requirements for specialty foods; storage and storage kinetics on quality; interactions of various environmental factors. Safety and regulatory issues for specialty foods, functional foods and nutraceuticals.

Block 3: Nutrigenomics

Unit 1: Concept of personalized medicine. Use of nanotechnology in functional food industry. Biological functionality of cruciferous vegetables, tropical, subtropical and temperate fruits, herbs and spices.

Practicals

Determination of antioxidant activity of given food sample by different techniques. Determination of total phenolic content of given food sample. Estimation of dietary fibre, beta carotene, carotenoids and total flavonoid content of food samples. Estimation of lycopene in tomato. Effect of heat processing on ascorbic acid. Determination of vitamin A content. Estimation of pectic substances in plant sample. Effect of drying on bioactive components of food samples. Packaging requirement of functional foods.

References

- CHADWICK R HENSON S AND MOSELEY B, 2003. Functional Foods, Springer-Verlag
- JEFFREY HURST W, 2008. Methods of Analysis for Functional Foods and Nutraceuticals, CRC Press
- WILDMAN REC, 2006. Handbook of Nutraceuticals and Functional Foods, CRC Press
- VATTEM DA AND MAITIN V, 2016. Functional Foods, Nutraceuticals and Natural Products, DE Stech publications

FPT 509 FROZEN AND CONCENTRATED FOODS (1+1)

Objective

To study the processes involved in the manufacture of various fruit, vegetables, meat and poultry based frozen foods and concentrated foods. Freezing and concentration are among the more commonly used methods for food preservation.

Theory

Block 1: Frozen Foods

Unit 1: Glass transitions in frozen foods and biomaterials; microbiology of frozen foods; physical properties of frozen foods; freezing loads and freezing time calculation innovations in freezing process, freezing methods and equipment.

Unit 2: Quality and safety of frozen foods: Quality and safety of frozen meat and meat product, poultry and poultry products, eggs and egg products, fish, shellfish and related products, frozen vegetables and fruits, frozen dairy products, frozen ready meals and confectionery.

Unit 3: Packaging of frozen foods: Selection of packaging materials; shelf-life prediction of frozen foods. Transportation and storage of frozen foods, retail display equipment and management.

Block 2: Concentrated Foods

Unit 1: Concentrated milk: Production and quality evaluation of evaporated milk and sweetened condensed milk.

Unit 2: Concentrated juice products: Production and quality of fruits and vegetable juice concentrate, puree and paste, tomato juice concentrates, mango pulp.

Practicals

Determination of glass transition temperature of food. Calculation of freezing time and freezing load of food sample. Effect of cold chain on quality of fruits and vegetables. Effect of cooling on egg quality. Effect of chilling and freezing on meat quality. Effect of clarification and concentration on juice quality. Effect of cold and hot break on tomato pulp quality. Production and quality evaluation of tomato puree and paste.

References

- HUI YH, LEGARRETTA IG, LIM, MH, MURRELL KD & NIP WK, 2004. Handbook of Frozen Foods, CRC Press
- KENNEDY C J, 2000. Managing Frozen Foods, Elsevier.

FPT 510 ASEPTIC PROCESSING AND PACKAGING (2+1)

Objective

To gain an in-depth knowledge of the various steps involved in the aseptic processing and packaging of foods since the process is among the most extensively used food processing technologies in recent times.

Theory

Block 1: Aseptic Processing

Unit 1: Introduction to aseptic processing; aseptic processing of semi-solid, fluid and particulate foods. Pre-sterilization and sterilization operations; cleaning and CIP. Advantages and disadvantages.

Unit 2: Quality Assurance: Effect of aseptic processing on nutrients, microorganisms; in-process and post-process assurance; HACCP; regulatory aspects of processing and packaging; shelf life modules.

Block 2: Aseptic Packaging

Unit 1: Equipment for aseptic processing and packaging for retail and institutional packages.

Unit 2: Packaging of aseptically processed foods: packaging material characteristics, aseptic filling, sterilization of packaging materials, package design; types of aseptic packaging systems: fill and seal; form, fill and seal; erect, fill and seal; thermoform, fill and seal; blow mold, fill and seal.

Practicals

Effect of aseptic processing on microbial quality of juice based beverage. Effect of aseptic processing on vitamins in selected foods. Effect of aseptic processing on colour pigments in selected foods. Effect of aseptic processing on browning of milk. Effect of aseptic processing

on viscosity of milk. Effect of aseptic processing on proteins in selected foods. Effect of different chemical sterilants on microbial quality of packaging material. Estimation of package integrity and leakage. Shelf life models and prediction.

References

- ROBERTSON GL, 2012. Food Packaging: Principles and Practices, CRC Press
- DAVID JRD, GRAVES RH AND SZEMPLENSKI T, 2016. Handbook of Aseptic Processing and Packaging, CRC Press
- REUTER H, 1993. Aseptic Processing of Foods, CRC Press
- WILLHOFT EM, 1993. Aseptic Processing and Packaging of Particulate Foods, Springer.

FPT 511 TRADITIONAL FOODS (2+1)

Objective

Traditional foods are gaining greater popularity in recent times because of their numerous nutritional and health benefits. Proper understanding of the methods of manufacturing various types of traditional foods is therefore necessary.

Theory

Block 1: Introduction to Traditional Foods

Unit 1: Introduction to traditional foods of India; composition and nutritive values. Present status of traditional food products; globalization of traditional food products.

Unit 2: Overview of heat-desiccated, coagulated, fried and fermented traditional food products. Process technology for traditional Indian breads, fried foods, fermented foods and traditional sweets. Packaging systems for traditional food products.

Block 2: New products based on fruits, vegetables and cereals

Unit 1: Application of membrane technology; microwave heating, steaming, extrusion for industrial production of traditional food products (shrikhand, dhokla, wadi, murukku).

Unit 2: Utilization and scope of legumes and grains in India for novel food product development such as ready to eat products and flour mixes.

Unit 3: Process technology for convenience traditional food products (ready to eat and serve - curried vegetables, pulses and legumes), chutneys, paste.

Block 3: Commercial manufacture of traditional products

Unit 1: Processing and preservation of sweets and desserts: kulfi, kheer, khoa, rabri, gulabjamun, peda, rasgolla and barfi.

Unit 2: Processing and preservation of traditional fermented foods: idli, dosa, vada, dhokla, dahi (curd), srikhand.

Unit 3: Processing and preservation of snacks**:** gujiya, samosa, potato chips, banana-chips, bhujiya, fried dhals.

Unit 4: Processing and preservation methods of baked products: roti, naan, parantha, kulcha, puri, bhatura.

Unit 5: Processing and preservation of beverages: murabba, sharbat, coconut water, flavoured milk and alcoholic beverages.

Practicals

Effect of different combinations of salt and oil on quality of traditional fermented foods like pickle. Effect of different starter cultures on taste and texture of idli. Shelf life of stuffed paratha under different storage conditions. Effect of time and temperature on quality of fried food products. Effect of sugar and artificial sweeteners in the preparation of kajukatli. Microwave heating in drying of dhokla. Effect of cold extrusion on mixing of vermicelli. Effect of different packaging materials on shelf life of traditional Indian food products. Preparation of spiced buttermilk. Preparation of puffed cereals and grains. Preparation of Indian traditional confections (chikki). Visit to ethnic food industry (instant mixes/pickle making industries).

References

- STEINKRUS KH. 1995. Handbook of Indigenous Fermented Foods. CRC Press
- WICKRAMASINGHE P. 2007. The Food of India OM Book Service
- ANEJA RP, MATHUR BN, CHANDAN RC AND BANERJEE AK. 2002. Technology of Indian Milk Products, India Year Book Publications.

FPT 512 TECHNOLOGIES OF CONVENIENCE FOODS (2+1)

Objective

To learn about the processing technologies for commercial scale manufacture of various grain, fruit and vegetable based convenience foods, and the equipment used for the manufacture and packaging of these foods.

Theory

Block 1: Overview of Convenience Foods

Unit 1: Equipment for frying, baking, toasting, roasting, flaking, popping, blending, coating, chipping.

Unit 2: Grain based foods: Roasted, toasted, puffed, popped and flaked products; Coated grains– salted, spiced and sweetened; Flour based snacks; batter and dough-based products; savoury, wafers and papads.

Unit 3: Fruit and vegetable-based snacks: Coated nuts – salted, spiced and sweetened products- chikkis, fried groundnut.

Block 2: Ready-to-Eat Foods

Unit 1: Technology of ready- to- eat baked food products; drying, toasting, roasting and flaking, coating, chipping. Technology for RTE puffed snacks.

Unit 2: Extruded snack foods: Formulation and processing technology, flavouring and packaging.

Block 3: Ready-to-Cook Food Products

Unit 1: Puddings and curries; vegetables and meat based food products. Technology of instant cooked rice; carrot and other cereal based food products.

Unit 2: Technology of cereal and pulse based ready-to-eat instant premix.

Practicals

Preparation of cereal based fried snack foods. Preparation of legume based fried snack foods. Preparation of cereal and legume based roasted snack foods. Preparation of cereal/pulse based ready-to-eat snack food by extrusion cooking and quality evaluation. Preparation of cereal grain based puffed products. Effect of frying time and temperature on potato chips. Development of instant food premixes. Effect of roasting time and temperature on quality of pop-corn. Determination of shelf-life and packaging requirements of snack food products. Visit to industries manufacturing snack foods.

References

- EDMUND WL 2001. Snack Foods Processing. CRC Press
- FRAME ND 1994. Technology of Extrusion Cooking, Blackie Academic
- GORDON BR 1997. Snack Food, AVI Publishers
- DENY AV AND DOBRASZCZYK BJ. 2001. Cereals and Cereal Products, Aspen Publishers.

FPT 513 FOOD POWDER AND PREMIXES (2+1)

Objective

To learn about the manufacture of various types of food powders and premixes and to study the functional properties of food powders.

Theory

Block 1: Food Powder Properties

Unit 1: Size, shape, particle size distribution, density; crystalline and amorphous microstructure of powders; cohesive forces in powders; adhesive forces and surface energies; stickiness of powders; surface structure of powders.

Unit 2: Fluidity of powders; compressibility of powders; mixing property of powders; segregation of powder particles; flow and packing properties.

Unit 3: Handling of food powders; basic flow patterns in storage vessels; storage vessel design; mass-flow operation; Powder conveying: belt, screw, chain, pneumatic.

Block 2: Size Reduction and Enlargement

Unit 1: Principles; equipment; criteria for selecting comminution process; aggregation and agglomeration; instantization.

Unit 2: Encapsulation: principles, methods of encapsulation, viz. spray drying, coacervation, extrusion, co-crystallization.

Block 3: Powder Production

Unit 1: Spray, drum and freeze-drying process and equipment for manufacture.

Unit 2: Undesirable properties: attrition, segregation, caking, dust explosion hazards, laboratory testing to assess explosion characteristics of dust clouds, safety from dust cloud explosion hazards. Packaging requirements, design of package, effect of environmental factors on quality of food powders, shelf life test and prediction.

Block 4: Food Powder Functionality

Unit 1: Principles of powder rehydration- wettability, sinkability, dispersibility, solubility; improvement of rehydration properties.

Unit 2: Surface composition of food powders: Microscopy and spectroscopy techniques for analysing the surface of food powder; factors affecting food powder surface composition; impact of powder surface composition on powder functionality.

Practicals

Estimation of bulk density, true density, porosity. Estimation of reconstitution properties: wettability, dispersibility, solubility. Effect of moisture on lump formation and caking. Flowability and hygroscopicity of food powders. Estimate glass transition and sticky point temperature of food powders. Effect of bulk density on packaging. Measurement of particle size using particle size analyser. Packaging of food powders. Effect of storage on quality of food powders. Production of various vitamin and mineral premixes and their application.

References

- HONG YAN. 2005. Food Powders: Physical Properties, Processing, and Functionality, Springer US
- BHANDARI BS, BANSAL N, ZANG M, SCHUCK P. 2013. Handbook of Food Powders-Process and Properties, Woodhead Publishing
- MASUDA H, HIGASHITANI K AND YOSHIDA H. 2006. Powder Technology: Fundamentals of Particles, Powder beds, and Particle Generation, CRC Press.

FPT 514 FOOD INGREDIENTS AND ADDITIVES (2+1)

Objective

To learn about the different types of additives such as antioxidants, emulsifiers, stabilizers, preservatives, sweeteners and hydrocolloids, and their role in food formulations.

Theory

Block 1: Role of Food Ingredients and Additives in Food Processing

Unit 1: Intentional and unintentional food additives, functions, classification; toxicology and safety evaluation of food additives; beneficial effects of food additives.

Unit 2: Food additives generally recognized as safe (GRAS); tolerance levels and toxic levels in foods - LD 50 values of food additives.

Block 2: Types of Food Additives

Unit 1: Preservatives: general mechanism of action; basis of selection; classes; chemical preservatives: characteristics, antimicrobial spectrum, mechanism of action, toxicology, regulations, application in food.

Unit 2: Antioxidants: characteristics, types/classes/groups, mechanism of action/ working of antioxidants, functions, sources, application in food, limits and toxic effects of synthetic antioxidants, synergistic effects of antioxidants, role of free radicals in human body, natural antioxidants.

Unit 3: Flavouring agents: functions, selection, forms, sources, process of flavour creation; natural and synthetic flavouring; extractions methods; production process; applications in food.

Unit 4: Emulsifiers and Stabilizers: characteristics/ functional properties; functions; basis of selection; types; mechanism of emulsion formation; mechanisms of emulsion stabilization and destabilization; applications in food.

Block 3: Other Food Additives

Unit 1: Hydrocolloids: definition, function and functional properties: sources; application in food.

Unit 2: Sweeteners: characteristics; classification/types; applications in food; limits and toxicology of non-nutritive sweeteners.

Unit 3: Colouring agents: properties; functions; classification; sources of natural and synthetic colours: extraction; applications in food, levels of use, misbranded colours, colour stabilization.

Unit 4: Other additives: humectants, clarifying agents, stabilizers and thickeners, bleaching and maturing agents, humectants, sequestrants /chelating agents, anti-caking agents, buffering agents, acidulants.

Practicals

Determination of benzoic acid in food samples. Estimation of sulphur dioxide in food samples. Estimation of sorbic acid in cheese and yoghurt. Determination of nitrate and nitrites in foods. Detection of aspartame by thin layer chromatography. Liquid chromatographic determination of caffeine, benzoate and saccharin in soda beverage. Identification of natural colours. Isolation, identification and estimation of synthetic food colours. TLC detection of antioxidants in fats and oils. TLC detection of emulsifiers. Detection of alginates in foods (chocolate, ice cream).

References

- BRANEN AL, DAVIDSON PM AND SALMINEN S. 2001. Food Additives, Marcel Dekker
- SMITH J AND SHUM LH. 2011. Food Additives Data Book, Wiley-Blackwell
- BAINES D AND SEAL R. 2012. Natural Food Additives, Ingredients and Flavorings, Woodhead Publishing.

FPT 515 FLAVOUR CHEMISTRY AND TECHNOLOGY (2+1)

Objective

To learn about food flavours, factors responsible for development of food flavours, flavour compounds in different types of foods, and the process of encapsulation and stabilization of flavours.

Theory

Block 1: Introduction to Food Flavours

Unit 1: Classification of food flavour, chemical compounds responsible for flavours, difficulties of flavour chemistry research. Chemical compounds, classes and their flavour response. Flavour intensifiers and their effects.

Unit 2: Flavour Extraction: Methods of flavour extraction, isolation, separation and equipment for flavour extraction.

Unit 3: Flavour development during biogenesis: Flavour compounds from carbohydrates and proteins; lipid oxidation; flavour formulation: creating and formulating flavour; synthetic flavours, blended flavouring, flavour creation for new products, delivery of flavours from food matrices.

Block 2: Flavour Analysis

Unit 1: Sensory evaluation, discrimination analysis, descriptive analysis, instrumental analysis (Absorption Spectroscopy (W/VIS), chromatography, mass spectrometry).

Unit 2: Food flavours in different food products: principal components in baked products, cheese, milk, meat, fish, wine, coffee, tea, chocolate, fruit and vegetable products and fermented foods.

Unit 3: Flavouring compounds generated during food processing: Volatile and non-volatile flavouring compounds.

Block 3: Flavour Encapsulation and Stabilization

Unit 1: Principles and techniques of flavour encapsulation, types of encapsulation, factors affecting stabilization of encapsulated flavour and their applications in food industry, Packaging and flavour compounds interaction.

Practicals

Qualitative identification of different flavouring compounds. Extraction of essential oil/ flavouring compound of basil leaves by hydro distillation. Extraction of essential oil/ flavouring compound of basil leaves and ginger by SCFE. Effect of storage conditions on flavouring compound of ginger. Effects of staling on food flavours and its adverse effects. Separation, purification and identification of flavouring compounds by GC/MS.Sensory evaluation of different flavours. Effect of cooking on flavour of food sample.Effect of fermentation on food flavour. Development of blended food flavour-based products. Effects of storage conditions on food flavour. To study flavour development on roasting/ baking.

References

- REINECCIUS G. 2005. Flavour Chemistry and Technology/ CRC Press
- TAYLOR AJ & LINFORTH RST. 2010. Food Flavour Technology, Blackwell Publishing Ltd.
- HUI YH. 2010. Handbook of Fruit and Vegetable Flavours, Wiley & Sons Inc.
- BRUCKNER B AND WYLLIE SG. 2008. Fruit and vegetable flavour: Recent advances and future prospectus, CRC Press.

FPT 516 BIOPROCESSING AND SEPARATION TECHNOLOGY (2+1)

Objective

To gain a greater understanding of the different types of separation processes employed in the food industry.

Theory

Block 1: Introduction to Separation Processes

Unit 1: Gas-Liquid, Gas–Solid, Liquid-Liquid, Liquid-Solid separation; concept of phase equilibrium, stage equilibrium, stage efficiency, equilibrium concentration; Single stage contact equilibrium, counter-current multiple contact stages, concept of equilibrium line and operating line, determination of optimum number of contact stages by analytical and graphical method.

Unit 2: Rate of extraction, Rate of gas absorption, Individual and over all mass transfer coefficient; calculation of tower height for gas absorption for both dilute and concentrated solution. Construction and working mechanism of different extraction equipment like single stage extraction, multiple stage static bed system.

Block 2: Separation Processes

Unit 1: Solid Separation Process: Introduction, concept of size, shape, cut-size, sieving, magnetic separation, Eddy-current separation, wet separation, ballistic separation, colour separation, liquid-solid and

liquid-liquid separation by hydro cyclones, surface velocity classifier, elutriators, impingement separator, electrostatic precipitation.

Unit 2: Distillation: Introduction, boiling point diagram, differential or simple distillation, flash or equilibrium distillation, continuous rectification with and without reflux, reflux ratio, optimum reflux ratio, batch distillation, application of distillation in food processing.

Block 3: Membrane Separation Technology

Unit 1: Introduction to micro-filtration, ultrafiltration, reverse osmosis, electro dialyses, dialyses, physical characteristics of membrane separation, factors affecting reverse osmosis process, concentration polarization.

Unit 2: Design of reverse osmosis and ultra-filtration systems, operation layout of the modules, electrodialysis, vaporization, fabrication of membranes, application of membrane technology in food industry.

Practicals

Determination of contact equilibrium in counter current and multiple contact model systems. Determination of rate of extraction in gas-liquid, gas-solid, liquid-liquid and liquid-solid systems. Study of working mechanisms of different extraction equipment. Evaluation of physical separation techniques based on size, shape and densities, magnetic and colour separation. Use of electrostatic and distillation techniques for fractionation and separation, application studies on microfiltration, ultrafiltration, reverse osmosis and dialysis.

References

- SARAVACOS GD & MAROULIS ZB. 2011. Food Process Engineering Operations, CRC Press
- SMITH PG. 2011. Introduction to Food Process Engineering, Springer.

FPT 517 ENZYMES IN FOOD PROCESSING (2+1)

Objective

To gain a greater understanding of the different types of enzymes, their production processes, and the application of enzymes in the production of various types of fruit, meat and milk based products.

Theory

Block 1: Introduction to Enzymes

Unit 1: General characteristics of enzymes, classes and nomenclature of enzymes; Enzymatic reactions; factors affecting enzyme activity; Enzyme kinetics; Enzyme inhibition.

Unit 2: Enzyme Production: Selection and sources of commercial enzymes; Advantages of microbial enzymes; rDNA in enzyme engineering; Problems of scale up; Enzyme extraction and purification.

Unit 3: Immobilization: Techniques, advantages and disadvantages, use of immobilized biocatalysts in food processing. Enzymes for protein and lipid modification.

Block 2: Application of Enzymes in Food Processing

Unit 1: Application of enzymes in baking: Fungal amylase for bread making; maltogenic – amylases for anti-staling xylans and pentosans as dough conditioners; oxidases as replacers of chemical oxidants; synergistic effect of enzymes

Unit 2: Enzymes in fruit processing: Applications of enzyme in fruit juice clarification, removal of haziness and bitterness, uses of enzymes in wine production.

Unit 3: Enzymes in meat, fish and milk processing: Meat tenderization and flavour development, fish processing (de-skinning, collagen extraction etc.), egg processing, cheese processing.

Unit 4 : Enzymes in flavour production: Role of enzymes (enzyme-aided extraction of plant materials for production of flavours, production of flavour enhancers such as nucleotides, MSG; flavours from hydrolysed vegetable/animal protein)

Unit 5: Enzymes in the processing of fats and oils: specificity, stability and application of lipases and related enzymes; Role of enzymes in hydrolysis of triglycerides, inter-esterification and randomization. Enzyme allergy.

Practicals

To investigate the kinetic properties of invertase. To study time course of the reaction catalysed by alkaline phosphatase. Quantitative estimation of endoglucanase. Quantitative estimation of exoglucanase. Quantitative estimation of a galactosidase. Quantitative estimation of Pectinase. Quantitative estimation of Protease. Quantitative estimation of Lipase. Immobilization of amylase by sodium alginate and comparative evaluation with native enzyme. To carry out amylase, protease and lipase fermentation.

References

- PALMER T. 2008. Enzymes: Biochemistry, Biotechnology and Clinical Chemistry, East West
- PRICE NC AND STEVENS L. 2000. Fundamentals of Enzymology, Oxford University Press
- REED G. 2007. Enzymes in Food Processing, Academic Press
- WHITEHURST RJ AND OORT MV. 2010. Enzymes in Food Technology, Blackwell Publishers.

FPT 518 FOOD PROCESS AUTOMATION AND MODELLING (2+0)

Objective

To understand the principles of modelling, applications of modelling in food industry, food processing equipment design and automation of food processing operations.

Theory

Block 1: Principles of Modelling

Unit 1: Linear programming-concepts, graphical and algebraic solution; Simplex method; Duality theory; Post-optimality analysis;

Sensitivity analysis; Transportation and assignment models; Computer applications to LP, queuing theory.

Unit 2: Project scheduling and management by PERT-CPM; Integer programming; Non-linear programming; Simulation; Goal programming; Decision theory; Markov chains; Sequencing problem.

Block 2: Food Process Modelling

Unit 1: The principles of modelling, kinetic modelling, the modelling of heat and mass transfer; introduction diffusion equation, the Navier-stokes equations, heat and mass transfer in porous media Luikov's equation. Modelling thermal processes: cooling and freezing, modelling product heat load during cooling and freezing.

Unit 2: Modelling foods with complex shapes, numerical solution of the heat conduction equation with phase change. Modelling thermal processes: heating, introduction, processing of packed and solid foods, continuous heating and cooling processes, Modelling food quality and microbiological safety. Case Studies in modelling.

Block 3: Food Process Equipment Design

Unit 1: Design considerations of agricultural and food processing equipment. Design of food processing equipment, Dryers, design of dryers. Determination of heat and air requirement for drying grains. Types of heat exchanger. Design of heat exchangers and evaporators. Design of material handling equipment like belt conveyor, screw conveyor, bucket elevator and pneumatic conveyors.

Unit 2: Measurement systems for post harvest fruit and vegetable quality control. Genetic algorithm optimization: traditional optimization techniques and their limitations, non-traditional method, fitness function in biological evolution, computational procedure for optimization of independent parameters using genetic algorithm.

Unit 3: Artificial neural network modelling: Developing predictive model between independent and dependent parameters by using artificial neural network – neural network architecture, weights and bias values of neurons, least square method for NN parameters optimization, matrix representation and computation of the values of NN parameters.

Block 4: Automation in Food Processing Unit Operations

Unit 1: Raw food material sorting, grading, size reduction, mixing and agitation, thermal processing, dehydration, packaging, CIP, quality control. Bottle washing machine automation; bottling plant drive system.

Unit 2: Demineralization plant control system; labelling machine control system; charger level automation; reverse osmosis plant automation; thermal plant automation; Dehydration and freezing plant automation.

References

- Ahmed J And Rahman S. 2012. Handbook of Food Process Design,Wiley-Blackwell
- TIJSKENS LMM, HERTOG MLATM AND NICOLAI BM. 2001. Food Process Modelling, Woodhead Publishing
- BERND H. 2017. Measurement, Modeling and Automation in Advanced Food Processing, Springer International Publishing
- MOREIRA RG. 2001. Automatic Control for Food Processing Systems, Aspen Publishers.

FPT 519 ZERO WASTE PROCESSING (2+0)

Objective

To learn the basics of food waste management and zero waste processing operations.

Theory

Block 1: Introduction to Zero Waste Processing

Unit 1: Food processing waste and by-product, ISO 14000 for environmental management system, biochemical and nutritional aspects of food processing byproducts.

Unit 2: Waste minimization: chain management issues and good housekeeping procedures; minimise energy use in food processing; minimise water use in food processing.

Block 2: Food Waste Management

Unit 1: Microbiological risk management, effects of postharvest changes in quality on the stability of plant co-products, separation technologies for food wastewater treatment and product recovery.

Unit 2: Co-product recovery techniques: Enzymatic extraction and fermentation for the recovery of food processing products, supercritical fluid extraction for extraction of high-value food processing co-products, membrane and filtration technologies, recovery of nutraceuticals, micronutrients, functional ingredients, natural dyes.

Unit 3: Waste management and co-product recovery: Meat, cereal, dairy, fish, fruit and vegetable processing; waste management of food packaging. Food processing waste water treatment and gas production from solid food processing.

References

- WALDRON K. 2009. Handbook of Waste Management and Co-product Recovery in Food Processing, Woodhead Publishing
- ARVANITOYANNIS IS. 2007. Waste Management for the Food Industries, Academic Press
- NOUT MJR AND SARKAR PK. 2013. Valorisation of Food Processing By-Products, CRC Press.

M. Tech. in Processing and Food Engineering

Course Code	Course Title	Credit Hours
PFE 501	Transport Phenomena in Food Processing	3 (2+1)
PFE 502	Unit Operations in Food Process Engineering	3 (2+1)
PFE 503	Field Crops Process Engineering	3 (2+1)
PFE 504	Horticultural Crops Process Engineering	3 (2+1)
PFE 505	Storage Engineering and Handling of Agricultural Produce	3 (2+1)
PFE 506	Food Package Engineering	2 (1+1)
PFE 507	Instrumentation and Sensors in Food Processing	3 (2+1)
PFE 508	Application of Engineering Properties in Food Processing	3 (2+1)
PFE 509	Food Quality and Safety	3 (2+1)
PFE 510	Food Processing Technologies	3 (2+1)
PFE 511	Food Processing Equipment and Plant Design	2 (1+1)
PFE 512	Seed Process Engineering	2 (1+1)
PFE 513	Agri-Project Planning and Management	3 (2+1)
PFE 514	Farm Structures and Environmental Control	3 (2+1)
PFE 515	Dairy Product Processing	3 (2+1)
PFE516	Processing of Meat, Poultry and Fish	3 (2+1)
PFE 517	Design of Aquacultural Structures	3 (2+1)
PFE 518	Thermal Environmental Engineering for Agricultural Processing	3 (2+1)
	Total	**51 (33+18)**
PFE 580	Qualifying Examination	2(0+2)
PFE 581	Seminar - I	1(0+1)
PFE 582	Seminar - II	1(0+1)
PFE 591	Research - I	13 (0+13)
PFE 592	Research - II	14 (0+14)

PFE501 TRANSPORT PHENOMENA IN FOOD PROCESSING (2+1)

Objective

To acquaint and equip the students with the principles of heat, mass and momentum transfer and its applications in food processing.

Theory

Block 1: Heat transfer and heat exchangers

Unit 1: Introduction to heat and mass transfer and their analogy. Steady and unsteady state heat transfer. Analytical and numerical solutions of unsteady state heat conduction equations. Use of Gurnie-Lurieand Heisler Charts in solving heat conduction problems :Applications in food processing including freezing and thawing of foods.

Unit 2: Convective heat transfer in food processing systems involving laminar and turbulent flow. Heat transfer in boiling liquids. Heat transfer between fluids and solid foods. Functional design of heat exchangers: shell and tube, plate and scraped surface heat exchangers. Radiation heat transfer: governing laws, shape factors, applications in food processing.

Block 2: Momentum Transfer

Unit1: Momentum transfer. Mass flow and balance. Steady and unsteady flow. Theory and equation of continuity. Bernoulli's theorem and application. Flow through immerged bodies, Measurement of flow, pressure and other parameters. Flow driving mechanism.

Block 3: Mass Transfer

Unit 1: Molecular diffusion in gases, liquids and solids. Molecular diffusion in biological solutions and suspensions. Molecular diffusion in solids. Unsteady state mass transfer and mass transfer coefficients. Molecular diffusion with convection and chemical reaction. Diffusion of gases in porous solids and capillaries. Mass transfer applications in food processing.

Practicals

- Solving problems on steady conduction
- Solving problems on steady conduction with or without heat generation
- Solving problems on steady and unsteady state conduction
- Steady and unsteady state conduction with or with outh eatgeneration
- Numerical analysis in heat transfer
- Problems in natural and forced convection
- Solving problems of heat transfer by radiation
- Design of heat exchangers.
- Experiments on heat conduction, convection
- Experiments on radiation heat transfer

References

- BIRD, STEWART, LIGHTFOOT 2002. *Transport Phenomena*, John Wiley & Sons.
- BODHRAJ 2012. *Introduction to Transport Phenomena*, PHI.
- CHRISTIEJ.1993. *Transport Process and Unit Operations*. Prentice-Hall of India Private Limited, New Delhi ISBN0-13-045253-X.
- COULSON J MAND RICHARDSON JF. 1999. *Chemical Engineering*. Vol. II, IV. The Pergamon Press.
- EARLE RL.1985.*Unit Operations in Food Processing*. Pergamon Press.
- HOLMAN JP 1992. Heat Transfer. McGraw Hill.
- JORGE WELTI-CHANES, JORGE F AND VELEZ-RUIZ 2002. *Transport Phenomena in Food Processing*. CRC Press ISBN: 9781566769938 Geankoplis.
- Mc Cabe WL and Smith JC 1999. *Unit Operations of Chemical Engineering*. Mc Graw Hill.
- PLAWSKY, JOELL 2014. *Transport Phenomena Fundamentals*, CRC Press, ISBN: 978-1-4665-5535-

8,1466555351

- JORGE WELTI-CHANES, JORGE F AND VELEZ-RUIZ 2002. *Transport Phenomena in Food Processing*. CRC Press ISBN: 9781566769938 Geankoplis.
- MC CABE W L AND SMITH JC 1999. *Unit Operations of Chemical Engineering*. Mc Graw Hill.
- PLAWSKY, JOELL 2014. *Transport Phenomena Fundamentals*, CRC Press, ISBN: 978-1-4665-5535-8,1466555351.

PFE 502 UNIT OPERATIONS IN FOOD PROCESS ENGINEERING (2+1)

Objective

To acquaint and equip the students with different unit operations applicable in food industries.

Theory

Block 1: Drying and thermal processing

Unit1: Review of basic engineering mathematics. Units and dimensions. Mass and energy balance. Principles of fluid flow. Heat transfer: Conduction, convection and radiation. Heat exchangers and their designs.

Unit2: Drying and dehydration: Psychrometry, theories of drying, EMC, equipment for drying of solid, pastes and liquid foods. Evaporation: Components, heat and mass balance in single and multiple effect evaporators, equipment and applications, steam economy. Thermal processing: Blanching, pasteurization and sterilization, death rate kinetics, process time calculations, sterilization equipment.

Block 2: Refrigeration and freezing

Unit1: Refrigeration and freezing: Principles, freezing curve, freezing time calculation, freezing equipment, cold chain.

Block 3: Mechanical separation, material handling and size reduction

Unit1: Mechanical separation: Principle and equipment involved in sieving, filtration, sedimentation and centrifugation, cyclone separation. Material handling: Conveyors and elevators, components and design considerations for belt, chain, bucket and screw conveyors.

Unit 2: Size reduction: Principles of size reduction, size reduction laws. Size reduction equipment: Jaw crusher, gyratory crusher, roller mill, hammer mill.

Practicals

- Use of units, dimensions and basic mathematical applications.
- To judge the student sability for solving mass balance problems
- To judge the student sability for solving energy balance problems.
- To assess the flow rate of fluids through pipes and channels
- To verify the Bernoulli's Equation
- To study heat exchangers and calculation of log mean temperature difference
- To solve the heat transfer problems
- To study different dryers used in drying of biological materials
- To study single effect and multi effect evaporators
- To calculate the thermal process time using trapezoidal/Simpson's formulae
- To find the graphical solution for calculation of thermal process time
- To study different separation equipments
- To study the size reduction equipments

References

- BERK. 2018. *Food Process Engineering and Technology*, Academic Press, ISBN:978-0-12-812018-7
- BRENNANJG, BUTTERS JR, COWEL LND AND LILLY AEI. 1990. *Food Engineering Operations*. Elsevier.
- FELLOWS P1988. *Food Processing Technology: Principle and Practice*. VCH Publ.

- MCCABE WL AND SMITH JC. 1999. *Unit Operations of Chemical Engineering*. McGraw Hill.
- SAHAY KM AND SINGH KK. 1994. *Unit Operation of Agricultural Processing*. Vikas Publ. House.
- SINGH RP AND HELDMAN DR. 1993. *Introduction to Food Engineering*. Academic Press.
- SMITH. 2011. *Introduction to Food Process Engineering*, Springer.
- TOLEDO. 2007. *Fundamental sof Food Process Engineering*, Springer.
- VARZAKAS. 2015. *Food Engineering Hand book*, CRC press.

PFE 503 FIELD CROPS PROCESS ENGINEERING (2+1)

Objective

To acquaint and equip the students with the post-harvest technology of cereals, pulses and oilseeds with special emphasis on equipment used in the milling and processing.

Theory

Block 1: Milling, parboiling and drying

Unit 1: Production and utilization of cereals and pulses, grain structure of major cereals, pulses and oilseeds and their milling fractions. Grain quality standards and physico-chemical methods for evaluation of quality of flours.

Unit 2: Pre-milling treatments and their effects on milling quality. Parboiling and drying, conventional, modern and integrated rice milling operations. Wheat roller flour milling. Processes for milling of corn, oats, barley, gram, pulses, paddy and flour milling equipment. Layout of milling plants.

Block 2: Extraction, storage and by-product utilization

Unit 1: Dal mills handling and storage of by-products and their utilization. Storage of milled products. Expeller and solvent extraction processing. Assessment of processed product quality.

Block 3: Value added products and packaging

Unit1: Packaging of processed products. Design characteristics of milling equipment, selection, installation and their performance. Quality standards for various processed products. Value added products of cereals, pulses and oilseeds.

Practicals

- Engineering properties of grains, raw and milled products
- Physical, milling and cooking quality of grains
- Study of paddy milling process and equipments
- Study of wheat milling process and equipments
- Study of oil extraction process and equipments
- Study of pulse milling process and equipments
- Planning and layout of various milling plants
- Development of value added products for cereals, pulses and oilseeds
- Visit to various agro processing industry

References

- ASIEDU JJ. 1990. *Processing Tropical Crops*. ELBS/MacMillan.
- CHAKRAVERTYA.1995. *Post-Harvest Technology of Cereals, Pulses and Oilseeds.* Oxford and IBH.
- GOLOB 2002. *Crop Post-Harvest: Science and Technology* Vol.1, Wiley-Blackwell.
- HODGES 2004. *Crop Post-Harvest: Science and Technology* Vol.2, Wiley-Blackwell.
- MORRIS LIEBERMAN.1983. *Post-Harvest Physiology and Crop Preservation*. Plenum Press.
- PANDEY PH. 1994. *Principles of Agricultural Processing*. Kalyani. publishers
- PILLAIYAR P. 1988. *Rice-Post Production Manual.* Wiley Eastern.
- SAHAY KM AND SINGH KK. 1994. *Unit Operations in Agricultural Processing*. Vikas Publ. House.

PFE 504 HORTICULTURAL CROPS PROCESS ENGINEERING (2+1)

Objective

To acquaint and equip the students with processing of fruits and vegetables and the design features of the equipment used for their processing.

Theory

Block 1: Canning and minimal processing

Unit 1: Importance of post harvest technology of fruits and vegetables, structure, cellular components, composition and nutritive value of fruits and vegetables, fruit ripening, spoilage of fruits and vegetables.

Unit2: Harvesting and washing, pre-cooling, blanching, preservation off ruits and vegetables, commercial canning of fruits and vegetables, minimal processing of fruits and vegetables.

Block 2: Cold storage, CA and MAP

Unit 1: Cold storage of fruits and vegetables, controlled atmosphere and modified atmosphere packaging of fruits and vegetables, quality deterioration and storage.

Block 3: Drying and dehydration

Unit 1: Dehydration of fruits and vegetables, methods, osmotic dehydration, foammat drying, freeze drying, microwave heating, applications, radiation preservation of fruits and vegetables, irradiation sources.

Block 4: Ohmic heating, HPP and packaging

Unit 1 : Intermediate moisture foods, Ohmic heating principle, high pressure processing of fruits and vegetables, applications, sensory evaluation of fruit and vegetable products, packaging technology for fruits and vegetables, general principles of quality standards and control, FPO, quality attributes.

Practicals

- Determination of size of fruits and vegetables
- Determination of shape of fruits and vegetables
- Determination of bulk density and true density of fruits and vegetables
- Determination of area-volume-mass relationship of fruits and vegetables
- Determination of sugar-acid ratio of fruits
- Evaluation of different types of washers for fruits and vegetables
- Evaluation of different types of graders for fruits and vegetables
- Different types of packaging methods for fruits and vegetables
- Determination of the water vapor permeability of packaging materials
- Different types of drying methods for fruits and vegetables
- Comparative evaluation of different dryers for fruits and vegetables
- Determination of solid gain and moisture loss during osmotic dehydration in fruits
- Study of components and design of controlled atmosphere storage.
- Study of quality evaluation of fruits and vegetables

References

- BHATTI S AND VARMA U. 1995. *Fruit and Vegetable Processing*. CBS.
- CRUESSS WV. 2000. *Commercial Fruit and Vegetable Products*. Agrobios Publisher.
- DANTHY ME. 1997. *Fruit and Vegetable Processing*. International Book Publisher.
- SIMSON. 2016. *Post-Harvest Technology of Horticultural Crops*. AAP.
- SINGH. 2018. *Advances in Post-Harvest Technologies of Vegetable Crops*. AAP.

- SRIVASTAVA RP AND KUMAR S. 1994. *Fruit and Vegetable Preservation*. Principles and Practices. International Book Distr.
- THOMPSON AK. 1996. *Post-Harvest Technology of Fruits and Vegetables*. Blackwell.
- VERMA L R AND JOSHI V K. 2000. *Post-Harvest Technology of Fruits and Vegetables*. Vols.I-II. Indus Publisher.

PFE 505 STORAGE ENGINEERING AND HANDLING OF AGRICULTURAL PRODUCE (2+1)

Objective

To acquaint and equip the students with the safe storage of food materials, design of storage structures and the design of different material handling equipment used in the industries.

Theory

Block 1: Design of bag and bulk storage structures

Unit1: Storage of grains, biochemical changes during storage, production, distribution and storage capacity to estimate models, storage capacity models, ecology, storage factors affecting losses, storage requirements.

Unit2: Bag and bulk storage, godowns, bins and silos, rat proof godowns and rodent control, method of stacking, preventive method, bio-engineering properties of stored products, function, structural and thermal design of structures, aeration system.

Block 2: Cold storage, controlled and modified atmosphere storage

Unit1: Grain markets, cold storage, controlled and modified atmosphere storage, effects of nitrogen, oxygen and carbon dioxide on storage of durable and perishable commodities, irradiation, storage of dehydrated products, food spoilage and preservation, BIS standards.

Block 3: Design of conveyors and recent advances

Unit1: Physical factors influencing flow characteristics, mechanics of bulk solids, flow through hoppers, openings and ducts; design of

belt, chain, screw, roller, pneumatic conveyors and bucket elevators, principles of fluidization, recent advances in handling of food materials.

Practicals

- Determination of angle of repose
- Determination of coefficient of internal friction
- Determination of coefficient of external friction
- Physical factors influencing flow characteristics
- Determination of flow properties using shear apparatus
- Determination of Yield locus,Time yield locus and effective yield locus from Mohr's circle
- Flow through hoppers, openings and ducts
- Design of belt conveyors
- Design of chain conveyors
- Design of screw conveyors
- Design of bucket elevators
- Design of roller conveyors
- Design of pneumatic conveyors
- Principles of fluidization
- Recent advances in handling of food materials

References

- BOUMANS. 1985. *Grain Handling and Storage.* Elsevier.
- FAO. 1984. *Design and Operation of Cold Stores in Developing Countries*. FAO.
- GOLOB. 2002. *Crop Post-Harvest: Science and Technology.* Vol. 1 Wiley-Blackwell.
- HALLCW. 1970. *Handling and Storage of Food Grains in Tropical and Sub-Tropical Areas*. FAO Publisher Oxford & IBH.
- HENDER SONS AND PERRY SM. 1976. *Agricultural Process Engineering*. 5thEd. AVI Publisher.

- HODGES 2004. *CropPost-Harvest: Science and Technology*. Vol. 2, Wiley-Blackwell.
- RIPP BE. 1984. *Controlled Atmosphere and Fumigation in Grain Storage*. Elsevier.
- SHE FELT RL AND PRUSSISE. 1992. *Post-Harvest Handling–A System Approach*. Academic Press.
- VIJAYARAGHAVAN S 1993. *Grain Storage Engineering and Technology*. Batra Book Service.

PFE 506 FOOD PACKAGE ENGINEERING (1+1)

Objective

To acquaint and equip the students with packaging methods, packaging materials, packaging machineries and modern packaging techniques.

Theory

Block 1: Rigid and flexible packaging materials

Unit1: Introduction to packaging: Package, functions and design. Principle in the development of protective packaging. Deteriorative changes in food stuff and packaging methods of prevention.

Unit2: Food containers: Rigid containers, glass, wooden boxes, crates, plywood and wire bound boxes, corrugated and fibre board boxes, textile and papersacks, corrosion of containers (tinplate). Flexible packaging materials and their properties. Aluminum as packaging material. Evaluation of packaging material and package performance.

Block 2: Packaging equipment

Unit1: Packaging equipment: Food packages, bags, types of pouches, wrappers, carton and other traditional package. Retortable pouches: Shelf life of packaged foodstuff.

Block 3: Shelf life, package regulations and recent advances

Unit1: Methods to extend shelf-life. Packaging of perishables and processed foods. Special problems in packaging of food stuff.

Unit 2: Package standards and regulation: Shrink packaging, aseptic packaging, CA and MAP. Biodegradable packaging: Recent advances in packaging, active packaging, smart packaging, antioxidant and antimicrobial packaging, edible films and biodegradable packaging, micro encapsulation and nano encapsulation.

Practicals

- Familiarization of types of packaging material
- Determination of thickness of different types of packaging materials.
- To determine water absorption capability of flexible packaging materials
- Determination of tensile strength of packaging material
- Determination of compressive strength of packaging material
- Determination of water vapour transmission rate of packaging material
- Determination of gas transmission rate of packaging material
- Identification of different types of plastic films
- Testing of chemical and grease resistance of packaging materials
- Determination of bursting strength of packages
- Drop test for food package strength
- Vacuum packaging of various food products
- Nitrogen packaging of food products
- To study the effect of shrink wrapping on shelf life of fruits and vegetables
- To study the effect of active modified atmosphere packaging on shelf life of fruits and vegetables
- Determination of angle of repose
- Determination of coefficient of internal friction
- Determination of coefficient of external friction
- Physical factors in fluencing flow characteristics

- Determination of flow properties using Shear apparatus
- Determination of Yield locus, Time yield locus and effective yield locus from Mohr's circle
- Flow through hoppers, openings and ducts
- Visit to relevant industries

References

- CROSBY NT .1981. *Food Packaging Materials*. Applied Science Publisher.
- FRANK A .1992. *A Hand book of Food Packaging*. Springer.
- MAHADEVIAH M AND GOWRAMMA RV.1996. *Food Packaging Materials*. Tata McGraw
- HILL. PALLING S J. 1980. *Developments in Food Packaging*. Applied Science Publisher.
- ROBERTSON G L. 2013. *Food Packaging-Principles and Practice*. 3rd Ed Taylor & Francis.
- SACHAROW S AND GRITTIN R C. 1980. *Principles of Food Packaging*. AVI Publisher.

PFE507 INSTRUMENTATION AND SENSORS IN FOOD PROCESSING (2+1)

Objective

To acquaint and equip the students with instrumentation and use of sensors in food processing operations.

Theory

Block 1: Transducers and measuring techniques

Unit 1: Basic instrumentation systems and transducer principles. Displacement transducers, Potential meters, LDVT, Piezoelectric and capacitive transducers, Digital transducers, velocity transducers.

Unit 2: Acceleration and absolute motion measurement, Force transducer, strain gauge, Hydraulic load cell, Cantilever type and probing ring. Method of separation of force: Torque, power and energy measuring technique.

Block 2: Temperature and humidity sensors

Unit1: Temperature measurement using bi-metals, thermisters, thermocouples, humidity measurement, manometers. Flow transducer, positive displacement, venturimeter, Rotameter, Drag force, hot wire anemometer.

Block 3: Biosensors, imaging methods and spectroscopy

Unit1: Theory and classifications of chemical sensors, biosensors, fibre optic sensors, gas sensors etc. Biosensor: Concepts, types of biosensors, methods of immobilizing biosensors, application. Imaging methods: X-ray imaging, Computed tomography, MRI, Ultrasound, Hyperspectral imaging. Spectroscopy and chemometrics: UV and visual spectroscopy, NIR spectroscopy, FTIR spectroscopy.

Practicals

- Identification of components of generalized measuring system for temperature, pressure, relative humidity, moisture etc.
- Calibration of moisture measuring equipment
- Calibration of temperature control and measuring devices
- To study the working of Bourdon Pressure Gauge and to check the calibration of the gauge in a dead weight pressure gauge calibration setup.
- To study various temperature measuring instruments e.g. Mercury-in-glass thermometer,Thermocouple, Electrical resistance thermometer, laser thermometer and to estimate their response times.
- To determine the calorific value of different food products using a bomb calorimeter having temperature sensing device
- To study a Linear Variable Differential Transformer (LVDT) and use it in a simple experimental setup to measure a small displacement.
- To measure torque of a rotating shaft using torsionmeter/strain gauge torque transducer
- To measure the speed of a motor shaft with the help of non-contact

type pick-ups (magnetic or photoelectric)

- To measure static/dynamic pressure of fluid in pipe/tube using pressure transducer/pressure cell
- To determine the hardness/firmness of food samples using a texture analyzer
- To study the effect of vibrations during transportation on the quality of food (damage/bruising/texture etc.) using a simulated vibration test
- To study and use the data logging and data storage devices
- To study and understand the working principle of UV and visual spectroscopy for measurement of food properties
- To study and understand the working principle of NIR and FTIR spectroscopy form measurement of food properties
- To study the working principle of X-ray imaging, Computed tomography, MRI, Ultrasound and Hyper spectral imaging for measurement of food quality

References

- DOEBELINEO.1990. *Measurement Systems* : *Applications and Design*. Tata McGrawHill.
- ERIKAKR AND BRIMELOW JB. 2001. *Instrumentation and Sensors for the Food Industry.* CRC Wood head.
- NAKRA BC AND CHAUDHARY KK. 2004. *Instrumentation Measurement and Analysis*. Tata McGraw Hill.
- MUKHOPADHYAY. 2014. *Novel Sensors for Food Inspection: Modelling, Fabrication and Experimentation.*Springer.
- MUKHOPADHYAY SC. 2017. *Sensors for Everyday Life.* Springer.
- PARÉJRJ AND BÉLANGER JMR. 1997. *Instrumental Methods in Food Analysis.* Elsevier Academic Press.

PFE508 APPLICATION OF ENGINEERING PROPERTIES IN FOOD PROCESSING (2+1)

Objective

To acquaint the students with different techniques of measurement of engineering properties and their application in the design of processing equipment

Theory

Block 1: Physical and rheological properties

Unit 1: Physical characteristics of different food grains, fruits and vegetables: Shape and size, description of shape and size, volume and density, porosity, surface area. Rheology: ASTM standard, terms, physical states of materials,classical ideal material, rheological models and equations, viscoelasticity, creep-stress relaxation, non-Newtonian fluid and viscometry, rheological properties, force, deformation, stress, strain, elastic, plastic behaviour.

Block 2: Frictional and aerodynamic properties

Unit 1 : Contact stresses between bodies, Hertz problems, firmness and hardness, mechanical damage, dead load and impact damage, vibration damage, friction, effect of load, sliding velocity, temperature, water film and surface roughness. Friction in agricultural materials, rolling resistance, angle of internal friction, angle of repose, flow of bulk granular materials, aero dynamics of agricultural products, drag coefficients, terminal velocity.

Block 3: Thermal and electrical properties

Unit1: Thermal properties: Specific heat, thermal conductivity, thermal diffusivity, methods of determination, steady state and transient heat flow. Electrical properties: Dielectric loss factor, losstangent, A.C. conductivity and dielectric constant, method of determination, energy absorption from high frequency electric field.

Unit 2: Application of engineering properties in design and operation of agricultural equipment and structures.

Practicals

- To determine the size of grains, pulses, oilseeds, spices, fruits and vegetables.
- To determine the shape of various food grains and fruits and vegetables.
- To determine the bulk density of food grains and fruits and vegetables.
- To determine the particle density/true density and porosity of solid grains.
- To study the air comparison pycnometer for finding the particle density of food grains.
- To determine the angle of repose of grains,oilseeds etc.
- To determine the coefficient of external friction for different food grains
- To determine the coefficient of internal friction of different food grains.
- To plot the normal stress vs. shear stress curves for different food grains.
- To study the separating behaviour of a grain sample in a vertical wind tunnel (Aspirator column).
- To study the thermal properties (thermal conductivity, thermal diffusivity and specific heat) of food grains.
- To determine the Rheological properties: firmness and hardness of grain, fruits and vegetables.
- To study the electrical properties (dielectric constant, dielectric loss factor) of various food materials.
- To study the electrical properties (loss tangent and A.C. conductivity) of various food materials.

References

- LUDGERF AND TEIXEIRA AA. 2007. *Food Physics Physical Properties-Measurement and Application.* Springer.
- MOHESENINNN. 1980. *Thermal Properties of Foods and Agricultural Materials*. Gordon an Breach Science Publisher.

- MOHESENINNN. 1980. *Physical Properties of Plantand Animal Materials*. Gordon & Breach Science Publisher.
- PELEGMAND BAGELAY EB. 1983.*Physical Properties of Foods*. AVI Publisher.
- PETER B. 2007. *The Chemical Physics of Food.* Wiley-Blackwell.
- RAO MAAND RIZVISSH.1986. *Engineering Properties of Foods*. Marcel Dekker.
- SINGHA LOP AND SAMUEL DVK.2003. *Engineering Properties of Biological Materials*.Saroj Prakasan.
- SITKEI. 1986. *Mechanics of Agricultural Materials.* Elsevier.

PFE 509 FOOD QUALITY AND SAFETY (2+1)

Theory

Block 1: Food safety, contaminants and additives

Unit 1: Food safety: Need for quality control and safety, strategy and criteria, microbiological criteria for safety and quality, scope of food toxicology, toxic potential and food toxicants, biological and chemical contaminants.

Unit 2: Food additives and derived substances, factors affecting toxicity, designing safety in products and processes, intrinsic factors, establishing a safe raw material supply, safe and achievable shelf life.

Block 2: Machinery for food safety

Unit 1: Process equipment and machinery auditing, consideration of risk, environmental consideration, mechanical quality control

Unit 2: Personnel hygienic standards, preventative pest control, cleaning and disinfesting system, biological factors underlying food safety.

Block 3: Food safety standards and regulations

Unit 1: Preservation and stability, contaminants of processed foods, adulteration, prevention and control, FSSAI, ISO, Codex, GMP, BIS and HACCP. Practices, principles, standards, specifications, application establishment and implementation, HACCP and quality management system. Food Safety Management Systems (FSMS), Traceability.

Practicals

- To test microbiological contamination of food.
- To conduct hazard analysis.
- To study the premises design for food safety and quality.
- To study the HACCP project plan.
- To prepare CCP and CCP Decision tree.
- To prepare HACCP control chart.
- To conduct the Survey and study BIS-standards and specifications.
- To study the FPO standards and specifications.
- To study the code xstandard sands pecifications.
- Visits to food industries to study the various quality and safety aspects adopted.

References

- HERSCHDOERFER, S M.1984. *Quality Control in the Food Industry.*Vol.1 Academic Press.
- HERSCHDOERFER S M. 2012. *Quality Control in the Food Industry.* Vol. 2 Elsevier Science.
- HUBBARD M R. 2003. *Statistical Quality Control for the Food Iindustry* .Springer.

- MAHADEVIAH M AND GOWRAMMA R V. 1996. *Food Packaging Materials*. Tata McGraw Hill.
- MEHMET M. 2011. *Biosensors in Food Processing, Safety, and Quality Control.* CRC Press.
- PALLING S J. 1980. *Developments in Food Packaging*. Applied Science Publisher.
- SACHAROW S AND GRITTIN R C. 1980. *Principles of Food Packaging*. AVI Publisher.
- YANBO H, WHITTAKER A D AND LACEY R E. 2001. *Automation for Food Engineering.* Food Quality Quantization and Process Control-CRC Press.

PFE 510 FOOD PROCESSING TECHNOLOGIES (2+1)

Objective

To acquaint and equip the students with different unit operations to be performed in food industries and related equipment.

Theory

Block 1: Mixing and novel dehydration technologies

Unit1: Mixing and homogenization; Principles of solid and liquid mixing, types of mixers for solids, liquid and pastes homogenization. Emulsification: Principles and equipments.

Unit 2: Novel dehydration technologies; Osmotic dehydration, foam mat drying, puff drying, freeze drying, microwave drying, dehumidified air drying, extrusion: Theory, equipment, applications.

Block 2: Non-thermal processing technologies

Unit 1: Non-thermal processing; Principles and equipment involved in ohmic heating, pulsed electric field preservation, hydrostatic pressure technique (vacuum processing, high pressure processing of foods), ultrasonic technology, irradiation, quality changes and effects on microorganisms, nanotechnology in food processing.

Block 3: Distillation and extraction

Unit 1: Distillation, leaching and extraction: Principles and equipment for distillation, Crystallization, phase equilibria, multistage calculations, leaching principles and equipment, solvent extraction, super-critical fluid extraction, near critical fluid extraction: Equipment and experimental techniques used in NCF extraction and industrial application, advanced methods for extraction of food components and aroma recovery.

Block 4: Food plant hygiene

Unit 1: Food plant hygiene; Cleaning, sterilizing, waste disposal methods, Food processing plant utilities, steam requirements in food processing, HACCP in food processingindustries.

Practicals

- Conducting experiments and solving problems on mixing and mixing indices.
- To conduct the experiment on homogenization.
- To study the process of crystallization.
- To conduct the experiment on extraction.
- Experimentation on leaching process.
- To study the membrane separation process.
- To conduct the experiment on reverse osmosis technique.
- To conduct the experiment on ultra filteration process.
- Design of plate and packed tower.
- Visit to related food industry.

References

- BRENNAN JG, BUTTERSJR, COWELL ND AND LILLY AEI 1990. *Food Engineering Operations*. Elsevier.
- EARLE RL.1985. *Unit Operations in Food Processing*. Pergamon Press.

- FELLOWS P. 1988. *Food Processing Technology: Principle and Practice*. VCH Publisher.
- GEANKOPLIS J C. 1999. *Transport Process and Unit Operations*. Allyn & Bacon.
- GOULD G W. 1996. *New Methods of Food Preservation*. Blackie Academic & Professional.
- HELDMAN D R AND LUND B D. 1992. *Hand Book of Food Engineering*. Marcel Dekker.
- MCCABE W L AND SMITH J C. 1999. *Unit Operations of Chemical Engineering*. McGrawHill.
- SAHAY KM AND SINGH KK. 1994. *Unit Operation of Agricultural Processing*. Vikas Publ. House.
- SINGH R P 1991. *Fundamentals of Food Process Engineering*. AVI Publisher.
- SINGH R P AND HELDMAN D R 1993. *Introduction to Food Engineering*. Academic Press.

PFE 511 FOOD PROCESSING EQUIPMENT AND PLANT DESIGN (1+1)

Objective

To acquaint and equip the students with the design features of different food processing equipment being used in the industries along with the layout, planning of different food processing plants.

Theory

Block 1: Design of machinery

Unit 1: Design considerations of processing agricultural and food products.

Unit 2: Design of machinery for drying, milling, separation, grinding, mixing, evaporation, condensation, membrane separation.

Block 2: Food plant design and layout

Unit 1: Human factors in design, selection of materials of construction and standard component, design standards and testing standards. Plant design concepts and general design considerations: Plant location, location factors and their interaction with plant location, location in theory models, and computer aided selection of the location.

Block 3: Feasibility analysis, product and process design

Unit 1: Feasibility analysis and preparation of feasibility report; Plant size, factors affecting plant size and their interactions, estimation of break-even and economic plant size. Product and process design, process selection, process flow charts, computer aided development of flow charts.

Block 4: Capital investment, plant cost and profitability

Unit 1: Hygienic design aspects and worker's safety, functional design of plant building and selection of building materials, estimation of capital investment, analysis of plant costs and profitability's, management techniques in plant design including applications of network analysis, preparation of project report and its appraisal.

Practicals

- Detailed design and drawing of mechanical dryers
- Detailed design and drawing of milling equipment
- Design of separators
- Design of evaporators
- Design of mixers and separators
- Project report preparation by students. (Individual student will select a processing plant, developed sign report include product identification, site selection, estimation of plant size, process and equipment, process flow-sheeting, plant layout, its evaluation and profitability analysis)

References

- ANTONIOLG AND GUSTAVO VBC. 2005. *Food Plant Design*. CRC Press.
- COUPER. 2012. *Chemical Process Equipment*. Selection and

Design Elsevier.
- GEORGE S AND ATHANASIOS EK. 2015. *Handbook of Food Processing Equipment.* Springer.
- LLOYD EB AND EDWIN HY. 1959. *Process Equipment Design*. Wiley-Interscience.
- MICHAEL MC.2013. *Food Plant Sanitation: Design, Maintenance, and Good Manufacturing Practices.* CRCPress.

PFE 512 SEED PROCESS ENGINEERING (1+1)

Objective

To acquaint and equip the students with seed processing along with the design features of the equipment used in their processing**.**

Theory

Block 1: Engineering properties and unit operations

Unit 1: Processing of different seeds and their engineering properties, principles and importance of seed processing.

Unit 2: Performance characteristics of different unit operations such as pre-cleaning, grading, conveying, elevating, drying, treating, blending, packaging and storage,seed processing machines likes calper, debreader, huller, velvet separator, spiral separator, cleaner-cum-grader, specific gravity separator, indent cylinder, discseparator, and colour sorter, seed treater, weighing and bagging machines, their operation and maintenance, installation and determination of their capacity, seed quality maintenance during processing, plant design and layout,economy and safety consideration in plant design.

Block 2: Seed treatment, drying, storage and packaging

Unit 1: Seed drying principles and methods, theory of seed drying, introduction to different types of heat edairdryers, significance of moisture equilibrium, method of maintaining safe seed moisture, thum brule and its relevance.

Unit 2: Importance of scientific seed storage, types of storage structures to reduce temperature and humidity, management and

operation/cleanliness of seed stores, packaging-principles, practices, materials and hermetic packaging, seed treatment methods and machines used, method of stacking and their impact, design features of medium and long term seeds to rage building.

Practicals

- To study seed processing equipment such as pre-cleaners, scalpers and their performance evaluation.
- To study graders and their performance evaluation.
- To study air screen cleaners and their performance evaluation.
- To study spiral and pneumatic separators and their performance evaluation.
- To study seed treating equipment, bag closures, scale and their performance evaluation.
- To study design and layout of seed processing plant and its economics.
- To analyse the cost of operation and unit cost of processed product.
- To study the effect of drying temperature and duration of seed germination and storability.

References

- BABASAHEB. 2004. *Seeds Handbook: Processing and Storage.* CRC.
- GREGG *et al.* 1970. *Seed Processing*. NSC.
- GUAR. 2012. *AH and book of Seed Processing and Marketing* Agrobios.
- HENDERSON S AND PERRY S M. 1976. *Agricultural Process Engineering*. 5th Ed . AVI Publisher.
- MATHAD. 2017. *Seed Processing: A Practical Approach.* NIPA.
- SAHAY K M AND SINGH K K. 1994. *Unit Operation of Agricultural Processing*. Vikas Publisher House.
- VAUGHA. 1968. *Seed Processing and handling.* https://www. mcia. msstate.edu/pdf/seed-processing-and-handling_1.pdf.

PFE 513 AGRI-PROJECT PLANNING AND MANAGEMENT (2+1)

Objective

To acquaint and equip the students with the techniques of project development and evaluation along with different standards.

Theory

Block 1: Project planning and techno economic feasibility

Unit 1: Project development, market survey and time motion analysis.

Unit 2: Selection of equipment, technology option, techno-economic feasibility and processing in production catchment.

Block 2: Process design and standards

Unit 1: Product and process design, PERT, CPM, transport model, simple x, linear and dynamic programming, operation log book. Material balance and efficiency analysis, performance testing, performance indices, energy requirement and consumption. Marketing of agricultural products, market positioning

Unit 2: BIS/FSSAI/ISO standards/guidelines on best practices, equipment and their design and operation for handling, processing and storage of food/feed.

Practicals

- To study the preparation of project and feasibility report.
- To design salient features, design and layout of MSME.
- Design and layout of different food processing units: MSME, large processing unit.
- To study record keeping related to production.
- To study record keeping related to finance and marketing.
- To conduct experiment on agro project management and design techno-economic feasibility.

- To conduct SWOT analysis for different Start-ups

References

- AHMED T. 1997. *Dairy Plant Engineering and Management*. 4th Ed. Kitab Mahal.
- ALBERT L 2017. *Project Management, Planning and Control*.
- ANANDAJAYASEKERA M P. 2004. *Agricultural Project Planning and Analysis.*

PFE 514 FARM STRUCTURES AND ENVIRONMENTAL CONTROL (2+1)

Objective

To acquaint and equip the students with the different types of farm structures and techniques, to control atmospheric parameters and to create favourable environment in the agricultural structures

Theory

Block 1: Farmstead planning and design of farm structures

Unit 1: Farm stead planning, survey and data collection for information bank. Analysis of data, Layouts Cost estimation and appraisal. Project development; Time, motion and input analysis, flow charts and drawings and case studies.

Unit 2: Farm structures (farmstead, livestock, poultry, storage godowns, farm machinery storage, biogas, greenhouse, nethouseetc), their design, constructional details and design of low cost structures. Heating, ventilating and exhaust systems, air distribution and air cleaning, combustion of fuels and equipment.

Block 2: Drying and dehumidification systems, instruments & measurements

Unit 1: Drying and dehumidification system, air-water contact operations and evaporation, process and product air conditioning, energy efficient environmental control practices. Rural electrification, house holds electric wiring, rural water supply and sanitation.

Unit 2: Instruments and measurements: Codes and standards.

Practicals

- Planning and layout of a farmstead.
- Instruments for measurements of environmental parameters.
- Design of a farm fencing system.
- Study of moisture migration behaviour in storage bins.
- Design aspect of Septic tank.
- Design aspect of Nethouse.
- Design aspect of Grain storage structures.
- Design aspect of Greenhouse.
- Design aspect of Cold storage.
- Design of a feed/fodder storage structures.
- Design of abiogas plant.
- Calculation of heating and cooling load.
- Design calculation of moisture condensation in agricultural buildings.
- Design of ventilation system for dairy and poultry house.
- Visit to Green/Nethouse and cold storage.

References

- ALBRIGHTLD. 1990. *Environmental Control for Animals and Plants*. ASAE Textbooks.
- ESMAY ML AND DIXON J E. 1986. *Environmental Control for Agricultural Buildings*. The AVI Corp.
- GAUDY A F AND GAUDY E T. 1988. *Elements of Bioenvironmental Engineering*. Engineering Press.

- MOORE F F. 1994. *Environmental Control Systems: Heating, Cooling, Lighting*. Chapman and Hall.
- THRELKELD J L. 1970. *Thermal Environmental Engineering*. Prentice Hall.

PFE 515 DAIRY PRODUCT PROCESSING (2+1)

Objective

To acquaint and equip the students with the various dairy products, processing methods and related equipment.

Theory

Block 1: Special milks, dried milks and creams

Unit 1: Procurement, transportation and processing of market milk, cleaning and sanitization of dairy equipment. Special milks such as flavoured, sterilized, recombined and reconstituted one and double toned.

Unit 2: Condensed milk: Methods of manufacture and related equipment, evaluation of condensed and evaporated milk. Dried milk: Definition, methods of manufacture of skim and whole milk powder, instantiation, physiochemical properties, evaluation, defects in dried milk powder. Cream: Cream separation, neutralization, sterilization, pasteurization and cooling of cream, defects in cream, Butter: methods of manufacture, defects in butter.

Block 2: Ice cream, cheese and indigenous milk products

Unit 1: Ice cream: Methods of manufacture and related equipment, defects in ice cream, technology of softy manufacture. Cheese: Methods of manufacture, cheddar, Gouda, cottage and processed cheese, defects in cheese.

Unit 2: Indigenous milk products: Method of manufacture of *yoghurt, dahi, khoa, burfi, kalakand, gulabjamun, rosogolla, srikhand, chhana, paneer, ghee, lassi* etc. Probiotic milk product.

Practicals

- Estimation of fat and SNF in milk
- Operation of LTLT and HTST Pasteurizer
- Standardization of milk
- Preparation of special milks
- Cream separation: parts of separator and the process
- Preparation of table butter using the power driven churn
- Preparation of plain and fruit flavoured ice cream
- Preparation and analysis of *khoa* from cow and buffalo milk
- Preparation and analysis of *chhana* from cow and buffalo milk
- Preparation and analysis of *paneer* from cow and buffalo milk
- Preparation and analysis of *lassi* from cow and buffalo milk
- Preparation of *ghee* from cream and butter
- Preparation of *rosogolla* and *gulab jamun*
- Preparation of srikhand and burfi
- Visit to dairy plant

References

- ADNAN T. 2009. *Dairy Powders and Concentrated Products* (*Society of Dairy Technology*). Wiley-Blackwell.
- ADNAN T. 2006. *Probiotic Dairy Products* (*Society of Dairy Technology series*). Wiley-Blackwell.
- BRITZ. 2008. *Advanced Dairy Science and Technology*. Blackwell Publisher: Blackwell Publisher Professional.
- DE. 2001. *Outlines of Dairy Technology*. Oxford.
- HUIYH. 1992. *Dairy Science and Technology Handbook.* Vol. I, II and IIIWiley.
- SPREER E. 2017. *Milk and Dairy Product Technology* .Taylor and

Francis.

- WALSTRAP, JAN T M, WOUTERS AND GEURTST J. 2006. *Dairy Science and Technology*. CRC, Taylor and Francis.

PFE 516 PROCESSING OF MEAT, POULTRY AND FISH (2+1)

Objective

To acquaint and equip the students with processing of meat, fish and poultry and the design features of the equipment used for their processing.

Theory

Block 1: Processing of meat

Unit 1: Meat : Genetic engineering of farm animals for better meat quality, automation for the modern slaughter house, hot-boning of meat, new spectroscopic techniques for online monitoring of meat quality, real-time PCR for the detection of pathogens in meat, new developments in decontaminating raw meat, automated meat processing, developments in chilling and freezing of meat, high pressure processing of meat, approaches for the development of functional meat products, new techniques for analyzing raw meat, modified atmosphere packaging, perspectives for the active packaging of meat products.

Block 2: Processing of poultry

Unit 1: Poultry: Breeding and quality of poultry, stunning and slaughter of poultry, processing and packaging of poultry, new techniques of preservation of poultry, production of turkeys, geese, ducks and game birds, microbial hazards in poultryproduction and processing, latest trends in measuring quality of poultry and poultry products, treatment and disposal of poultry processing waste.

Block 3: Processing of fish and seafoods

Unit 1: Fish and seafood: Fresh fish handling and chill storage, modified atmospheric packaging of seafoods, fish odours and flavours,

assessment of freshness of fish and sea foods, traditional dried and salted fish products, proteolysed fish products, minced fish technology, retort pouch processing technology, irradiation and microwave in fish handling and processing, advanced freezing technology for fish storage, high pressure processing of seafoods, value addition of fresh water and aquacultured fish products, application of enzymes in fish processing and quality control, toxins, pollutants and contaminants in fish and seafoods.

Block 4: Processing of milk

Unit 1: Milk: Physical, chemical and nutritional properties of milk components, improvements in the pasteurization and sterilization of milk. Flavour generation in dairy products, controlling texture of fermented dairy products, functional dairy products, on-line measurement of product quality in dairy processing, high pressure processing of milk products, novel separation technologies to produce dairy ingredients, new technologies to increase shelf-life of dairy products, genetic engineering of milk proteins, production and utilization of functional milk proteins, methods of improving nutritional quality of milk, significance of milk fat in dairy products, chromatographic, spectrometric, ultrasound and other techniques for analysis of milk lipids.

Practicals

- Analysis of fresh and processed meat products
- Analysis of fresh and processed fish products
- Analysis of fresh and processed poultry products
- Analysis of fresh and processed milk products
- Preservation of fresh meat and fish
- Processing and production of different products from fresh meat
- Processing and production of different products from fresh fish
- Processing and production of different products from fresh poultry
- Processing and production of different products from fresh milk
- Shelf life studies on different meat, fish and milk products

- Visit to processing plants

References

- CHOOKSEY M K. 2003. *Fish Processing and Product Development*. CIFE, Kochi.
- CHOOKSEY M K AND BASUS. 2003. *Practical Manualon Fish Processing and Quality Control.* CIFE, Kochi.
- HALL G M. 1997.*Fish Processing Technology*. Blabie Academic and Professional.
- LAWRIE R S. 1985. *Developments in Meat Sciences*. Vol III Applied Science Publishers.
- MEAD G C. 1989. *Processing of Poultry*. Elsevier.
- PEARSONAM AND TAUBER F W. 1984. *Processed Meats*. AVI Publishers.
- STADELMAN W J AND COTTERILLOJ. 1980. *Egg Science and Technology*. AVI Publishers.

PFE 517 DESIGN OF AQUACULTURAL STRUCTURES (2+1)

Objective

To acquaint and equipth estudents with aquaculture structures and their design features.

Theory

Block 1: Aquacultural structures

Unit 1: Inland fish farming and associated considerations.

Unit 2: Fish physiology and micro-climatic considerations. Site selection for aquaculture structures.

Block 2: Design of aqucultural systems and water treatment plants

Unit 1: Design of dykes, sluice, channels etc. Aeration and feeding systems: Design of fish rearing structures, hatcheries, containers for

livefish, fingerlings, fishseeds.

Unit 2: Aquaculture in recirculatory systems, oxygen and aeration, sterilization and disinfection. Recirculation of water: Reuse systems, water exchange, design of re-use systems, Inlet and outlet structures and water treatment plants.

Practicals

- Study of aeration systems of fish ponds.
- Study of feeding systems of fish ponds.
- Design of dykes in fish farming structures.
- Design of feeder canals in fish farming structures.
- Design of drainage canals in fish farming structures.
- Design of drain ditch in fish farming structures.
- Design of internal pond drains in fish farming structures.
- Design of borrow pits in fish farming structures.
- Design of internal harvesting pits in fish farming structures.
- Study of waste water management through aquaculture.
- Design of recirculatory ponds for waste water treatment in fish farms.
- Different types of containers for live fish.
- Design of re-use systems in fish farms.
- Different types of inlet and outlet structures in fish farms.

Reference

- FAO.1983. *Inland Aquaculture Engineering*. ISBN92-5-102168-6.

PFE 518 THERMAL ENVIRONMENTAL ENGINEERING (2+1) FOR AGRICULTURAL PROCESSING

Objective

To acquaint and equip the students with the concept of thermo dynamic properties of air and its application in food processing.

Theory

Block 1: Psychrometric chart, heating and cooling load calculations

Unit 1: Requirements of temperature and moisture in food preservation, processing, storage, animal and plant production systems, human comfort etc.

Unit 2: Thermodynamic properties of moist air, psychrometric chart, psychrometric processes and applications. Mass transfer and evaporation of water from free surfaces, theory of psychrometer, direct contact transfer processes between moist air and water-air washer, cooling tower, heating and cooling of moist air by extended surface coils, dehumidification using moisture absorbing materials. Solar irradiations on structures, calculation of heating and cooling loads in buildings/storage structures.

Block 2: Design of AC systems and thermal insulation materials

Unit 1: Design of air conditioning systems, air distribution and duct design, air flow patternand control, equipment, components and controls. Instruments for measurement and control of temperature and moisture.

Unit 2: Thermal insulation materials for environmental control systems, applications of environmental controlling green house, dairy industry, potatos to rage *etc.*

Practicals

- Study and practice of psychrometric chart
- Design calculations of air conditioning systems, air distribution and duct design, air flow pattern and control
- Study of thermal insulation materials for environmental control
- Solving numerical problems on mass transfer and evaporation of water from free surfaces
- Solving numerical problems on heating and cooling load of moist air by extended surface coil

- Experiments on the role of moisture and temperature in food preservation and processing
- Instruments for measurement and control of temperature and moisture
- Design calculation of heating and cooling loads in buildings/storage structures.
- Solving numerical problems on psychrometric processes
- Solving numerical problems on direct contact transfer processes between moist air and water-air washer, cooling tower

References

- *Perry's Chemical Engineers' Handbook*, Section1 2. (2007).
- THRELKALD J L. *Thermal Environmental Engineering, Pearson.*

M.Tech. in Soil and Water Conservation Engineering

Course Code	Course Title	Credit Hours
SWC 501	Advanced Soil and Water Conservation Engineering	3 (2+1)
SWC 502	Applied Watershed Hydrology	3 (2+1)
SWC 503	Soil and Water Conservation Structures	3 (2+1)
SWC 504	Stochastic Hydrology	3 (2+1)
SWC 505	Watershed Management and Modeling	3 (2+1)
SWC 506	Flow Through Porous Media	2 (2+0)
SWC 507	Remote Sensing and GIS for Land and Water Resource Management	3 (2+1)
SWC 508	Climate Change and Water Resources	3 (3+0)
SWC 509	Numerical Methods in Hydrology	2 (2+0)
SWC 510	Dryland Water Management Technologies	2 (2+0)
SWC 511	Design of Drip and Sprinkler Irrigation Systems	3 (2+1)
SWC 512	Ground water Engineering	3 (2+1)
SWC 513	Minor Irrigation	3 (2+1)
SWC 514	Water Resources Systems Engineering	3 (2+1)
	Total	**39 (29+10)**
SWC 580	Qualifying Examination	2 (0+2)
SWC 581	Seminar - I	1 (0+1)
SWC 582	Seminar - II	1 (0+1)
SWC 591	Research - I	13 (0+13)
SWC 592	Research - II	14 (0+14)

SWC 501 ADVANCED SOIL AND WATER CONSERVATION ENGINEERING (2+1)

Objective

To acquaint and equip students with the advances in soil and water conservation measures, use of RS and GIS and Software's for design of soil and water conservation structures.

Theory

Block 1: Probability and frequency analysis and design software's

Unit 1: Concept of probability in design of soil and water conservation structures. Probability and continuous frequency distribution. Fitting empirical distributions.

Unit 2: Relevance of soil and water conservation in agriculture and in the river valley projects. Layout and planning of soil and water conservation measures. Software's for design of conservation structures.

Block 2: Soil erosion and design software's

Unit 1: Productivity loss due to soil erosion. Water stress and water excess. Types and mechanics of soil erosion. Software's for soil loss estimation, WEAP, EPIC

Unit 2: Theories of sediment transport. Control of runoff and sediment loss. Sediment deposition process. Estimation of sediment load.

Block 3: Soil conservation structures design and GIS and RS applications

Unit 1: Design of soil and water conservation structures: Check dams, gully plugs, gabion structures, earth dams, silt detention dams, farm ponds, etc., and the alternate use of the stored water for agriculture. Application of Remote Sensing and GIS in Soil and Water Conservation.

Practicals

- Study of probability in design of soil and water conservation structures
- Study of Probability and continuous frequency distribution Fitting empirical distributions

- Study of soil and water conservation in agriculture and in the river valley projects
- Layout and planning of soil and water conservation measures
- To use Software's for design of conservation structures
- Analysis of Productivity loss due to soil erosion
- Analysis of Water stress and water excess
- Study of types and mechanics of soil erosion
- Use of Software's for soil loss estimation, WEAP, EPIC
- To study Theories of sediment transport
- To study Control of runoff and sediment loss
- Estimation of Sediment deposition and sediment load
- Design of soil and water conservation structures: Check dams, gully plugs, gabion structures, earth dams, silt detention dams, farm ponds, etc., and the alternate use of the stored water for agriculture
- Application of Remote Sensing and GIS in Soil and Water Conservation.

References

- GARG, S. K., 1987, Irrigation Engineering and Hydrauli Structures. Khanna Publishers, New Delhi.
- KIRKBY, M. J. AND MORGAN, R. P. C., (eds),1980, Soil Erosion. John Wiley and Sons New York, USA SureshR.2016.
- SURESH, R., 2016, Soil and Water Conservation Engineering. Standard Publishers and Distributors, Delhi.

SWC 502 APPLIED WATERSHED HYDROLOGY (2+1)

Objective

To provide in depth knowledge of surface and sub-surface hydrology of watershed including stream flow measurement and computer simulation of hydrological processes in small watersheds.

Theory

Block 1: Rainfall and runoff analysis

Unit 1: Hydrology in water resources planning, rainfall, surface runoff and sub-surface runoff as components of hydrologic cycle. Runoff phenomena, relationship between precipitation and runoff. Stream flow measurement and analysis of data in detail.

Unit 2: Synthetic unit hydrograph. Recent advances in analysis of hydrologic data and flow from small watersheds. Methods of runoff estimation from small watersheds. Use of IUH and various methods of estimation. Runoff estimation models: SCS, CN software.

Block 2: Simulation and hydrologic modeling

Unit 1: Micro climate, estimation methods of evaporation. Advances and improvements in rational approach. SCS approach criticism and improvements.

Unit 2: Hydrological hazard functions. Methods of estimation of hydrologic parameters. Data transformation.

Unit 3: Calibration and evaluation of hydrologic models. Computer simulation of hydrological process in small watersheds.

Practicals

- Delineation of watershed and study of watershed characteristics
- Measurement of rainfall and runoff in a watershed
- Analysis of hydrologic data and flow from small watersheds
- Estimation of infiltration and runoff from a watershed
- Measurement and analysis of stream flow data
- Analysis of synthetic unithydrograph for complex storm
- Analysis of S-hydrograph for complex storm
- Use of runoff estimation models: SCS, CN software
- Study of different types of flood routing methods
- Computer simulation of hydrological process in small watersheds

- Study of reservoir sedimentation
- Study of watershed model components
- Visit to a watershed

References

- HAAN, C. T., Hydrologic Modeling of Small Watershed.
- SINGH, V. P., 2010, Rainfall-Runoff Modeling (Vol. I)-Prentice Hall, New York.
- SINGH, V. P., 2010, Environmental Hydrology. Springer, New York.

SWC 503 SOIL AND WATER CONSERVATION STRUCTURES (2+1)

Objective

To acquaint students with the planning and design of soil and water conservation structures, their stability check sand mechanized soil conservation techniques.

Theory

Block 1: Design of soil and water conservation structures

Unit 1: Design, planning and layout of soil and water conservation structures. Criteria of selection of appropriate structures as per soil, land use and climatic conditions.

Unit 2: Design and construction of earthen dam, stability analysis of land slopes and soil mass including landslides.

Unit 3: Hydrological and structural design including stress analysis. Hydraulic jump and energy dissipaters for soil conservation structures.

Block 2: Energy dissipation and water harvesting structures

Unit 1: Seepage through dams, flow net and determination of uplift pressure in drop structures, design of energy dissipaters.

Unit 2: Design of water harvesting structures, construction, maintenance and utilization of stored water. Mechanized construction techniques for soil and water conservation structures.

Practicals

- Study of various probability distribution function for rainfall analysis
- Construction of specific energy and specific force diagram
- Measurement of hydraulic jump parameters and amount of energy dissipation
- Hydrologic and hydraulic design of a straight drop spillway
- Determination of uplift force and construction of uplift pressure diagram
- Determination of loads on headwall and construction of triangular load diagram
- Stability analysis of a straight drop spillway
- Hydraulic design of a chute spillway
- Design of drop inlet spillway
- Design of energy dissipating structures
- Design of earthen dam
- Seepage analysis in earthen embankment
- Design of water harvesting structures
- Economic analysis of water harvesting structures
- Field visit to already constructed water harvesting structures in the nearby area/watershed.

References

- MAHNOT, S. C., SINGH, P. K. AND CHAPLOT, P. C., 2011, Soil and Water Conservation and Watershed Management. Apex Publishing House, Udaipur.
- MURTY, V. V. N., 1988, Land and Water Management Engineering. Second Edition Kalyani Publishers, New Delhi.
- SINGH GURMEL, C.,VENKATARAMAN, G., SASTRI. AND JOSHI, B. P., 1991, Manual of Soil and Water conservation Practices. Oxford and IBH Publishing Co.Pvt. Ltd, NewDelhi.

- SINGH, P. K., 2000, Watershed Management (Design and Practice). E-media publications, Udaipur.
- SURESH, R., 2006, Soil and Water Conservation Engineering. Fourth Edition Standard Publishers and Distributors, Delhi.
- SINGH RAJ, V. I. R., 2003, Watershed Management. Second Edition, Yash Publishing, Bikaner.

SWC 504 STOCHASTIC HYDROLOGY (2+1)

Objective

To acquaint students about the stochastic processes in hydrology including statistical characteristics of hydrological time series data, modeling hydrologic uncertainty and analysis of multivariate hydrologic series,

Theory

Block 1: Stochastic hydrology and approaches

Unit 1: Hydrologic cycle, Systems concept, Hydrologic systems model. Classification of hydrologic models, Statistical, stochastic and deterministic approaches. Statistical characteristics of hydrological data, probability distribution of hydrologic variables. Deterministic and stochastic hydrology, Cause and effect analysis. Hydrologic time series analysis - nature, stationarity and ergodicity, components of time series, trend, periodicity and stochastic parts, parameter estimation of probabilitydistributions. Analysis of hydrologic extremes.

Unit 2: Multivariate regression analysis, correlation analysis,correlation coefficient and its significance in regional analysis. Developing prediction equation by simple and multiple linear regression. Reliability of the Model.

Unit 3: Stochastic Process: Classification, stationary process. Time series: Classification, component of time series. Methods of investigation: Auto correlation coefficient, moving average process, auto regressive process, auto regressive moving average process, auto regressive integrated moving average process. Spectral analysis, analysis of multivariate hydrologic series.

Block 2: Stochastic models and uncertainty analysis

Unit 1: Thomas Fiering model, Box Jenkins model. Model formulation: Parameter estimation, calibration and validation. Application to hydrologic data. Generation and forecasting. Regional flood frequency analysis. Transformations, Hypothesis testing.

Unit 2: Modeling hydrologic uncertainty. First order Markov process, Markov chain, Data generation, Hydrologic time series analysis, Modelling of hydrologic time series.

Practicals

- Development of regression models
- Estimation of missing data in historical series
- Parameter estimation-Method of Moments
- Parameter estimation-method of maximum likelihood
- Parameter estimation- method of mixed moments, Probability of weighted moments
- Fitting discrete and continuous distribution functions to variables
- Transformation techniques to historical data for estimating variables at different return periods
- Regression analysis, Correlation analysis,
- Analyzing multivariate regression,
- Auto correlation coefficient for independent and correlated events,
- Fitting ARMA models to rainfall runoff data
- Fitting Markov models of first and second order,
- Regional frequency analysis,
- Estimating parameters of Thomas Fiering Model
- Fitting of Thomas Fiering Model

References

- CLARKE, R. T., Mathematical Models in Hydrology. FAO Publication.

- HAAN, C. T., 2002, Statistical Methods in Hydrology. Iowa State Press.
- KOTTEGUDA, N. T., 1982, Stochastic Water Resources Technology. The Macmillan Press, NewYork.
- MC CUEN, R. H. AND SNYDER, W. M., Hydrological Modelling–Statistical Methods and Applications. Prentice HallInc., NewYork
- YEVJEVICH, V., Stochastic Processes in Hydrology. Water Resources Publications, Colorado.

SWC 505 WATERSHED MANAGEMENT AND MODELING (2+1)

Objective

To acquaint students with watershed management concept and its benefit for sustainable rural development through participatory approach, including environmental impact as well as policy frame work.

Theory

Block 1: Geomorphological analysis of watershed

Unit 1: Concept of watershed, its hydrological and geomorphological characteristics. Status of watershed management programs in India. Problems of desertification and degradation.

Unit 2: Concept of watershed management and sustainability, participatory approach and operational watershed. Surveys, monitoring, reclamation and conservation of agricultural and forest watersheds, hill slopes and ravines.

Block 2: Watershed management and applications of GIS, RS and models.

Unit 1: Watershed management research instrumentation and measurement, problem identification, simulation and synthesis. Rainfed farming and drought management. Modeling of flood and drought phenomenon.

Unit 2: Use of Remote Sensing and GIS in watershed management

and modeling. Watershed modeling approaches, mathematical bases and structure of models.

Unit 3: Environmental impact assessment of watersheds. Quantitative policy, legal and social aspects. Case studies of watershed management.

Practicals

- Selection and delineation of a watershed
- Benchmark surveys
- Preparation of watershed land use map
- Preparation of watershed development proposal
- Preparation of watershed evaluation and impact assessment report
- Application of watershed models for evaluation of conservation treatments
- Use of Remote Sensing and GIS in watershed management and modeling

References

- DHALIWAL, G. S. HANSRA, B. S. AND LADHAR, S. S., 1993, Wetlands, their Conservation and Management. Punjab Agricultural University, Ludhiana.
- DHRUVANARAYANA, V. V., SASTRY, G. AND PATNAIK, U. S., Watershed Management Publand Inf. Dv., ICAR, Krishi Anusandhan Bhavan, New Delhi.
- SINGH, R. V., 2000, Watershed Planning and Management. Second Edition Yash Publishing House, Bikaner.
- SURESH, R., 2017, Watershed Planning and Management. Standard Publication and Distribution, Delhi.
- TIDEMAN, E. M., 1999, Watershed Management (Guidelines for

Indian Conditions). Omega Scientific Publishers, New Delhi.

SWC 506 FLOW THROUGH POROUS MEDIA (2+0)

Objective

To acquaint and equip with the hydraulics and process of water flow in the water bearing formation under saturated as well as unsaturated conditions.

Theory

Block 1: Hydro dynamic properties of aquifers

Unit 1: Aquifer and fluid properties, forces holding water in soils, hydrodynamics in porous media and limitations of governing laws.

Unit 2: Differential equations of saturated flow, initial and boundary conditions. Dupuit and Business approximations and linearization techniques.

Block 2: Seepage theory and analysis

Unit 1: Stream functions, potential functions and flow net theory. Analysis of seepage from canals and ditches.

Unit 2: Unsaturated flow theory, Infiltration and capillary rise flux dynamics. Hydro-dynamic dispersion in soil-aquifer system.

References

- HARR MILTON, E., 1962, Groundwater and Seepage. McGraw-Hill.
- JACOB BEER., 1972. Dynamics of Fluid Flow in Porous Media. Elsevier.
- MUSKAT, M. AND WYCKOFF, R. D., 1946, The Flow of Homogeneous Fluids through Porous Media. JW Edwards.
- PATRICK, A. DOMENICO. AND SCHWARTZ, F. W., 1998, Physical and Chemical Hydrogeology. John Wiley & Sons.

• REMSON, I., HORNBERGER, G. M. AND MOIZ FRED, J., 1971, Numerical Methods in Subsurface Hydrology. Wiley Inter science.

SWC 507 REMOTE SENSING AND GIS FOR LAND AND WATER RESOURCE MANAGEMENT (2+1)

Objective

To acquaint students with recent technology of RS and GIS including satellite data analysis, digital image processing and thematic mapping of land use, surface and ground water.

Theory

Block 1: Remote sensing and Image processing

Unit 1: Physics of remote sensing, electromagnetic radiation (EMR), interaction of EMR with atmosphere, earth surface, soil, water and vegetation. Remote sensing platform, monitoring atmosphere, land and water resources: LANDSAT, SPOT, ERS, IKONOS and others, Indian Space Programme.

Unit 2: Satellite Data analysis: Visual interpretation, digital image processing, image pre- processing, image enhancement, image classification and data merging.

Block 2: GIS and its applications for watershed management

Unit 1: Definition: Basic components of GIS, map projections and co-ordinate system, spatial data structure-raster, vector, spatial relationship, topology, geodatabase models, hierarchical network, relational, object-oriented models, integrated GIS database- common sources of error–data quality: Macro, micro and usage level components, meta data, Spatial data transfer standards.

Unit 2: Thematic mapping, measurements in GIS: Length, perimeter and areas. Query analysis, reclassification: Buffering, neighborhood functions, map overlay: Vector and raster overlay: Interpolation, network analysis, digital elevation modelling. Analytical Hierarchy Process, Object oriented GIS–AM/FM/GIS, Web Based GIS.

Unit 3: Spatial data sources: 4M GIS approach water resources system, Thematic maps, rainfall runoff modelling, groundwater modelling, water quality modelling and flood inundation mapping and

modelling. Drought monitoring, cropping pattern change analysis, performance evaluation of irrigation commands. Site selection for artificial recharge, reservoir sedimentation.

Practicals

- Familiarization with the remote sensing instruments and satellite imagery
- Methods of establishing ground truth survey and Comparison between ground truth and remotely sensed data
- Aerial Photograph and scale determination with stereoscope
- Interpretation of satellite imagery and aerial photograph
- Determination of Parallaxes in images
- Demonstration on GPS; Provision of Ground Control by GPS in different mode
- Introduction to digital image processing software
- Introduction to GIS software
- Data input; Data editing and Topology creation -Digitization of point, line & polygon features
- SRTM & CARTO DEM download from web and Georeferencing of an image
- Delineation of Watershed, DEM generation: slope, Aspect, flow direction, Flow accumulation, Drainage, network and morphometric analysis
- LULC by supervised classification and LULC by unsupervised classification
- Application of Remote Sensing data and GIS for water quality parameters
- Temporal satellite data analysis for vegetation condition, crop water requirement calculation
- Erosion mapping using aerial and satellite Data

References

- IAN, H. S., CORNELIUS. AND STEVE, C., 2002, An Introduction

to Geographical Information Systems. Pearson Education, New Delhi.

- JAMES, B. C. AND RANDOLPH, H. W., 2011, Introduction to Remote Sensing. The Guilford Press.
- LILLES, T. M. AND KIEFER, R., 2008, Remote Sensing and Image Interpretation. John Wiley and Sons.
- PAUL CURRAN, P. J., 1985, Principles of Remote Sensing. ELBS Publications.
- REES, W. G., 2001, Physical Principles of Remote Sensing. Cambridge University Press.

SWC 508 CLIMATE CHANGE AND WATER RESOURCES (3+0)

Objective

To acquaint students about the concept of climate change and its impact on surface and ground water resources. To understand adaptation and mitigation strategy under climate change scenario.

Theory

Block 1: Climate system and climate change

Unit 1: The climate system: Definitions, climate, climate system, climate change. Drivers of climate change, characteristics of climate system components: Greenhouse effect, carbon cycle, wind systems. Trade winds and the Hadley Cell, ozone hole in the stratosphere, El Nino, La Nina– ENSO, teleconnections.

Unit 2: Impacts of climate change: Observed and projected, global and Indian scenario, observed changes and projected changes of IPCC: Impacts on water resources, NATCOM Report, impacts on sectoral vulnerabilities, SRES, different scenarios, climate change impacts on ET and irrigation demand.

Block 2: Climate change assessment, mitigation and adaptation

Unit 1: Tools for vulnerability assessment: Need for vulnerability

assessment, steps for assessment, approaches for assessment. Models: Quantitative models, Economic models, impact matrix approach, Box models, Zero-dimensional models, Radioactive- convective models, Higher-dimension models, EMICs (Earth-system models of intermediate complexity), GCMs (global climate models or general circulation models), Sectoral models.

Unit 2 : Adaptation and mitigation water: Related adaptation to climate change in the fields of ecosystems and biodiversity, agriculture and food security, land use and forestry, human health, water supply and sanitation, infrastructure and economy (insurance, tourism, industry and transportation), Adaptation, vulnerability and sustainable development.

Unit 3: Sector specific mitigation: Carbon dioxide capture and storage (CCS), bio-energy crops, biomass electricity, hydropower, geothermal energy, energy use in buildings, land-use change and management, cropland management, afforestation and reforestation. Potential water resource conflicts between adaptation and mitigation. Implications for policy and sustainable development.

Case studies: Water resources assessment case studies: Ganga Damodar Project, Himalayan glacier studies, Ganga valley project. Adaptation strategies in assessment of water resources. Hydrological design practices and dam safety, operation policies for water resources projects. Flood management strategies, drought management strategies, temporal and spatial assessment of water for irrigation, land use and cropping pattern, coastal zone management strategies.

References

- MAJUMDAR, P. P. AND NAGESH, K. D., Floods in a Changing Climate: Hydrological Modelling. Cambridge University Press, New York.
- PATHAK, H, AGARWAL, P. K. AND SINGH, S. D., Mitigation in Agriculture: Methodology for Assessment and Application Division of Environmental Sciences, IARI New Delhi.

- RAO, Y. S., ZHANG, T. C. OJHA., GURJAR, B. R., TYAGI, R. D., KAO, C. M., (eds), Climate Change Modelling, Mitigation, and Adaptation. American Society of Civil Engineers.
- SRINIVASA, R. K. AND NAGESH, K. D., Impact of Climate Change on Water Resources with Modelling Techniques and Case Studies. Springer publications, New York.Tamim Y and Caitlin AG. Climate Change and Water Resources. Springer Publication.

SWC 509 NUMERICAL METHODS IN HYDROLOGY (2+0)

Objective

To acquaint students about the concept of linear space, triangular and quadrilateral shape functions, iso parametric elements and transformation of coordinates

Theory

Block 1: Numerical methods

Unit 1: Review of finite difference operators. Concept of linear space and basic functions. Approximating from finite dimensional sub spaces.

Unit 2: Variational and weighted residual methods. Lagrange polynomials. Triangular and quadrilateral shape functions.

Unit 3: Isoperimetric elements and transformation of coordinates. Basis functions in three dimensions.

Block2: Numerical solutions for hydrology

Unit 1: Galerkin finite element solution of Laplace, diffusion and dispersion-convection equations.

Unit 2: Method of collocation, application in surface and sub-surface hydrology.

References

- BEAR, J. AND VERRUIJT, A., 1987, Modeling Ground water Flow and Pollution.414pp. Dordrecht, Boston.

- CARR, J. R., 1995, Numerical Analysis for the Geological Sciences. 592pp. Prentice-Hall, Engle wood Cliffs NJ.
- GEORGE HAND PATRICIA, W., 2000, Numerical Methods in the Hydrological Sciences. American Geophysical Union, Florida Avenue, NW.
- GERALD, C. F. AND WHEATLEY, P. O., 1999, Applied Numerical Analysis. 6th ed., 768pp, Addison- Wesley ,Reading, MA.
- MIDDLETON, G. V., 2000, Data Analysis in the Earth Sciences using MATLAB 260 pp., Prentice Hall, Saddle River NJ.

SWC 510 DRYLAND WATER MANAGEMENT TECHNOLOGIES (2+0)

Objective

To provide detail knowledge about analysis of severity of drought assessment and various dry land water management technologies suitable for conservation, harvesting and enhancing productivity of rainfed areas.

Theory

Block 1: Drought analysis and management

Unit 1: Drought severity assessment: Meteorological, hydrological and agricultural methods. Drought indices. GIS based drought information system, drought vulnerability assessment and mapping using GIS. DPAP programme, drought monitoring constraints, limiting crop production in dry land areas. Types of drought, characterization of environment for water availability, crop planning for erratic and aberrant weather conditions.

Unit 2: Stress physiology and crop resistance to drought, adaptation of crop plants to drought, drought management strategies. Preparation of appropriate crop plans for dry land areas. Mid contingent plan for aberrant weather conditions.

Unit 3: Land shaping and land development for soil moisture

conservation. Improvement of tillage and soil management by implements and engineering practices. Soil and moisture conservation for rainfed lands through improved implements and engineering practices. Gel technology.

Ex-situ measures: Water harvesting-micro catchments. Design of small water harvesting structures: Farm Ponds, percolation tanks their types and design, recycling of runoff water for crop productivity.

Block 2: Dryland farming techniques

Unit 1: Crops and cropping practices related to soil and moisture conservation. Fertility management in dryland farming. Planning and development of watersheds from engineering view point. Case studies.

Block 3: Applications of Remote sensing for dryland farming

Unit 1: Application of aerial photography in surveys and planning of watersheds for rainfed agriculture. Use of Remote Sensing in soil moisture estimation.

References

- DAS, N. R., 2007, Tillage and Crop Production. Scientific Publishers.
- DHOPTE, A. M., 2002, Agro Technology for Dryland Farming. Scientific Publ.
- GUPTA, U. S., 1995, Production and Improvements of Crops for Dryland s. Oxford & IBH
- SINGH, R. P., 1988, Improved Agronomic Practices for Dryland Crops. CRIDA.
- SINGH, R. P., 2005, Sustainable Development of Dryland Agriculture in India. Scientific Publ.
- SINGH, R. V., 2003, Watershed Planning and Management. Second Edition. Yash Publishing House, Bikaner.

• SINGH, S. D., 1998, Arid Land Irrigation and Ecological Management. Scientific Publishers

SWC 511 DESIGN OF DRIP AND SPRINKLER IRRIGATION SYSTEMS (2+1)

Objective

To provide exposure of new cutting-edge technologies to the students in design of drip and sprinkler irrigation systems including selection of pipe and fertigation techniques.

Theory

Block 1: Suitability and hydraulics of drip and sprinkler irrigation

Unit 1: Suitability of sprinkler and drip irrigation systems under Indian conditions. Basic hydraulics of sprinkler and micro irrigation system.

Unit 2: Pipe flow analysis. Friction losses and pressure variation. Flow in nozzles and emitters.

Block 2: Design evaluation and fertigation techniques of micro irrigation systems

Unit 1: Design and evaluation of sprinkler and micro irrigation systems in relation to source, soil, climate and topographical conditions.

Unit 2: Selection of pipe size, pumps and power units. Layout, distribution, efficiency and economics.

Unit 3: Fertigation through sprinkler and micro irrigation systems. Fertigation techniques involved in drip and sprinkler irrigation system.

Practicals

- Study of different components of drip and sprinkler irrigation system
- Determination of physical properties of soil
- Design of drip irrigation system for orchards

- Design of micro-irrigation system for row crops
- Design of sprinkler irrigation system for vegetable crops
- Design of sprinkler irrigation system for field crops
- Estimation of total head in drip and sprinkler irrigation system
- Determination of filtration efficiency of different filters
- Evaluation of drip irrigation system
- Determination of uniformity of sprinkler discharge at field
- Study of hydraulics of drippers
- Estimation of fertigation rate in drip irrigation system
- Calculation of different types of efficiencies of installed drip system
- Study of Automation in micro-irrigation system
- Calculation of cost benefits of drip irrigation system
- Calculation of cost benefits of sprinkler irrigation system.

References

- JENSEN, M. E., (Editor), 1983, Design and Operation of Farm Irrigation Systems. ASAE, Monograph No. 3. USA.
- JAMES, L. G., 1988, Principles of Farm Irrigation System Design. John Wiley and Sons, New York, USA.
- MICHAEL, A. M., 2006, Irrigation Theory and Practice. Vikas Publ. New Delhi.
- WITHERS BRUCE AND VIPOND STANLEY., 1974, Irrigation: Design and Practice. B.T. Batsfordm Ltd, London
- SIVANAPPAN, R. K., 1987, Sprinkler Irrigation. Oxford and IBH Publishing Co. New Delhi.

SWC 512 GROUND WATER ENGINEERING (2+1)

Objective

To provide comprehensive knowledge to the students in aquifers, groundwater flow, artificial groundwater recharge techniques, well hydraulics and groundwater models.

Theory

Block 1: Ground water flow principles, recharge techniques and groundwater modeling studies

Unit 1: Water resources of India. Occurrence, storage and movement of groundwater in alluvial and hard rock formations. Principles of groundwater flow. Interaction between surface water and groundwater.

Unit 2: Natural and artificial groundwater recharge. Conjunctive use of surface and groundwater. Groundwater balance. Fluctuation of water table beneath a recharge site. Delineation of groundwater potential zones using RS and GIS, MODFLOW equation.

Block 2: Mathematical equations for well hydraulics pumping tests and applications of Ground water models.

Unit 1: Derivation of hydraulics of fully and partially penetrating wells in confined, leaky and unconfined aquifers. Flow net analysis.

Unit 2: Analysis of multi aquifers. Flow analysis in interfering wells. Pumping tests for estimation of aquifer parameters. Wells near recharge and impermeable boundaries. Skimming well technology.

Unit 3: Design of well field. Salt water intrusion in inland and coastal aquifers. Application of groundwater models for groundwater management. Calibration and validation of models.

Practicals

- Delineation of water table contour maps
- Determination of groundwater flow using contour maps
- Estimation of aquifer characteristics by Theis and Cooper-Jacob method
- Estimation of aquifer characteristics by Chow's and Theis recovery method
- Hand on exercise for analysis groundwater flow through well in leaky aquifers
- Hand on exercise for analysis groundwater flow through well in non-leaky aquifers

- Analysis of pumping test data for estimation of aquifer parameters
- Computation of drawdown and discharge under interference of wells
- Simulation of groundwater flow using various computer models (MODFLOW, *etc.*)

References

- BOONSTRA, J. AND DE RIDDER, N. A., 1981, Numerical Modeling of Groundwater Basins. ILRI.
- DEMENICO, P. A., 1972, Concept and Models in Groundwater Hydrology. McGraw Hill.
- HUISMAN, L., 1972, Ground Water Recovery. Mac Millan.
- JAT, M. L. AND S. R. BHAKAR., 2008, Ground Water Hydrology. Agro-tech Publishing Academy. Udaipur.
- POLUBARINOVA KOCHINA, P. YA., 1962, Theory of Ground Water Movement. Princeton Univ. Press.
- RAGHUNATH, H. M., 1992, Ground Water. Wiley Eastern.
- TODD, D. K., 1997, Ground Water Hydrology. Wiley Eastern.

SWC 513 MINOR IRRIGATION (2+1)

Objective

To acquaint students about the need and scope of minor irrigation in India. To provide in- depth knowledge in design and operation of surface and ground waterbased irrigation practices.

Theory

Block1: Design and operation of surface water storage structures and ground water development and augmentation methods

Unit 1: Definition, scope, historical background and progress in minor irrigation works in India, Assessment of surface water resource. Design and operation of surface water storage structures.

Unit 2: Evaporation and seepage control. Groundwater development methods and their scope. Groundwater extraction devices and methods. Aquifer characteristic and their evaluation. Wells in alluvial and rocky

aquifers.

Unit 3: Well interference, spacing and multiple well point system for controlled groundwater pumping. Safe yield from wells. Augmentation of well yield through pumping and recovery time management.

Block 2: Design of well, drilling and constructions, water lifting devices and conjunctive use ground and surface water

Unit 1: Well design, drilling and construction. Tube well strainers, gravel packing and resistance to flow. Pumps and prime movers for groundwater lifting. Diagnosis of sick and failed wells and their remediation.

Unit 2: Conjunctive use of surface and groundwater. Legislation for groundwater development and management. Ground water recharge and its use.

Practicals

- Measurement of seepage loss from reservoirs
- Estimation of inflow to surface reservoir
- Measurement of evaporation loss from surface reservoirs
- Pumping test and determination of aquifer parameters
- Establishment of draw down-discharge characteristic
- Well log analysis and deciding on length and placement of strainers
- Computation of well interference and deciding on well spacing\
- Estimation of irrigation for given discharge from well
- Estimating pumping cost for irrigation
- Analysis of ground water quality
- Problems on well design

References

- GARG, S. K., 1987, Irrigation Engineering and Hydraulic Structures. Khanna Publisher, Delhi.
- GARG, S. K., 1987, Hydrology and Water Resource Engineering.

Khanna Publishers, Delhi.

- MICHAEL, A. M., 2006, Irrigation Theory and Practice. Vikas Publications, New Delhi.
- SHARMA, R. K., 1987, Hydrology and Water Resources Engineering. DhanpatRai and Sons, New Delhi.
- SUBRAMANIAN, K., 1993, Engineering Hydrology. Tata McGraw-Hill Co. New Delhi.

SWC 514 WATER RESOURCES SYSTEMS ENGINEERING (2+1)

Objective

To acquaint students about the concept of optimization and its application in water resources management, mathematical programming techniques and multi objective water resources planning.

Theory

Block 1

Unit 1: Concepts and significance of optimization in water resources management. Model development in water management. Objective functions, deterministic and stochastic inputs.

Unit 2: Soil plant atmosphere system. Problem formulation. Mathematical programming techniques: Linear programming, simplex method.

Unit 3: Non-linear programming, quadratic programming, integer programming. Transportation problem and solution procedure. Geometric programming and dynamic programming.

Unit 4: Application of optimization techniques for water resources planning. Conjunctive use of water resources. Crop production functions and irrigation optimization.

Unit 5: Multi objective water resources planning. Critical path method. Programme evaluation and review technique. Economic models.

Project evaluation and discounting methods.

Practicals

- Assessment of water resources of the region
- Problems on water allocation in agriculture under single and multiple cropping system
- Familiarization with computer software for linear programming
- Hands on exercise for non-linear programming on computer
- Hands on exercise for dynamic programming on computer
- Sensitivity analysis of different alternatives of water resources development and allocation
- Analysis of water demand and supply
- Benefits and cost of water resources development

References

- LARRY, W. M., 1996, Water Resources Handbook. McGraw-Hill.
- LOUCKS, D. P., *et al.,* 1981, Water Resources System Planning and Analysis. Prentice Hall.
- RAO, S. S., 1978, Optimization Theory and Application. Wiley Eastern.
- WALLANDER, W. W. AND BOS, M., 1990, Water Resource System Planning and Management

Master of Business Administration (MBA) in Agri-Business Management (ABM)

Course Code	Course Title	Credit Hours
ABM 501	Principles of Management and Organisational Behaviour	3 (3+0)
ABM 502	Managerial Accounting and Control	3 (2+1)
ABM 503	Applied Agribusiness Economics	2 (1+1)
ABM 504	Human Resource Management for Agricultural Organizations	2 (2+0)
ABM 505	Production and Operations Management	2 (1+1)
ABM 506	Agricultural and Food Marketing Management-I	2 (1+1)
ABM 507	Agricultural and Food Marketing Management- II	2 (2+0)
ABM 508	Agri Supply Chain Management	2 (1+1)
ABM 509	International Trade in Agricultural Products	2 (2+0)
ABM 510	Food Technology and Processing Management	3 (3+0)
ABM 511	Rural Marketing	3 (3+0)
ABM 512	Fertiliser Technology and Management	3 (3+0)
ABM 513	Management of Agro-Chemical Industry	3 (3+0)
ABM 514	Seed Production Technology Management	3 (3+0)
ABM 515	Technology Management for Livestock Products	3 (3+0)
ABM 516	Fruit Production & Post Harvest Management	3 (3+0)
ABM 517	Farm Power & Machinery Management	2 (2+0)
ABM 518	Food Retail Management	2 (2+0)
ABM 519	Management of Agricultural Input Marketing	2 (2+0)
ABM 520	Feed Business Management	2 (2+0)
ABM 521	Management of Veterinary Hospitals	2 (2+0)
ABM 522	Poultry and Hatchery Management	2 (2+0)
ABM 523	Management of Floriculture and Landscaping	2 (2+0)

Course Code	Course Title	Credit Hours
ABM 524	Risk Management in Agri Business	2 (2+0)
ABM 525	Management of Agri-Business Co-Operatives	2 (2+0)
ABM 526	Business Analytics for Agriculture	2 (1+1)
ABM 527	Dairy Business Management	1 (1+0)
ABM 528	Agri Extension Management	1 (1+0)
ABM 529	Renewable Energy Sources Management	1 (1+0)
ABM 530	Quality Management for Agri Business	1 (0+1)
ABM 531	Advertising and Brand Management	1 (1+0)
ABM 532	Agri Infrastructure and Warehousing Management	1 (1+0)
ABM 533	Contract Farming	1 (1+0)
ABM 534	Human Resource Competence and Capacity Building Systems	1 (1+0)
ABM 535	Agri Commodity Markets and Futures Trading	1 (0+1)
	Total	**70 (62+8)**
ABM 580	Qualifying Examination	2 (0+2)
ABM 581	Seminar - I Seminar - II	1 (0+1)
ABM 582	Research / IDEA	1 (0+1)
		27 (07+20)

IDEA		
Course Code	**Course Title**	**Credit Hours**
	Research (Summer Internship+Research Project)	27 (07+20)
ABM 545	Summer Internship/ Industrial Attachment	4
	Basic Courses mandatory for Summer Internship	6
ABM 539	Communication for Management and Agri Business	3 (3+0)
ABM 540	Research Methodology for Agri Business Management	3 (2+1)
ABM 545	**Project work**	**07**
	Basic courses mandatory for Project	**10**
ABM 541	Computer Applications for Agri Business	3 (2+1)
ABM 542	Project Management and Agri Business Entrepreneurship	3 (2+1)
ABM 543	Agribusiness Environment and Policy	2 (2+0)
ABM 544	Agri Business Laws and Ethics	2 (2+0)

ABM 501 PRINCIPLES OF MANAGEMENT AND ORGANIZATIONAL BEHAVIOUR (3+0)

Objective

Provide students with opportunities to understand a wide variety of topics related to business management, focusing on fundamental management principles and concepts that apply to agribusiness, traditional management skills, and new competencies needed to succeed in a fast-paced environment that demands ongoing innovations.

Theory

Block I: Basic Concepts of Management

Unit-1: Introduction to Management: Nature, Scope and Significance of Management-Managerial Roles-Management skills-Evolution of Management Thought- Approaches to Management.

Unit- 2: Management functions: Planning – Objective- Process-Types, Steps- MBO - Decision Making-Organizing – Structure & Process, Line, Staff, Authority & Responsibility- HRM- Recruitment and Selection-Training and development programmes–Communication- - importance-types-barriers - Leadership styles and influence process-leadership theories-Controlling- Significance, Process, Techniques, Standards & Benchmarks, Management Audit

Block II: Insights about Organizational Behaviour

Unit 1: Nature, Scope and Significance of Organizational Behaviour; Foundations of Individual behaviour Perception, Learning-Process-approaches to learning—Personality-Motivation- Types of motivation, theories of motivation, motivational practices at workplace, managing stress and work life balance,

Unit 2: Group dynamics- types of groups, group formation – Team working and developing collaboration- Individuals in groups.

Block III: Organisational Dynamics

Unit 1: Understanding and managing organisational culture - conflict Management -power and political behaviour in organisations-

Managing Organizational change- Organisational Development-Process-Future directions.

References

- ROBBINS SP, COULTER M AND VOHRA N. 2010. *Management.* Pearson Edu.
- WEIHRICH H, CANNICE MV AND KOONTZ H. 2015*, Management, A Global, Innovative and Entrepreneurial Perspective,* 14th Edition, McGraw Hill Education Pvt Ltd.
- BEIERLEIN JG, SCHNEEBERGER KC, OSBURN DD. 2014. *Principles of Agribusiness Management.* Fifth edition. Waveland Press
- NECK CP, HOUGHTON JD AND MURRAY EL. 2017, *Organizational behavior*, Sage Publication India Private Limited.
- GREENBERG J. 2013, *Behavior in Organisations*, PHI Learning Private Limited, New Delhi.
- JOHN A, WAGNER III JA AND HOLLENBECK JR. 2015. *Organizational Behaviour*, Routledge Taylor & Francis Group, New York.
- KOONTZ H AND WEIGHT RICH K. 2010. *Essentials of Management*. Tata McGraw Hill.

ABM 502 MANAGERIAL ACCOUNTING AND CONTROL (2+1)

Objective

The objective of this course is to expose the learner to the concept and methods offinancial and management accounting. Focus will be on understanding techniques, uses and applications of financial and management accounting.

Theory

Block I: Financial Accounting

Unit 1: Financial Accounting- Meaning, Need, Accounting principles: Accounting Concepts and Conventions; Branches of

Accounting, Users of Accounting information, Advantages and Limitations of Financial Accounting, Accounting Standards.

Unit 2: The Double Entry System- Its Meaning and Scope, The Journal, Cash Book, Ledger, Trial Balance, Trading Account Profit and Loss Account, Balance Sheet, entries and adjustments of different heads in different Books and Accounts, Introduction of Company Accounts, Use of Accounting Software.

Block II: Managerial Accounting

Unit 1: Management Accounting-Meaning, Functions, Scope, Utility, Limitations and Tools of Management Accounting, Analysis of Financial Statements- Ratio, time series, common size and Du pont Analysis, Comparative and Common Size Statements, Cash Flow and Fund Flow Analysis.

Block III: Cost Accounting

Unit 1: Cost Accounting–Nature, Course, Significance of Cost Accounting; Classification of Cost, Costing for Material; Labour and overheads; Marginal Costing and cost volume profit Analysis- Its Significance, Uses and Limitations; Standard Costing – Its Meaning, Uses and Limitations, Determination of Standard Cost, Variance Analysis-Material, Labour and Overhead.

Unit 2: Budget and Budgetary Control- Meaning, Uses and Limitations, Budgeting and Profit planning, Different Types of Budgets and their Preparations: Sales Budget, Purchase Budget, Production Budget, Cash Budget, Flexible Budget, Master Budget, Zero Based Budgeting. Mergers and Acquisition, Tax System- GST.

Practical

1. Visit to business entities of different types, interaction with Accountants on accounting practices and presentation of results to Management.
2. Analysing annual reports, Notes to Accounts, audit reports of at least 5 Corporates.

3. Exercises on Construction of Accounting Problems and solution based on accounting principles and practices.
4. Interface with Chartered Accountants with consulting exposure to IFRS.
5. Interaction with a bank branch on Bank Reconciliation.

References

- JAIN SP AND NARANG KL. 2014. *Financial Accounting*. 12th Edition. Kalyani publisher.
- SHARMA AND GUPTA. 2018. *Management Accounting* 13th Edition, Kalyani Publisher.
- MAHESHWARI SN AND MAHESHWARI SK. 2018. *Financial Accounting*. 6th Ed. Vikas Publ. House.

ABM 503 APPLIED AGRIBUSINESS ECONOMICS (1+1)

Objective

This course applies basic economic tools and models to problems involving supply,demand, individual consumer and firm behavior, and market structure. Basic marketstructure models covered include perfect competition, monopolistic competition,oligopoly, and monopoly. Economic tools and models are related to business strategies throughout the course.

Theory

Block I: Overview of Applied Agribusiness Economics

Unit 1: Meaning and Scope of applied Agribusiness Economics, Basic Tools. Scope of managerial economics, objective of the firm and basic economic principles; mathematical concepts used in managerial economics. Introduction to behavioural economics.

Unit 2: Indifference curves and budget sets - Demand analysis - meaning, types and determinants of demand; demand function; demand elasticity; demand forecasting-need and techniques. Theory of Revealed

Preference: Strong and Weak Ordering and Theory of Demand. Hicks' Revision of Demand Theory.

Block II: Production, Cost and Supply Analysis

Unit 1: Production, cost and supply analysis- production function, Multi period Production and cost least-cost input combination, factor productivities and returns to scale, cost concepts, cost-output relationship, short and long-run supply functions.

Unit 2: Market and Pricing: Pricing-determinants of price - pricing under different market structures, pricing of joint products, pricing methods in practice, government policies and pricing.

Price discrimination (First, Second and Third level).

Block III: Macroeconomics

Unit 1: The national income; circular flow of income: consumption, investment and saving: money-functions, factors influencing demand for money & supply of money; inflation; economic growth; business cycles and business policies; business decisions under certain and uncertain situations.

Practical

Quick look at algebraic equations and functions & their uses in applied economics, calculation of utility function. Computation of different types of demand function. Computation of elasticity of demand (price, income, cross and promotional) Computation of total, average and marginal revenue under different market conditions. Demand estimation. Analysis of important demand forecasting methods. Computation of average product, marginal product and elasticity of output with respect to one variable input. Computation of elasticity. Calculation of optimal output combination of multi-product firms. Derivation of cost functions from production functions. Computation break-even point.

References

- DWIVEDI D N. 2015. *Managerial Economics*. 8th Edition, Vikash Publishing.

- GUPTA GS. 2015. *Managerial Economics*. Tata McGraw Hill.
- SAVATORE D. SRIVASTAV R. 2012. *Managerial Economics*. 7th Edition, Oxford University Press.
- SUMA DAMODARAN. 2010. *Managerial Economics*. Oxford.

ABM 504 HUMAN RESOURCE MANAGEMENT FOR AGRICULTURAL ORGANISATIONS (2+0)

Objective

The objective of this course is to expose the learner to the field of human resource management. The focus will be on human resource practices and their utility for managers in agri based organizations.

Theory

Block I: Introduction to Human Resource Management

Unit 1: Strategic Human Resource Management, Human Resource Planning-Nature and Significance, Job Analysis and talent management process, Job Description, job Specification, Job enlargement, Job enrichment, Job rotation.

Unit 2: Recruitment and Selection Process, Induction, Training and Human Resource Development-Nature, Significance, Process and Techniques, e- recruitment, use of Big Data for recruitment, use of Artificial Intelligence and machine learning tools in recruitment practices Career planning and Development Internal mobility including Transfers, Promotions, employee separation.

Unit 3: Performance Appraisal–Significance and methods, Compensation management, Strategic pay plans, Job Evaluation, Wage and Salary Administration; Wage Fixation; Fringe Benefits, Incentive Payment, bonus, and Profit Sharing. Employee Engagement.

Block II: Industrial Relations

Unit 1: Role and Status of Trade Unions; Collective Bargaining; Worker's Participation in Management, employee retention. Quality of work life, employee welfare measure, work life balance, Disputes and

Grievance Handling Procedures; Arbitration and Adjudication; Health and Safety of Human Resources;

Block III: Ethical and Global Issues in HRM

Unit 1: Ethical issues in HRM**,** Managing Global Human Resources, Managing Human Resources in Small and Entrepreneurial firms, Human Resources accounting, Human Resources outsourcing. HR Information System, Human Resource Metrics and Workforce Analytics, Future trends in workforce technologies.

References

- GARY DESSLER& BIJU VARKKEY 2016, *Human Resource Management*, XIV Edition, Pearson India
- VSP RAO. 2010, *Human Resource Management, Text and Cases,* 3rdEdition, Excel Books
- ASHWATHAPA K. 2016. *Human Resource Management, Text and Caes*. Tata McGraw Hill
- MICHAEL J. KAVANAGH, MOHAN THITE & RICHARD D. JOHNSON. 2016, *Human Resource Information Systems*, Sage Publications
- SUBBA RAO P. 2004. *Essentials of Human Resource Management and Industrial Relations*. Himalaya Publ. House.

ABM 505 PRODUCTION AND OPERATIONS MANAGEMENT (1+1)

Objective

The objective of this course is to expose the learner to the field of production and operations management. The focus will be on imparting knowledge of the basic concepts, tools, and functions of production management.

Theory

Block I: Introduction to Production and Operations Management

Unit 1: Nature Concept and Scope of Production and Operations Management; Factors Affecting System; Facility location, Types of

Manufacturing Systems and Layouts, Process Selection and Facility Layout, Layout Planning and Analysis, Forecasting.

Unit 2: Operations Strategy: Operations Strategy, Competitive Capabilities and Core Competencies, Operations Strategy as a Competitive Weapon, Linkage Between Corporate, Business, and Operations Strategy, Developing Operations Strategy, Elements or Components of Operations Strategy, Competitive Priorities, Manufacturing Strategies, Service Strategies, Global Strategies and Role of Operations Strategy.

Unit 3: Productivity Variables and Productivity Measurement, Production Planning and Control, Mass Production, Batch Production, Job Order Manufacturing, Product Selection, Product Design and Development, Process Selection, Capacity planning.

Block II: Inventory Management

Unit 1: An Overview of Inventory Management Fundamentals, Determination of Material Requirement, Safety Management Scheduling, Maintenance Management Concepts, Work Study, Method Study, Work Measurement, Work Sampling, Work Environment, Production Planning and Control (PPC) Industrial Safety, human machine interface, types of interface designs. Cloud operations management.

Block III: Quality Management

Unit 1: Quality Assurance, Accepting Sampling, Statistical Process Control, Total Quality Management, ISO standards and their Importance, Introduction to reengineering, value engineering, check sheets, Pareto charts, Ishikawa charts, JIT Pre-requisites for implementation Six Sigma, Lean Management, Reliability Engineering, Safety Engineering, Fault Tree Analysis.

Practical

- Demand forecasting for production planning. Quantitative and qualitative forecasting. Operations Strategy Matrix for efficiency assessment.
- Operations strategy based on competitive priority.

- Construction of process selection through case study.
- Work Breakdown Structure (WBS) for a project.
- Single Facility Location Problem, Multi facility Location Problems.
- Scheduling techniques - (i) Program evaluation and review technique (PERT) (ii) Critical path method (CPM).
- Developing check sheets, pareto charts, Ishikawa charts, six sigma, lean management for quality management.

References

- WILLIAM J. STEVENSON. 2014. *Operations Management*, 12th Edition, McGraw-Hill
- PANNEERSELVAM K. 2012. *Production and Operations Management* 3rd Edition, Prentice Hall India Learning Private Limited
- S. N CHARY, 2017. *Production and Operations Management*, McGraw Hill Education; 5th edition

ABM 506 AGRICULTURAL AND FOOD MARKETING MANAGEMENT - I (1+1)

Objective

To develop the understanding the concept of marketing system with specific inputsof product, pricing, availability and promotional details.

Theory

Block I: Overview of Marketing Management

Unit 1: Introduction and Concept/ philosophies of Marketing Management; Product Management: The product, The product mix, Product line extensions, Product Line deletions, Branding products, The advantages and disadvantages of branding, Branding decisions Brand loyalty models, Homogenous first-order markov models, Higher-order markov models Packaging, The functions of packaging, Packaging technology, Recent developments in packaging

Block II: Pricing Decisions

Unit 1: Pricing objectives, the laws of supply and demand, Elasticity of demand, Cross-price elasticity of demand, Practical problems of price theory, Cost – revenue - supply relationships, The meaning of price to consumers, Price as an indicator of quality, Pricing strategies, Cost-plus methods of price determination, Breakeven analysis, Market-oriented pricing, Psychological pricing, Geographical pricing, Administered pricing.

Block III: Channel Management and Physical Distribution

Unit 1: Channel decisions in relation to marketing strategy, The value of middlemen, Key decisions in channel management, Types of distribution system, Marketing to middlemen, Power and conflict in distribution channels, Physical distribution, Customer service levels, Developing a customer service policy, The total distribution concept, Warehouse management, Inventory management, Calculating the economic order quantity, Transport management, Technological advances in physical distribution, Vehicle scheduling and routing, Fixed and variable routing systems, Vehicle scheduling tools, Vehicle scheduling models, Computer-based vehicle scheduling.

Block IV: Marketing Communications

Unit 1: The nature of marketing communications, Setting marketing communication objectives, Factors influencing the communications mix, The marketing communications mix, Advertising, Sales promotion, Public relations, Personal selling, Digital Marketing, Mobile Marketing, Social Marketing and Social Media Marketing, Training the sales force, Change agents, Selecting the media, Establishing the promotional budget, Monitoring the effectiveness of marketing communications.

Unit 2: Marketing Costs and Margins: Assessing the performance of a marketing system, Marketing efficiency and effectiveness, Operational efficiency, Pricing efficiency, Identifying marketing costs and margins, The reference products concept, Handling costs, Packaging costs, Transport costs, Storage costs, Processing costs, Capital costs.

Practical

1. Case Study discussion on Branding
2. Collection of different packaging material of different products-presentation and discussion
3. Group discussion on pricing of agricultural inputs
4. Visit to packaging products manufacturing company
5. Case study discussion on distribution management
6. Visit to accredited warehouse and acquainting with inventory management
7. Vehicle scheduling, routing in online trading of company (Big bazaar, Ninja kart, Amazon, ID- Idly, Dosa Batter, etc.)
8. Case study of any company in marketing communication mix
9. Case study discussion on social media marketing of FMCGs
10. Preparation of marketing cost of agriculture inputs
11. Presentation of case studies by individual students

References

- KOTLER P, KELLER K, KOSHY A AND JHA M. 2013. Marketing Management–Analysis, Planning, *Implementation and Control*. Pearson Education.
- RAMASWAMY VS. 2017. *Marketing Management: A Strategic Decision Making Approach* McGraw Hill Education
- SAXENA R. 2009. *Marketing Management*. Mc Graw Hill.4th Edition
- WILLIAM PERREAULT JR., MCCARTHY E. JEROME., 2006, *Basic Marketing: A Global Marketing Approach,* Tata McGraw Hill
- GAY R, CJARLESWORTH A, ESEN R. 2014, *Online Marketing*, Oxford University Press
- MOHAMMED, FISHER, JAWORSKI AND CAHILL: *Internet Marketing – Building Advantage in anet worked economy* Tata McGraw-Hill

- STRAUSS J AND FROST R. 2013. *E-Marketing*, Prentice-Hall
- ROBERTS M. 2018. *Internet Marketing*, Cengage Learning
- VASSOS: *Strategic Internet Marketing – Practical e-commerce and branding Tactics*, Que Books
- CHAFFEY, MEYER, JOHNSTON AND ELLIS – Chadwick. 2009. *Internet Marketing*, Prentice-Hall/Financial Times

ABM 507 AGRICULTURAL AND FOOD MARKETING MANAGEMENT-II (2+0)

Objective

To develop learning about the basic concept of marketing with major emphasis onagri and food marketing by equipping the students with the understanding of ecosystem in which the agri organization functions to meet the requirements of the customer profitably

Theory

Block I: Agricultural and Food Marketing

Unit 1: The importance of agricultural and food marketing to developing countries, the marketing concept and marketing systems, Marketing sub-systems Marketing functions, Links between agriculture and the food industry, Agricultural and food marketing enterprises, Marketing boards in developing countries, Cooperatives in the agriculture and food sectors, Control and management of secondary co-operatives, The weaknesses of co-operatives, Selling arrangements between cooperatives and their members

Unit 2: Market Liberalisation: Economic structural adjustment programmes, Macro-economic stabilisation, The role of the state in liberalised markets, Strategies for reforming agricultural marketing, Obstacles to be overcome in commercialisation and Privatisation of agricultural marketing, Dealing with accumulated deficits, Encouraging private sector involvement in agricultural marketing, Impediments to private sector participation in agricultural markets, impact of the macro-

economic environment on private traders, Government action to improve private sector performance.

Block II: Marketing Strategy, Planning and Control

Unit 1: Marketing Strategy, Planning and Control: Strategy, policy and planning, Strategic business units, The need for marketing planning, The process of marketing planning, Contents of the marketing plan, Monitoring, evaluating and controlling the marketing planning, Marketing controls, Marketing plan control, Efficiency control.

Unit 2: New Product Development: The impetus to innovation, New product development process, The adoption process, The effect of products characteristics on the rate of adoption, Buyer behaviour: The influences on buyer behaviour, Exogenous influences on buyer behaviour Endogenous influences on buyer behaviour, The consumer buying decision process, Buyer behaviour and market segmentation, Lifestyle segmentation, Organisational markets Industrial markets, Industrial buyer characteristics.

Block III: Commodity Marketing

Unit 1: Stages in a commodity marketing system, Grain marketing, Challenges for grain marketing systems, fruits and vegetables, Livestock and meat marketing, Poultry and eggs marketing, marketing of fresh milk.

References

- ACHARYA SS AND AGARWAL NL. 2011. *Agricultural Marketing in India*. 4th Ed. Oxford and IBH.
- KOHLS RL AND UHJ JN. 2005. *Marketing of Agricultural Products*. 9th Ed. Prentice Hall.
- MOHAN J. *AGRi-Marketing Strategies in India*, NIPA
- SHARMA PREMJIT. 2010. *Agri-Marketing Management*, Daya Publishing House

ABM 508 AGRI SUPPLY CHAIN MANAGEMENT (1+1)

Objective

To introduce the students to the concepts, processes and framework of agricultural supply chain management.

Theory

Block I: Overview of Supply Chain Management

Unit 1: Supply Chain: Changing Business Environment; SCM: Present Need; Conceptual Model of Supply Chain Management; Evolution of SCM; SCM Approach; Traditional Agri. Supply Chain Management Approach; Modern Supply Chain Management Approach; Elements in SCM. Innovations in Global Agri-SCM. Introduction to Lean Management.

Unit 2: Demand Management in Supply Chain: Types of Demand, Demand Planning and Forecasting; Operations Management in Supply Chain, Basic Principles of Manufacturing Management. SCM Metrics/ Drivers and Obstacles.

Block II: Procurement Management in Agri. Supply Chain

Unit 1: Purchasing Cycle, Types of Purchases, Contract/Corporate Farming, Classification of Purchases Goods or Services, Traditional Inventory Management, Material Requirements Planning, Just in Time (JIT), Vendor Managed Inventory (VMI).

Block III: Logistics Management

Unit 1: History and Evolution of Logistics; Elements of Logistics; Management; Distribution Management, Distribution Strategies; Pool Distribution; Transportation Management; Fleet Management; Service Innovation; Warehousing; Packaging for Logistics, Third-Party Logistics (TPL/3PL); GPS Technology. Introduction to incoterms.

Unit 2: Concept of Information Technology: IT Application in SCM; Advanced Planning and Scheduling; SCM in Electronic Business; Role of Knowledge in SCM; Performance Measurement and Controls in Agri. Supply Chain Management- Benchmarking: introduction,

concept and forms of Benchmarking. Case Studies on the following: (a) Green Supply Chains (b) Global Supply Chains (c) Coordination in a SC. Value of and distortion of information: Bullwhip effect (d) Sourcing and contracts in SC (e) Product availability with uncertain demand (f) Inventory planning with known/ unknown demand (g) Cases from FAO/ IFPRI, etc.

Concepts of quality management. Introduction to the concepts of Exports.

Practical

Supply chain coordination – reducing the distribution cost, Supply chain analytics: Descriptive Analytics – Calculation of yield and distribution, Predictive Analytics – Calculation of sales forecast (Baseline, Baseline plus seasonality, Baseline plus trend, Baseline trend and seasonality), Prescriptive Analytics – Calculation of economic ordering cost, Reducing the costs using linear programming.

References

- ACHARYA SS AND AGARWAL NL. 2011. *Agricultural marketing in India*. Oxford and IBH.
- ALTEKAR RV. 2006, *Supply Chain Management: Concepts and Cases*. PHI
- CHOPRA S, MEINDL P AND KALRA DV. 2016. *Supply chain management: Strategy, Planning and Operation*, Pearson Education India.
- MOHANTY RP. 2010. *Indian Case studies in Supply Chain Management & other Learning Resources.* Oxford.
- CHANDRASEKARAN N. 2010. *Supply Chain Management: Process, system & Practice*. Oxford.
- SINGH S. 2004. *Organic Produce Supply Chains in India-Organisation and governance*. Allied Publ.

ABM 509 INTERNATIONAL TRADE IN AGRICULTURAL PRODUCTS (2+0)

Objective

To impart knowledge to the students about international trade in agriculture and various provisions under WTO in the new trade regime.

Theory

Block I: Introduction to International Trade

Unit 1: International trade–basic concepts, WTO and its implications for Indian economy in general and agriculture sector in particular.

Unit 2: TRIPS, TRIMS quotas, anti-dumping duties, quantitative and qualitative restrictions, tariff and non-tariff measures, trade liberalization, subsidies, green and red boxes, issues for negotiations in future in WTO; CDMs and carbon trade.

Unit 3: Importance of foreign trade for developing economy; absolute and Comparative advantage, foreign trade of India. Cases on Agri business commoditytrade practices. Theories of international trade. Economic Integration and its impact on agricultural trade with reference to India.

Block II: Regulations and Policy Measures for International Trade

Unit 1: India's balance of payments; inter regional vs international trade; tariffs and trade control; exchange rate; the foreign trade multiplier.

India's export and import policies regarding agricultural products

Unit 2: Foreign demand, supply side analysis, opportunity cost, trade and factor prices, implications for developing countries, market entry methods, export procedures & documentations.

International commodity agreements and its impact on agricultural exports from India.

References

- Study materials by the Center for WTO Studies, ITPO, New Delhi, *The Future of Indian Agriculture.*
- BROUWER F AND JOSHI PK. 2016. *International Trade and Food Security*, LEI – Wageningen UR, The Netherlands.

ABM 510 FOOD TECHNOLOGY AND PROCESSING MANAGEMENT (3+0)

Objective

Food Technology is the application of food science to the selection, preservation, processing, packaging, distribution and use of safe, wholesome and nutritious food. The food processing industry covers a range of food products.

Theory

Block I: Food Technology

Unit 1: Food Industry in India: Present status of food industry in India; Organization in food industry; Introduction to operations of food industry; Deteriorative factors and hazards during processing, storage, handling and distribution.

Block II: Processing Management

Unit 1: Basics of Food Processing: Basic principles of food processing and food preservation through technology interventions; Application of energy, radiations, chemicals and other agents for food preservation; aseptic modes of processing freezing, quick, cryogenic, high pressure, membrane technology; Packaging of foods, labelling techniques, advanced technologies for packaging.

Unit 2: Food Safety and Costs Analysis: Analysis of costs; risk management; Laws and regulations w.r.t to food industry including production, processing and marketing; Food Safety and Quality Standards-AGMARK, BIS/ISO, FPO, FSSAI, TQM, HACCP etc.

Unit 3: Case studies on project formulation in various types of food industries: Discussion sessions and analysis of Case studies related

to dairy, cereal milling, sugarcane production; baking/confectionary, vegetable storage, handling, egg processing, fish and meat products; Cases related HACCP.

References

- ACHARYA SS AND AGGARWAL NL. 2004. *Agricultural Marketing in India*. Oxford & IBH.
- EARLY R. 1995. *Guide to Quality Management Systems for Food Industries*. Springer
- JELEN P. 1985. *Introduction to Food Processing*. Reston Publishing.
- POTLY VH AND MULKY MJ. 1993. *Food Processing*. Oxford & IBH
- FELLOWS PJ. 2016. *Food Processing Technology Principles and Practice,* Woodhead Publishing, 4th Edition
- POTTER NN. 2018. *Food science*. McGraw-Hill Education, 6th Edition
- SINGH RP, HELDMAN DR. 2013. *Introduction to Food Engineering.* Elsevier Inc., 5th Edition
- SMITH JS, HUI YH. 2013. *Food Processing: Principles and Applications*, Wiley

ABM 511 RURAL MARKETING (3+0)

Objective

To explore the possibilities and potential of the rural market. It aims at critically analysing the market opportunities, consumer trends and patterns and development of better marketing strategies for the rural areas.

Theory

Block I: Rural Marketing Environment

Unit 1: Rural Market Concept & Scope: Concept, Definition and Scope of rural marketing, nature and characteristics of rural markets, potential of rural markets in India, rural V/S urban market.

Unit 2: Environmental factors: Socio-cultural, economic, demographic, technological and other environmental factors affecting rural marketing.

Unit 3: Rural finance: Concept, demand, banking model; Finance Schemes of NABARD, Other Schemes of State Govt, Central Govt.

Unit 4: Rural consumer's behaviour: Behaviour of rural consumers and farmers; buyer characteristics and buying behaviour; customer relationship management, rural market research.

Block II: Rural Marketing Strategy

Unit 1: Rural Product strategy: Marketing of consumer durable and non-durable goods and services in the rural markets with special reference to product planning; marketing mix, product mix.

Unit 2: Pricing for rural markets: Pricing policy and pricing strategy, distribution strategy, Rural retailing and modern store formats in rural areas.

Unit 3: Promotion and communication strategy: Media Planning, Distribution channels, personal selling strategies in rural markets, innovations in rural marketing.

References

- KRISHNAMACHARYULU AND RAMAKRISHNAN. 2010. *Rural Marketing: Text and Cases*: Pearson Education. 2nd edition
- SINGH S. 2004. *Rural Marketing: Focus on Agricultural Inputs,* Vikas Publishing
- KASHYAP P. 2011. *Rural Marketing*. Pearson Education
- KUMAR D AND GUPTA P. 2017. *Rural Marketing: Challenges and Opportunities*. Sage Publications.

ABM 512 FERTILISER TECHNOLOGY AND MANAGEMENT (3+0)

Objective

Enhance the participants' analytical and trouble-shooting skills by generating awareness to identify and resolve operational inefficiencies, if any, of their facilities.

Theory

Block I: Fertilizer Production

Unit 1: Fertiliser development: Concept, scope, need, resource availability; import and export avenues for fertilizer; types of fertilizers, grading and chemical constituents, role of fertilisers in agricultural production, production and consumption of fertilizer in India

Unit 2: Raw material Supply; Principles of manufacturing- potassic fertilizers, secondary and micro-nutrient formulations

Unit 3: Production efficiency: Production efficiency and capacity utilization; quality control and legal aspects fertilizer control order

Block II: Testing and Field Trials

Unit 1: Testing facilities; constraints in fertiliser use; assessment of demand and supply of different fertilizers, fertilizer distribution, fertilizer storage.

Unit 2: Field trials and demonstrations; environmental pollution due to fertilizers.

References

- BRADY NC & WEIL RR. 2002. *The Nature and Properties of Soils*. 13th Ed. Pearson Edu.
- *Fertiliser Control Order* (different years). Fertilizer Association of India, New Delhi.
- *FERTILISER STATISTICS* (different years). Fertilizer Association of India, New Delhi

- *Indian Journal of Fertilizers* (different years). Fertilizer Association of India, New Delhi.
- SAN CHILLI V. 1960. *Chemistry and Technology of Fertilizers*. American Chemical Soc. Monograph Series. Reinhold Publ. Corp.
- TISDALE SL, NELSON WL, BEATON JD &HAVL IN JL. 2002. *Soil Fertility and Fertilizers*. 5th Ed. Prentice Hall

ABM 513 MANAGEMENT OF AGRO CHEMICAL INDUSTRY (3+0)

Objective

Plant protection chemicals have and will continue to play a crucial role in meetingthe food, feed and fibre needs of the mankind.

Theory

Block I: Agro Chemicals

Unit 1: Introduction: Agro-chemicals: Definition and classification; Basic knowledge of agro- chemicals; role and status of agro-chemical industry in India; Pesticides – Classification and Introduction, knowledge of different pesticides.

Unit 2: Insecticides: Insecticides – Definition and classification based on (a)Mode of Entry (b) Mode of Action and(c) Chemical Structure with example; Insecticidal formulation; preliminary knowledge of mode of action of insecticides; knowledge of plant protection equipments.

Unit 3: Fungicides: Fungicides – Classification and preliminary knowledge of commonly used fungicides; Biomagnifications of pesticides and pesticidal pollution.

Block II: Insecticide Act and Plant Protection

Unit 1: Insecticide Act: Introductory knowledge about development of agrochemicals; Insecticidal poisoning, symptoms and treatment; Main features of Insecticide Act.

Unit 2: Plant Protection: Directorate of Plant Protection, Quarantine and Storage–A brief account of its organizational set up and functions; IPM Concept – Bio pesticides– Plant products.

References

- DHALIWAL GS, SINGH R AND CHHILLAR BS. 2014. *Essentials of Agricultural Entomology*. KalyaniPublishers.
- HAYES WT AND LAWS ET. 1991. *Hand Book of Pesticides*. Academic Press.
- MATSUMURA F. 1985. *Toxicology of Insecticides*. 2nd Ed. Plenum Publ.
- RAJEEV K AND MUKHERJEE RC. 1996. *Role of Plant Quarantine in IPM*. Aditya Books.

ABM 514 SEED PRODUCTION TECHNOLOGY MANAGEMENT (3+0)

Objective

The course covers a wide range of seed science and technology issues related to production of high-quality seeds, processing, testing, certification, quality control, seed policies and regulations, variety release and registration, seed quality management in *seed* multiplication systems, seed storage, marketing.

Theory

Block I: Seed Technology

Unit 1: Seed Technology: Role of Seed Technology, its Course Objective and goal, Seed Industry in India, National Seed Corporation – Tarai Seed Development, Corporation, State Seed Corporations, National Seed Project and State Farms and their role.

Block 2: Seed Management

Unit 1: Development and Management of Seed Programmes: Seed Village Concept, Basic Strategy of Seed Production and Planning and Organization of Seed Programme; Types of Seed Programme–Nucleus seed, Breeders seed, Foundation seed and Certified seed etc.

Unit 2: Maintenance of genetic purity: Minimum seed certification standard and Management of breeders & Nucleus seed; Management of seed testing laboratory and research and development.

Unit 3: Management of seed processing plant seed storage management; seed packaging and handling.

Unit 4: Seed Marketing: GM Crop seed, IPR, PBR, Patents and related issues and their impact on developing countries; Statutory intervention in the seed industry; Seed legislation and seed law enforcement, Seed act; Orientation and visit to seed production farms, seed processing Units, NSC, RSSC, RSSCA and seed testing laboratories.

References

- AGRAWAL RL. 2017. *Seed Technology*. Oxford & IBH.
- DESAI BB, KATECHA PM AND SALUNKHE DK. 2009. *Seed Handbook: Biology, Production, Processing and Storage*. Marcel Dekker.
- KELLY A. 1988. *Seed Production of Agricultural Crops*. Longman.
- MCDONALD MB JR. AND COPELAND LO. 2012. *Seed Production: Principles and Practices*. Chapman & Hall.

ABM 515 TECHNOLOGY MANAGEMENT FOR LIVESTOCK PRODUCTS (3+0)

Objective

The main aim of this course is to disseminating knowledge about hygienic milk production, hygienic slaughter, utilization of slaughterhouse by-products, preparation of value-added meat products, preparing of value-added indigenous as well as milk products, and dressing of food animals.

Theory

Block I: Livestock Product and Technology

Unit 1: Present status of livestock products industry in India: Dairy, meat, skin and hides, wool, etc; SWOT analysis of livestock product industry, importance of value addition of livestock products, Concept of organic milk and meat. New techniques of biotechnology for improving food value.

Unit 2: Manufacturing technologies: Dairy-Manufacturing technologies of various dairy products and byproduct utilization. Meat-

Manufacturing technologies of meat and its products, industrial processing and utilization of wool and animal byproducts, value added egg product development.

Unit 3: Milk and meat processing plant: Layout and designing of milk and meat processing plant, abattoir design, sanitation and basic slaughterhouse practices, Plant Management- Production, planning and control, packaging, preservation and storage system for livestock products; transportation system for domestic markets and international markets.

Block II: TQM and Marketing of Livestock Products

Unit 1: Total quality management in processing Total quality management in processing of milk and its byproduct, meat and byproduct, value added egg duct and wool, Quality control measures during storage transit; extent of losses during storage and transport, management measures to minimize the loss.

Unit 2: Marketing livestock products Milk, meat, wool, fish etc and its byproduct, Marketing and distribution system of animal products; National and international specifications and quality standards for various products; environmental and legal issues involved.

References

- MANDAL PK AND BISWAS AK. 2014. *Animal Products Technology,* Studium Press India Pvt.Ltd.; 1st Edition
- BISHWAS AK AND MANDAL PK. 2014. *Textbook of Poultry, Egg and Fish Processing Technology,* Studium Press (India) Pvt. Ltd.

ABM 516 FRUIT PRODUCTION AND POST-HARVEST MANAGEMENT (3+0)

Objective

A dual purpose of preventing losses that occur due to harvest losses of fruits and vegetables vary from 25% to 40%, depending on the kind of produce and the pre and post-harvest practices they are put through.

Theory

Block I: Fruit Production

Unit 1: Introduction: Global and National Status of Horticultural production in India and emerging scenario

Unit 2: Management of horticultural crops: Establishing an orchard, basic cultural practices, regulation of flowering, fruiting and thinning, protection against insect pest,

weeds: Maturity indices, Harvesting and its relationship with quality, sorting and grading, pre-harvest crop management practices and their influence on quality during storage and marketing.

Block II: Post-Harvest Management

Unit 1: Post-harvest management in horticulture-procurement: Procurement management, important factors for marketing, standardization and quality control, packaging. Physiology of ripening and senescence. Storage system: on-farm storage evaporatively cooled stores, ventilated storage, pit storage etc. Refrigerated storage, refrigeration cycle, controlled/modified atmosphere, hypobaric storage.

Unit 2: Post harvest management in horticulture process: Application of growth regulators for quality assurance, post-harvest treatments: pre cooling, heat treatments (hot water, hot air and vapor heat), fungicides & biologically safe chemicals, irradiation, curing, pulsing *etc*. Packing line operations, packaging of horticultural produce. Transportation rail, road, sea, air. Codex norms for export of perishables. Development of fruit-based carbonated drinks, development of dehydrated products from some important fruits, storage of pulp in pouches, essential oils from fruit waste, dehydrated fruits. Market structure and export potential of fruits.

Unit 3: Marketing of fruits: Problems in marketing of fruits, and government policy; quality standards for domestic and international trade.

References

- RATHORE NS, MATHUR GK AND CHASTA SS. 2013. *Post-Harvest Management and Processing of Fruits and Vegetables*, ICAR.
- CHADHA KL AND PAREEK OP. 1993. *Advances in Horticulture*. Vols. I-IV. Malhotra Publ. House.
- KADER AA. 1992. *Post-harvest Technology of Horticultural Crops*. Univ. of California. Div. Of Agri. & Natural Resources.
- JACOB JP. 2012. Handbook on Post Harvest Management of Fruits and Vegetables, ASTRAL Publishing.
- NIIR Board of Consultants & Engineers. 2016. *The Complete Technology Book on Processing, Dehydration, Canning, Preservation of Fruits & Vegetables*, NIIRPROJECT CONSULTANCY SERVICES; 3rd Revised Edition.
- THOMPSON K. 2003. *Fruit and Vegetables: Harvesting, Handling and Storage*, Wiley-Blackwell; 2nd Edition

ABM 517 FARM POWER AND MACHINERY MANAGEMENT (2+0)

Objective

Agricultural machinery management is the section of farm management that deals with the optimization of the equipment phases of agricultural production. It is concerned with the efficient selection, operation, repair and maintenance, and replacement of machinery.

Theory

Block I : Farm Power and Machinery

Unit 1: Farm power and tractors: Farm power in India - sources, IC engines – working principles, two stoke and four stoke engines, IC engine terminology, different systems of IC engine. Tractors – types and utilities.

Unit 2: Tillage and Tillage machinery: Tillage – ploughing methods – primary tillage implements – mould board, disc plough and chisel

plough – secondary tillage implements –cultivators, harrows and rotovators – wetland equipment – puddlers, tramplers and cage wheels.

Unit 3: Sowing, Planting and Intercultural Equipment: Sowing methods – seed drills, seed cum fertilizer drills – Paddy transplanters – nursery requirements – implements for intercultural operations –wet land, dry land and garden land intercultural tools. **P**lant Protection Gadgets, Harvesting Machinery and Horticulture tools: Plant protection equipment, tools for horticultural crops.

Block II: Agricultural Equipments Industry and Cost Analysis of Operations

Unit 1: Agricultural equipments industry: Agricultural equipments production, marketing and constraints; establishment of agricultural engineering enterprises (agro service centers, etc.). Equipment for land development and farm machinery selection: Equipment for land development and soil conservation.

Unit 2: Cost analysis of operations: Cost analysis of operations using different implements, economic performance of machines, optimization of tractor implements system and transport of farm produce. Cost of operation of farm machinery – Tractor and implement selection.

References

- SENTHILKUMAR T, KAVITHA R AND DURAISAMY VM. 2015. *A text book of farm machinery*, Thannambikkai Publications, Coimbatore.
- JAGADISHWAR S. 2010. *Elements of agricultural engineering.* Standard Publishers Distributors, New Delhi.

ABM 518 FOOD RETAIL MANAGEMENT (2+0)

Objective

Identify the most dramatic change in food retailing today; Assess the variety and define a target market; Explain why a retailer would want to meet the needs ofa Customer. Describe the steps to recruiting top talent; Identify selection and training.

Theory

Block I: Introduction

Unit 1: Introduction to Food market: Introduction to International Food market, India's Competitive Position in World Food Trade, Foreign Investment in Global Food Industry, Retail management and Food Retailing, The Nature of Change in Retailing, Organized Retailing in India, E-tailing and Understanding food preference of Indian Consumer, Food consumption and Expenditure pattern, Demographic and Psychographic factors affecting Food Pattern of Indian Consumer.

Unit 2: Value Chain in Food Retailing: **V**alue chain and value additions across the chain in food retail, Principal trends in food wholesaling and retailing, Competition and pricing in food retailing, various retailing formats, the changing nature of food stores, market implications of new retail developments, food service marketing.

Block II: Retail Marketing Strategy

Unit 1: Marketing Mix in Food Retail Management: Merchandise Management, Pricing Strategies used in conventional and non-conventional food retailing, Public distribution system, Promotion mix for food retailing, Management of sales promotion and Publicity, Advertisement Strategies for food retailers & Brand Management in Retailing.

Unit 2: Managing Retail Operations: Managing Retailers' Finances, Merchandise buying and handling, Logistics, procurement of Food products and Handling, Transportation of Food Products.

Unit 3: Retail Sales Management: Types of Retail Selling, Salesperson selection, Salesperson training, Evaluation and Monitoring, Customer Relationship Management, Managing Human Resources in retailing, Legal and Ethical issues in Retailing.

References

- Singh S. 2011. *Fresh food retails in India: Organisation and impacts,* Allied publishers Pvt. Ltd., New Delhi
- Mahapatra. S, *Food Retail Management*, Kalyani Publishers
- Zentes, Joachim, Morschett, Dirk, Schramm-Klein, Hanna 2017. *Strategic Retail Management: Text and International Cases,* Springer Gabler.
- Agrawal N and Smith SA. 2015. *Retail Supply chain Management: Quantitative Models and Empirical Studies,* Springer; 2nd revised edition.

ABM 519 MANAGEMENT OF AGRICULTURAL INPUT MARKETING (2+0)

Objective

The present course aims at familiarizing the participants with various aspects of agricultural input marketing in India.

Theory

Block I: Introduction

Unit 1: Market for agricultural inputs: Nature of demand, promotional media, nature of competition, a framework for understanding the markets for inputs, agronomic potential, agro economic potential, effective demand, actual consumption.

Block II: Marketing of Agricultural Inputs

Unit 1: Marketing of seeds: Government policy, product, trade practices in seed production, seed pricing, input costs, distribution system, management of seed distribution. proper storage of seeds, promotion, problems faced by seed industry, strategy for a seed enterprise, source of seeds, terms of transaction for seed procurements.

Unit 2: Marketing of fertilizers: Nature of Indian fertilizer market, product, fertilizer distribution, marketing cost and margins, credit, dealer selection and management, fertilizer promotion and extension, promotional program, advertising in fertilizers, emerging marketing mix in fertilizer, extension strategy for the future, marketing of bio fertilizers, strategies for fertilizer marketing.

Unit 3: Marketing of pesticides: Market profile, structure of industry, farmer behaviour, problems of farmers in pesticide purchase and usage, marketing mix, bio pesticides market development and promotion activities, problems in marketing of bio pesticides. Integrated pest management.

Unit 4: Marketing of tractors: Segments in tractor market, market share, nature of demand, buyer behaviour, role of distribution, promotion, MNC's. Marketing of credit-Nature of market, market segment, market players, marketing mix, marketing options. Strategies for input marketing-Client and location specific promotion, joint promotion, interdependence of input markets, management of demands, developmental marketing, USP, extension services, ethics in business, sustainability.

References

- MAHAPATRA. S. *Management of Agricultural Inputs*, NIPA Publishers
- SEETHARAMAN SP.: *Agricultural Input Marketing,* Oxford & IBH Pub. Co.
- KRISHNAMACHARYULU CSG. :*Rural Marketing: Text and Cases*, Pearson Education India
- VENUGOPAL P. 2014. *Agri-input Marketing in India,* SAGE Publication; 1st Edition.

ABM 520 FEED BUSINESS MANAGEMENT (2+0)

Objective

The present course aims at familiarizing the participants with various aspects feed for livestock and poultry.

Theory

Block I: Introduction

Unit 1: Feed resources: Gap between demand and availability of nutrients; status of feed industry in India and world, constraints in the development of Indian feed industry.

Unit 2: Nutrients requirements of livestock and poultry: Knowledge about the quality of feed ingredients used in feed manufacturing. Procurement procedure of feed ingredients, scientific storage of feeds and feed ingredients. BIS, CLAFMA and all other commercial standards of all class of livestock and poultry feeds.

Block II: Feed Preparation and Distribution

Unit 1: Feed preparation: Layout and design of feed plants, feed plant management; Basic principles of processing of feeds, Feed preparation for cattle and poultry and as specialty feeds for aqua and pet animals.

Unit 2: Importance of mineral mixture: Feed additives, supplements and pass feed, to know the new technology regarding improving the feeding value of poor quality roughages. To acquaint the concept of silage technology, complete feed block technology, hydroponics technology and UMMB technology.

Unit 3: Feed Distribution: Distribution channels, regulations relating to manufacture and sale of feed stuffs.

References

- MORRISON FB. 1961. *Feeds and Feeding*, Abridged, Morrison Publishing; 9th edition John.
- MORAN. 2005. Tropical Dairy Farming: Feeding Management for Small Holder Dairy Farmersin the Humid Tropics, Csiro Publishing.
- MORAN J AND MCDONALD S. 2010. *Feedpads for Grazing Dairy Cows,* Csiro Publishing.
- KELLEMS RO AND CHURCH DC. 2009. *Livestock Feeds and Feeding*, Pearson; 6th Edition

ABM 521 MANAGEMENT OF VETERINARY HOSPITALS (2+0)

Objective

It will help in gaining a deeper understanding of the Veterinary Science is the science of treating and curing the diverse types of Animals.

Theory

Block I: Veterinary Hospital Administration

Unit 1: Needs, aims and objectives: Objectives of Veterinary hospitals; the existing and simulated situations under which veterinary hospitals work or are to work.

Unit 2: Designing and planning an ideal hospital: Optimizing the use of resources - human, space, equipment, drugs, time, capital, etc.; Materials management and problems Normal purchase procedure. Receipt; storage and distribution of materials, Cost reduction & scientific inventory control. Information system and materials management performance. Equipment maintenance, condemnation & disposal.

Unit 3: Authority, responsibility: Accountability of management for optimizing the use of skill, developing and upgrading skills and technology; efficient system of record keeping and accounting; Concept of quality & Total quality management (TQM) Introduction to Veterinary audit, Statistical quality control (SQC), Quality control Circle (QCC).

Block II: Information System & Quality Control

Unit 1: Hospital information system: Hospital information system as an aid to efficient controlling and monitoring; need for financial resources - investment and working capital; Records: Types & Methodology, Reports and Reporting system.

Contemporary and need-based methods of accounting; General consideration. Need based information system. Applicability in surveillance & monitoring; planning & policy making; cost control.

Unit 2: Quality control system: Economic functions and quality control system; Animal health Economics: An introduction Need for

financial resources (type and need). Investment planning and working capital; Budgeting and cost cutting (cost control). legal aspects in the functioning of the hospital.

References

- JOHN MCCARTHY, Basic Guide to Veterinary Hospital Management. Published by Amer Animal Hospital Assn
- IGNACIO MERIDA ISLA, 2022, Veterinary Practice Management, 2nd edition, SERVET Publications.

ABM 522 POULTRY AND HATCHERY MANAGEMENT (2+0)

Objective

To give the opportunity for trainees to learn about raising chickens for their meat and eggs in order to manage a small-scale, commercial poultry enterprise that will be profitable

Theory

Block I: Introduction to Poultry and Hatchery Industry

Unit 1: Poultry and hatchery Business: Poultry and hatchery industry; Present scenario of Poultry industry, Integration in poultry farming, Scope and future perspective, role of management in poultry industry.

Unit 2: Poultry and hatchery unit: Planning and establishing a poultry and hatchery unit- location, size and construction; farm and hatchery equipments and physical facilities; organizing and managing a poultry farm and hatchery.

Block II: Hatcheries and Risk Management

Unit 1: Incubation and hatching Production of quality chicks and eggs; factors affecting hatchability; bio-security and hatchery sanitation; handling of hatching eggs; maintaining chick quality-chick grading, sexing, packing, dispatch, transportation and chick delivery.

Unit 2: Franchise hatcheries management: Custom hatching; brooding; growing and laying management; crisis management;

industrial breeding, feeding, housing and disease management; waste management; Record management; cost accounting and budgetary control.

Unit 3: Personal management and insurance: Labour relations including wages and salaries, job evaluation and employee appraisal; marketing management direct sale and sale through franchisees/ agents, advertisement, sale and after sale services, other innovative sales strategies.

References

- Handbook of Poultry Science.
- RATHINAM GK. 2015. *Manual of Hatchery Management: For Poultry Professionals* Hardcover.

ABM 523 MANAGEMENT OF FLORICULTURE AND LANDSCAPING (2+0)

Objective

The objective of this course is to expose the students with floriculture and land scaping technologies and their Agri-business implications including international trade.

Theory

Block I: Management of floriculture

Unit 1: Introduction: Introduction, importance and scope of floriculture industry and landscaping; Recent advances in floriculture industry.

Unit 2: Indoor and ornamental plants: Raising of foliage plants in pots, production technology of ornamental plants, commercial cultivation of flower crops (rose, jasmine gladiolus, tuberose, marigold, aster, carnation, gerbera, cilium chrysanthemum; special techniques for forcing of flowers for export.

Block II: Landscaping and Trading

Unit 1: Introduction: Drying and dehydration of flowers; bonsai; scope of landscaping, response of flowering plants to environmental stresses;

Unit 2: Landscape gardening: Styles of gardening; modern and traditional garden planning; Socio-aesthetic planning; use of computers in designing gardens; planning towns

Unit 3: Value Addition in floriculture: Extraction, purification and storage of essential oils and perfumes; post-harvest storage changes; packing techniques of produce harvesting of flowers for export and home use, Export-Import trade in flowers and their specifications along major trading countries.

References

- BANKER N. 2011. *Landscape gardening*, IBDC publishers, Lucknow
- MISRA RL AND MISRA S. 2012. *Landscape gardening*, Westville Publishing House, New Delhi
- CHADHA KL AND CHOUDHARY B. 2006, *Ornamental Horticulture in India*. ICAR. New Delhi
- GRINDAL EW. *Every Day Gardening in India*. DB Tarporevala Sons.
- RANDHAWA GS AND MUKHOPADHYAY A. 1998, *Floriculture in India*. Allied Publ., New Delhi

ABM 524 RISK MANAGEMENT IN AGRI BUSINESS (2+0)

Objective

Identification, mitigation and management of risk is unique to agriculture production, markets, finance, Institutions and HR. Policy implications at local, regional, national as well as international level. Data analysis and research findings to help in decision making at firm

and industry levels using history to guide future events/projection, Degree of risk varies in agri-business compared to other sectors.

Theory

Block I: Risk Management Process

Unit 1. Financial Intermediation, Indian Financial system, Origin and Growth of Banking. RBI and its functions. Principles of Banking, Banking Law and Practice. Nationalization of Banks in India, Deposit Products, Lending Activities, Retail Banking, Wealth Management, Financing SMEs, Corporate Banking, Forex Management, Fee-Based & Subsidiary Services, Plastic Money, Role of Central Banks, Emerging Trends in Banking, Fundamentals of International Banking.

Unit 2: Strategic Issues in Bank Marketing, Positioning Bank Services in the Market, New Product Development, Pricing and Launching, New Distribution Channels for Bank Marketing, Communicating and Promoting Bank Services, Improving Quality and Productivity, Customer Relationship Management in Banks, Globalizing Bank Services, Opportunities and Challenges in Bank Marketing.

Unit 3: Credit Policy in Banks, Principles of Credit Management, Objectives of Credit Management, Credit Disbursal and Monitoring, Credit Deployment and Types of Borrowers, Follow up and Recovery Management, Treasury Operations, Introduction to Risk Management in Banks, Rural Banking in India, Security Considerations, Control System in Banks, Corporate Governance in Banks, Annual Reports and Statutory Audit.

Block II: Risk Management and Strategies

Unit 1: Introduction to Risk, Risk Management Essentials, Measurement of Risk, Loss Exposure, Risk Management – Non-insurance Techniques, Introduction to Insurance, Principles of Insurance, Insurance Industry, Insurance Market, Insurance as Risk Management Techniques, Selection and Implementation of Risk Management Techniques.

Unit 2: Risk in Agriculture: Production, Marketing, Financial, Legal and Human resources Risk.

Unit 3: Strategies for Managing Risk in Agriculture: Diversification, Vertical integration, contract farming, Hedging through futures and Option contracts and various-Crop insurance, liability insurance, life insurance, health insurance and social insurance.

References

- SETHI J AND BHATIA N. 2012. *Elements of Banking and Insurance*. PHI Learning
- JIAN W AND REHMAN A. 2016. *Risk Management in Agriculture: Theories and Methods*. Science Publishing group
- HARDAKER JB, HUIRNE RBM, ANDERSON JR AND LIEN G. 2004. *Coping With Risk in Agriculture,* CABI Publishing, 2nd Edition
- ROSE PS AND HUDGINS SC. 2006. *Bank Management & Financial Services.* Mcgraw-Hill College; 7th edition

ABM 525 MANAGEMENT OF AGRIBUSINESS COOPERATIVES (2+0)

Objective

These cooperatives were usually initiated by small scale farmers, as a response to their weak position in the market. By joining forces they could improve this position and obtain better prices and services for the purchase of inputs and the marketing of produce.

Theory

Block I: Introduction

Unit 1: Cooperative administration: Global perspective, ecology of cooperative administration, cooperative sector and economic development.

Unit 2: Cooperative management: Nature, functions and purpose of cooperatives –procurement, storage, processing, marketing, process of cooperative formation, role of leadership in cooperative management.

Block II: Cooperative Movement and Management

Unit 1: Cooperative Movement: The state and cooperative movement, effects of cooperative law in management, long range planning for cooperative expansion, policy making.

Unit 2: Human resource management: Placement and role of board of directors in cooperative management.

Unit 3: Overview of agribusiness cooperative: Credit cooperatives, cooperative marketing, dairy cooperative; financing agribusiness cooperative.

References

- KAMAT GS. 2011. *New Dimensions of Cooperative Management*. Himalaya Publ. House.
- ANSARI AA. 1990. *Cooperative Management Patterns*. Anmol Publ.
- RAVICHANDRAN AND NAKKIRAN. 2009. *Cooperation* (*Theory & Practice*) Neha Publishers &Distributors;
- SAH AK. 1984. *Professional Management for the Cooperatives*. Vikas Publ. House.
- ANWAR SA. *HRM Practise in Cooperative Sector*. Idea Publishing.

ABM 526 BUSINESS ANALYTICS FOR AGRICULTURE (1+1)

Objective

To make the students understand the concepts of data science tools and techniques and develop the skills for using it strategically and for the developing of the agribusiness sector.

Theory

Block I: Introduction

Unit 1: Introduction to data science, evolution of data science, work profile of a data scientist, career in data science, nature of data science, typical working day of a data scientist, importance of data science in

agribusiness; defining algorithm, big data, business analytics, statistical learning, defining machine learning, defining artificial intelligence, data mining; difference between analysis and analytics, business intelligence and business analytics, typical process of business analytics cycle.

Unit 2: Fundamental of Research

Fundamentals of R and R Studio, fundamentals of packages of R Studio, data manipulations, data transformations, normalization, standardization, missing values imputation, dummy variables, data visualization (2D and 3D), basic architecture of machine learning analytical cycle, descriptive analytics-case study covering data manipulation, measures of central tendency, measures of dispersion, measures of distribution, measures of associations, t-test, f-test, ANOVA, Chi-square test, basic statistical modeling framework.

Block II: Machine Learning and Deep Learning

Unit 1: Supervised machine learning: Basic framework, regression models and classification models. Linear regression, nonlinear regression, multiple regression, polynomial regression, lasso regression, ridge regression, stepwise regression, quantile regression, logistic regression.

Unit 2: Unsupervised machine learning: Linear discriminant analysis, principal component analysis, factor analysis, support vector machines, naïve Bayes, nearest neighbors, decision trees, random forest, ensemble methods, *k*-fold cross validation, X gradient boosting. Unsupervised machine learning—basic framework, concept of clustering, k-means, c-means, hierarchical clustering, hidden markov models, forecasting models (AR, MA, ARMA and ARIMA).

Unit 3: Deep learning: Basic framework of neural nets, types of neural nets, computer vision, object detection and localization, gradient descent optimization for loss function, regularization L1 and L2, feed forward neural nets, back propagation, recurrent neural nets, convolutional neural nets, reinforcement neural net, concurrent net, introduction to IoT. All the illustrations used in the syllabus of Data Science in Agribusiness will be primarily from agribusiness domains and RStudio will be used for practical purposes.

Practical

Data types: Character, String, Numeric,; For loops, while loops; Descriptive Statistics: Mean, Mode, Median, Mean Deviation, Standard deviation, Skewness, Kurtosis, Coefficient of Variation; Tests of Significance: Parametric and non-parametric tests, ANOVA, Correlation, Regression, Panel data regression, Logistic Regression, Discriminant Analysis, MANOVA, Factor analysis, Cluster analysis, Conjoint analysis; Machine Learning Algorithms: Decision tree, random forest, SVM, KNN, K-means, Gradient Boosting algorithms; Deep Leaning: Artificial Neural Network, Convolutional Neural Network, Recurrent Neural Networks.

References

- *Deep Learning with R*. MEAP Edition, Manning Early Access Program. Version 1, © 2017,Manning Publication.
- JAMES RG, WITTEN D, HASTIE T AND TIBSHIRANI R. 2017. *An Introduction to Statistical Learning with Application.* Springer Publication
- MILLSTEIN F. 2018. *Machine Learning With Tens or flow: A Deeper Look At Machine Learning With Tensor Flow* Frank Millstein
- STANTON J. 2012. *Introduction to Data Science.* Version 3, SAGE Publications, Inc.

ABM 527 DAIRY BUSINESS MANAGEMENT (1+0)

Objective

To emphasize on the application of Principles of Management in dairy business with special emphasis on co-operative dairy units. The emphasis shall be on main functional areas like Finance, Marketing, Human Resources, Production and Information Technology.

Theory

Block I: Introduction

Unit 1: Dairy Development in India: Dairy organizations: functioning, Challenges and Opportunities, Anand pattern dairy Cooperatives: features and impact; Public sector dairy schemes, Dairy

Development schemes, Dairy problems and policies, National Dairy Plan-I, Rise of Producer Companies. Policy Frameworks in context to dairying.

Unit 2: Dairy Plant Management System: Production Planning and control in dairy plants, milk procurement from the rural milk producer, milk processing and products manufacturing. Pricing and marketing of milk and milk products. Survey on milk production potential and marketed surplus of milk for setting up of milk plants, energy utilization, Conventional and nonconventional sources of energy used in dairy sector. Concept of Quality; TQM concept and Kaizen in Dairy Industry, new concepts in quality assurance (HACCP; ISO certification); patent laws, pollution control laws in relation to dairy plants. Guidelines for obtaining ISO/HACCP certification for dairy plants. SQC in dairy operations.

Block II: Dairy Business Strategy:

Unit 1: Marketing Management, Supply Chain and International Trade in Dairy sector: Marketing- mix in relation to dairy sector, marketing environment. Marketing Opportunities Analysis in Milk and Milk Products: Demand status of Milk and milk products in the country, growth rates, Marketing research and marketing information systems; Market measurement present and future demand; Market forecasting. Market segmentation, Product-mix; Promotion mix decisions.

Advertising; Sales Promotion. Food and Dairy Products Marketing, Consumer Buying Behaviour; New product development process Price determination and pricing

Policy International Marketing; Composition & direction of Indian Exports. Exports- Direct exports, indirect exports; WTO and its Implications; SPS/ TBT; Supply chain Management in Dairy sector Logistics Management: Primary and Secondary Markets; Distribution channels; chilling points

Unit 2: Strategic, HR Management and Entrepreneurship in Dairy Sector: PESTLE analysis, BCG matrix, Strategic Management in dairy industry, Governance Structure in Dairy Sector, Management control

System. Organisational Performance parameters – Quantitative and Financial, Use of Balanced Score card and other strategy control tools. HR management practices in dairy sector, Promotions, transfers employee remuneration and other HR benefits and problems. Motivation, turnover, employee capacity building, Training and orientation etc. social and business economics; industrial relations and human values; labour laws; trade unionism Business Plan Preparation; TIDP plant setting; Compliances Systems in Dairy Industry

Unit 3: Financial Management and Financial Analysis in dairy sector: Nature and uses of financial analysis, Liquidity ratios, Leverage ratios, Activity ratios, Profitability ratios, Utility of Ratio analysis. Sources of long term capital in dairy Industry: Grants from NDDB, Grants from NABARD, Government and Other Schemes, cost of debt, debentures, preference share capital, equity share capital & retained earnings, overall cost of capital. Capital budgeting in dairy Industry.

Various techniques: NPV, IRR, etc. Financial Planning and control in dairy Industry: Budgeting process, Problems and practices in Budgeting and evaluation. Cost Volume – Profit analysis and operating leverage, Break-even analysis, Profit analysis and operating analysis, Utility of CVP analysis. Costing in Dairy sector: Costing Techniques and Costing of various dairy products – Milk costing based on Fat and SNF, Ice cream, milk, Paneer, etc. Essentials of sound costing system. Different methods of costing, elements of cost: Labour- recording of time, idle time, methods of remunerating labour, Premium & Bonus Plans, Materials, Overheads.

References

- ACHARYA R M AND KUMAR P. *Dairy Production & Business Management* EIRI, Dairy Darming
- RAO VENKATESWARA, *Dairy Farm Business Management*
- SINGH UMASHANKAR, *Dairy Farming*

ABM 528 AGRI EXTENSION MANAGEMENT (1+0)

Objective

To equip the extension functionaries in latest tools and techniques for participatory decision making and to develop an insight into various extension models to enrichthe agri– value chain.

Theory

Block I: Introduction

Unit 1: Approaches of Agricultural Extension: A critical analysis of different approaches of agricultural extension. Importance and relevance of indigenous knowledge system, identification and documentation of ITK, Integration of ITK system in research formulation, Concept of Agricultural Knowledge and Information System, Training of Stakeholders of AKIS.

Unit 2: Cyber Extension: Concept of cyber extension, national and international cases of extension projects using ICT and their impact of agricultural extension, alternative methods of financing agricultural extension - Scope, limitations and experience and cases. Research - Extension -Farmer - Market linkage: Importance, Scope, Implications etc., Market – Led Extension, Farmer - Led Extension, Concept of Farm Field School, Farm School, Public - Private Partnership: Meaning, Models, Identification of various areas for partnership. Stakeholder's analysis in Extension. Main streaming gender in Extension - Issues and Prospects

Block II: Implications and Contemporary Issues

Unit 1: Implications of WTO: OA for extension services, re-orientation of extension services for agri-business and marketing activities, GOI- NGO collaboration to improve efficiency of extension.

Unit 2: Extension and contemporary issues: Extension and issues related to rural poverty. Privatization of Extension. Intellectual Property Rights (IPRs). Extension Reforms in India –Decentralized decision making, Bottom up planning, Farming

System and Situation based Extension Delivery System, Extension delivery through Commodity Interest Groups. Organization innovations in Extension - ATIC, IVLP, Kisan Call Centres.

References

- BAGCHI J. 2007. *Agriculture and WTO Opportunity for India*.
- SANSKRUTI CHAMBERS R, PACY A AND THRUPP LA. 1989. *Farmers First*. Intermediate Technology Publ.
- CROUCH BR AND CHAMALA S. 1981. *Extension Education and Rural Development*. Macmillan.
- JOHN KC, SHARMA DK, RAJAN CS AND SINGH C. 1997. *Farmers Participation in Agricultural Research and Extension Systems*. MANAGE, Concept Publ. Co.
- KHAN PM. 2002. *Text Book of Extension Education*. Himanshu Publ.
- NARASAIAH ML. 2005. *Agricultural Development and World Trade Organization*. Discovery Publ.
- TALWAR S. 2007. *WTO Intellectual Property Rights*. Serials Publ.
- VAN DEN BAN BW AND HAWKINS BS. 1998. *Agricultural Extension*. S.K. Jain Publ.
- VENKAIAH S. 2001. *New Dimensions of Extension Education*. Anmol Publ.

ABM 529 RENEWABLE ENERGY SOURCES MANAGEMENT (1+0)

Objective

The course aims to provide fundamental clarity regarding various Renewable & alternative energy sources/ technologies options available today, its usage potential & related aspects like cost, impact on environment, etc.

Theory

Block I: Introduction

Unit 1: Introduction: Concept on alternate and non-conventional energy sources. Bio fuels, Geothermal, Ocean, Hydropower, Biogas, Solar and Wind energy.

Unit 2: Commercial application: Commercial application of renewable energy sources and its benefits. Government Policy towards promoting renewable energy.

Block II: Institutional Framework and Types

Unit 1: Institutional Framework: MNRE, CREDA-Renewable Energy Development Authority, State level Renewable Energy Development Agency, Society of Renewable Energy.

Unit 2: Devices for renewable energy development: Biogas plant, Wind Mills, Solar Cells – Solar Pumps, Solar Dryers, Solar water heating system, etc.

References

- SORENSEN B. 2010. *Renewable Energy: Physics, Engineering, Environmental Impacts, Economics and Planning*, Elsevier Publishing; 4th Edition
- ARMAROLI N, BALZANI V AND SERPONE N. 2013. *Powering Planet Earth–Energy Solutions forthe Future*, Wiley
- BOYLE G. 2012. *Renewable Energy: Power for a Sustainable Future*, Oxford; 3rd Edition
- TWIDELL J, WEIR T. 2013. *Renewable Energy Resources,* CRC Press; 3rd Edition
- AHMED AI. *Renewable Energy Sources* by Jain Brothers

ABM 530 QUALITY MANAGEMENT FOR AGRIBUSINESS (0+1)

Objective

The course will help the students to have an understanding of the quality standards in agri business.

Practical

Basic concepts of quality management: importance of quality and the role of quality assurance in agribusiness.

Total Quality Management: TQM and business strategy. Quality control process and its relevance.

Quality grades and standards: Overview and relevance, benefits to consumers, producers and food processors, food grades and standards for various food commodities; cereals, fruits and vegetables, meats, poultry products.

Statistical to quality control: Statistics relevant to quality control, quality control charts used in the food industry, process control to assure food quality, food processing.

Food quality standards: Food quality standards and world food trade. HACCP, ISO9000, auditing and certification.

References

- LUNING PA, MARCELIS WJ. 2009. *Food Quality Management: Technological and Managerial Principles and Practices*. Wageningen Academic Publishers.
- DALE BG. 2004. *Managing Quality*. Blackwell Resources.

ABM 531 ADVERTISING AND BRAND MANAGEMENT (1+0)

Objective

It aims to ensure consistency of message and the complementary use of media, measurable, persuasive brand communication programs with consumers.

Theory

Block I: Introduction

Unit 1: Introduction to Advertising Management: Integrated Marketing Communications, Setting Goals and Objectives. How advertising works: Segmentation and Positioning Assess the strengths,

weaknesses, opportunities and threats (SWOT) of different kinds of promotional campaigns

Unit 2: Message Strategy: Attention and comprehension, Advertising appeals, Associating Feelings with the Brand, Brand Equity, Image and Personality and Group Influence and word of mouth advertising, Media Planning and Media Strategy, Media Strategy and Tactics, Legal, Ethical and Social concerns of Advertising.

Unit 3: Consumer Promotions and Trade Promotions: Their purpose and types. How to plan and evaluate a successful promotion, The relationship between advertising and promotions, Introduction to Global Marketing, Advertising and sales promotion.

Block II: Branding Decision

Unit 1: Major Brand Concepts and branding Decision: Identifying and selecting brand name Building brand personality, image and identity; Brand positioning and re-launch; Brand extension; Brand portfolio; communication for branding Enhancing brand image through sponsorship and even management.

Unit 2: Managing Brand Equity and Loyalty: Brand Building in Different Sectors - Customers, industrial, retail and service brands. Building brands through Internet, social Media. Building Indian brands for global markets.

References

- KELLER KL. *Strategic Brand Management; Pearson education, New Delhi Verma, Harsha: Brand Management;* Excel Books; New Delhi
- KAPFERER JN. *Strategic Brand Management;* Kogan Page; New Delhi
- KUMAR S. RAMESH; *Marketing and Branding–The Indian Scenario;* Pearson Education; NewDelhi Kapoor, Jagdeep; *24 Brand Mantras*, Sage Publications; New Delhi
- SENGUPTA S. *Brand Positioning: Strategies for competitive advantage*; Tata McGraw Hill; New Delhi.

• CLIFTON R AND SIMMONS J. *Brands and Branding*; The Economist; Delhi

ABM 532 INFRASTRUCTURE AND WAREHOUSING MANAGEMENT (1+0)

Objective

The course provides an introduction to the key principles and activities related to the warehousing function in a modern organization designed for receiving, shipping, picking, packing etc. It also includes cold chain project, logistics awareness &training programs.

Theory

Block I: Introduction

Unit 1: Agricultural Infrastructure in India: Incentive schemes, Agri-infra fund, Agri-market Infrastructure, Agri-technological infrastructure fund, Central Government policy on Infrastructure promotion for the development of primary sector such as Irrigation, Watershed development, Rural electrification, Connectivity, Communication and Markets in coordination with the Institutional framework.

Unit 2: Warehouse Functions: Meaning of Warehousing - Importance –Functions: Receiving: Logistics support for Inward Transportation, Unloading, Inspection, Acceptance and Recording; Storing: Space allocation, Facilitation to stocking, Guarding &Recording; Risk bearing- Processing- Grading and branding – Disinfecting services -Issuing: Order preparation, Picking, Dispatching/ Delivery & Recording- Handling, Transportation & Storage of ISO Containers– Utility and Advantages of warehouses- Problems and issues in receiving processes.

Unit 3: Warehouse Types, Characteristics: Warehouse Types, Characteristics of ideal warehouses- Warehouse Layout-Principles and Facilities- Types, Internal Operations: Measures and metrics of warehouse operations, Logistics in the warehouse- Localization of materials in a warehouse, Identification and classification of Materials and products

in the warehouse, Managing the material/products turns in warehouse (FIFO/LIFO) - Problems and issues in shipment processes. Warehousing Equipment, Inventory management.

Block II: Warehouse Management

Unit 1: IT for Warehouse Management (WM): Warehouse documentation- Information flows in the warehouse- ERP-WMS - Bar code – RFID- Organization Data- Warehouse Structure- Warehouse Master Data - WM Material master view- Organization Data- Define Warehouse structure, Warehouse number – Storage type- Storage section - Storage Bin - Picking Area -Storage unit – Quantity- Creating Transfer requirement automatically/ manually – Creating Transfer requirement for storage.

Unit 2: Agri-warehousing Management in India: Agri-warehousing in India, capacity development and utilisation, Role and significance of Central Warehousing Corporation, State warehousing Corporation, Private sector in Agri-warehousing. Status of Warehousing Industry: Agri-warehousing organisations in India, e-NAM to promote agri-warehouse.

References

- Study materials of NABARD as well as by the Ministry of Rural development
- EDWARD F. 2001. *World-Class Warehousing and Material Handling,* Mc Grraw Hill
- JEROEN P. VAN DEN BERG. 2009. *Integral Warehouse Management*, Management Outlook Max Muller. 2009. *Essentials of Inventory Management*. AMACOM
- STEVEN M. BRAGG. 2011. *Inventory Best Practices*. Wiley

ABM 533 CONTRACT FARMING (1+0)

Objective

The course provides an agreement between a farmer and a buyer. At the same time, the buyer also needs to provide the farmer with the

necessary inputs required for the farm like land preparation, technical aspects etc. It is an effective means to develop markets and bring about crop rotation.

Theory

Block I: Introduction

Unit 1: Need for contract farming: objectives and its definition; contract farming framework, contract farming arrangement-centralized model, nucleus estate model, multipartite model, informal model, intermediary model.

Unit 2: Project formulation and management: Planning, Coordination, and resource management for crop & livestock contract farming. Advantages of contract farming for farmers and sponsors and the problems faced by them.

Block II: Policies, Prospects and Global Issues

Unit 1: Policies for promoting contract farming: Agreement for contract farming parties, duration, produce and quality specification, delivery arrangements, pricing, insurance, support services, etc. Legal aspects of contract farming.

Unit 2: Prospects of contract farming in India: Prospects of contract farming in India in view of interest for commercialization of agriculture. Progress of contract farming in India. Active organizations in contract farming and their success stories.

References

- SHARMA P. 2007, C*ontract Farming*, Genetech Books.
- KUZILWA JA, FOLD A, HENNINGSEN A AND LARSEN MN. *Contract farming and the development of smallholder* agricultural business. Routledge.
- KUMARAVEL KS 2006. *Contract farming in India* - An Introduction.

ABM 534 HUMAN RESOURCE COMPETENCE AND CAPACITY BUILDING SYSTEMS (1+0)

Objective

This course is designed to provide an in-depth understanding and enable the participants to manage capacity building processes and performance system for developing human resource.

Theory

Block I

Unit 1: Human Resource competence: Concept and rationale; processes, Organization and Management of competence and competency mapping.

Unit 2: Competency modelling and assessment: Approaches, tools and techniques, competency based human resource management applications.

Block II: Capacity Building

Unit 1: Competency based training and development: Training methods compared with objectives, learning process and facilities, Developing Group and the Climate: the social process – indicators of group development, the training climate, Trainers and Training Style: Post training support for improved performance at work.

Unit 2: Performance Management System: Establishing and operationalising performance management system; measuring performance- results and behaviour; conducting performance review discussions; harnessing performance management system for performance improvement.

Unit 3: Capacity building systems in agriculture and agri business: Capacity building of farmers and agri stakeholders through e-learning, knowledge management for agri business.

References

- KANDULA SR. 2013. *Competency Based Human Resource Management*. PHI

- NOE RA AND KODWANI AD. 2012. *Employee Training and Development*. McGraw Hill Education. Fifth Edition
- SAKS AM AND HACCOUN RR. 2013. *Managing Performance through Training and Development*. Cengage Learning. Sixth Edition

ABM 535 AGRI-COMMODITY MARKETS AND FUTURES TRADING (0+1)

Objective

To make the students understand the marketing procedure for commodity futures through commodity exchanges.

Practical

Introduction to commodity derivatives and price risk management in agricultural markets; organizational setup of exchanges and specifications of futures contracts in world's leading commodity exchanges.

Futures trading; hedging price risk using futures contracts; option transaction and forward transaction – concept and mechanism, price discovery mechanism and market efficiency. Clearing house and margin system; clearing, settlement and delivery of contracts. Market surveillance and risk control; trading in warehouse receipts (WRs): WRs and collateralized commodity financing.

Regulation of futures and trading practices in leading national and regional Exchanges in India.

Patterns of Trading & Settlement, Efficiency of Commodity Markets – Size of volumes of commodity market. Fundamental analysis of Commodity assets. Supply and demand relationship, trade cycle. Technical analysis using Moving averages, MACD, RSI, stochastic and time series analysis.

References

- HULL, JOHN C. 2017. *Fundamentals of futures and options markets*, Boston, Pearson publication.

• RAM PV AND BALA SD. 2016. *Strategic Financial Management*. Snow White Publ. 80.

ABM 539 COMMUNICATION FOR MANAGEMENT AND BUSINESS (3+0)

Objective

The course aims to make students proficient in written as well as in oral communication with focus on business related communication.

Theory

Block I: Introduction to Business Communication

Unit 1: Communication process, barriers to communication, methods of communication, effective communication, assertive communication, types of organisational communication. Listening skills, active listening, barriers to effective listening, Non Verbal Communication.

Block II: Reading and Writing Skills

Unit 1: Reading comprehension and techniques, rules of good writing, business letter writing, e-mail writing, crafting messages for electronic media, social media, business blogs, podcasts, employment messages.

Block III: Oral, Visual Communication and Technical Writing

Unit 1: Visual presentation, oral presentation skills, conducting business meetings, brainstorming sessions and presentations, public speaking skills, Communicating across cultures, Various forms of scientific writings, theses, technical papers, reviews, manuals, research work, various parts of thesis and research communication Title page, authorship, contents, preface, introduction, review of literature, material and methods, experimental results and discussion, Technical Writing Style and Editing, Writing Introductions & Conclusions, Editing and Proof reading, Writing a review article and book summary.

Block IV: Team and Interpersonal Communication

Unit 1: Developing interpersonal skills (transactional analysis), Business Etiquettes, essentials of business conversations. Business

meeting agenda and minutes, circulars and sales letters, notices, overview of business proposals.

Unit 2: Developing self-awareness (Johari Window), solving problems analytically and creatively, introduction to case method of learning, case reading, approaches and analysis.

References

- CARDON PW. 2015. *Business Communication, Developing leaders for a networked world* McGraw Hill Edication
- CHATURVEDI PD AND CHATURVEDI M. 2017. *Business Communication, Skills, Concepts, Cases and Applications*, Pearson India Education
- BOVEE CL, THILL JV AND CHATERJEE A. 2013. *Business Communication Today*, Pearson Education, Tenth Edition

ABM 540 RESEARCH METHODOLOGY FOR AGRI BUSINESS MANAGEMENT (2+1)

Objective

To develop an understanding of research methodology related to efficient agribusiness management

Theory

Block I: Overview of Research

Unit 1: Meaning, Course Objective, types, and process of research; research methodology in management- exploratory, descriptive, experimental, diagnostic, Problem formulation, setting of Course Objective, formulation of hypotheses, models, types of models, process of modeling.

Unit 2: Scales of measurement - nominal, ordinal, interval, ratio, Likert scale and other scales; Primary and secondary data, sources of data, Questionnaire Designing, instruments of data collection, data editing, classification, coding, validation, tabulation, presentation, analysis, development process of scale, identification of variables, variable measurement, variable standardization and dummy variables.

Block II: Use of Softwares for Statistical Analysis

Unit 1: introduction to multivariate statistical analysis techniques, Multivariate Line regression models, principal component analysis, linear discriminant analysis, factor analysis, evaluation matrices and model diagnostics for regression models.

Unit 2: Logistic regression, decision trees, cluster analysis, random forest, GARCH, CART models, support vector machines, Forecasting techniques (AR, MA, ARMA and ARIMA models)

Block III: Introduction to Data Science

Unit 1: Definition, scope and importance, machine learning, types of machine learning, linear and nonlinear models in machine learning, introduction to deep learning, basic differences in machine learning and deep learning, concept of cloud machine learning, Big data analysis.

Practical

Questionnaire Designing, Scales of measurement Preparation. Application of Logistic regression, decision trees, cluster analysis, factor analysis, random forest, GARCH, CART models, support vector machines. Application of Forecasting techniques - AR, MA, ARMA and ARIMA models. Principal Component Analysis. Understanding of Software's for Statistical Analysis.

References

- COOPER DR AND SCHINDLER PS. 2006. *Marketing Research Concepts and Cases*. TMH
- KUMAR R. 2014. *Research Methodology,* Sage publications, 4th Edition
- GLENN JC. 2010. *Hand book of Research Methods.* OXFORD.
- KOTHARI CR. 2018. *Research Methodology- Methods and Techniques*. New Age International Publishers; Fourth edition

ABM 541 COMPUTER APPLICATIONS FOR AGRI BUSINESS (2+1)

Objective

The course aims to instill the significance of computer applications in the organizations and handling recent trends in information technology and system for improved decision making.

Theory

Block I: Basics of Computers

Unit 1: Concept of Computers- Brief History of Computers, Generation and Its Evolution, Characteristics of Computers and their Applications; Classification of Computers, Input-Output Devices, Memory Types (Cache, RAM, ROM), Memory Units.

Unit-2: System Software and Application Software, Open source software, introduction to computer language- basics of C language, structure of C program, I/O statements, selection statements, iteration statements, Introduction to Operating Systems – Functions, Features and Types., MS Windows and LINUX. MS Office (MS Word, MS Power Point, MS Excel, MS-Access).

Block II: Business Value of Internet

Unit 1: The business value of internet, Intranet, extranet and Internet, Introduction to Web page design using HTML, Introduction to CSS. Introduction to Computer networks and its types, Network topologies, Communication media-wired media and wireless media. Security and ethical challenges: Computer crime – Hacking, cyber theft, unauthorized use at work. Piracy – software and intellectual property. Health and Social Issues, Ergonomics and cyber terrorism.

Block III: Management Information System

Unit 1: The concept of MIS–Definition, Pyramid Structure of MIS, prerequisites, advantages and challenges; Information Needs of organization, Organizational behaviour, MIS and Decision – Making. Types/Classification of Information System for organizations;

Unit 2: e-business/ e-commerce: e-business models, e-commerce processes, electronic Payment systems, e-commerce trends with special reference to agribusiness. Applications of MIS in the areas of Human Resource Management, Financial Management, Production/Operations Management, Materials Management, Marketing Management.

Practical

MS-office: MS Word-creating document, inserting tables, Mail merge, MS Power Point-creation of presentations slides and animations, MS Excel-basic inbuilt functions, MS-Access-create table, generate report and simple query. **HTML& CSS**- creation of static web pages with features like tables, lists, hyperlink among pages and images. **C** - Simple C programs using I/O statements, selection and iteration statements.

References

- LAUDON KC AND LAUDON JP. 2016. *Management Information Systems- Managing the digital Firm,* 14h Edition, Pearson India
- TURBAN, VOLONINO, WOODS. WALI OP. 2015. *Information Technology for Management, Advancing Sustainable, Profitable Business Growth*, Wiley
- JAISWAL M AND MITTAL M. 2005. Management Information System, Oxford.

ABM 542 PROJECT MANAGEMENT AND AGRIBUSINESS ENTREPRENEURSHIP (2+1)

Objective

This course aims at providing student an insight into the nature of small-scale industry. They will be exposed to various aspects of establishment and management of a small business unit.

Theory

Block I: Concept of Project Management

Unit 1: Concept, characteristics of projects, types of projects, project identification, and Project's life cycle. Project feasibility- market

feasibility, technical feasibility, financial feasibility, and economic feasibility, social cost-benefit analysis, project risk analysis.

Unit 2: Undiscounted measures of project worth – Accounting Rate of Return and Payback Period. Principle of time comparison, compounding, discounting. Discounted measures of project appraisal – Net Present Value (NPV) / Net Present Worth (NPW), Benefit-Cost Ratio (BCR) and Internal Rate of Return (IRR). Risk and uncertainty, cost overrun, sensitivity analysis and general kinds of sensitivity analyses. Project implementation; Network Methods: Meaning, Network Analysis, Critical Path Method (CPM), Programme Evaluation and Review Technique (PERT), Project scheduling and resource allocation, Project management information system.

Block II: Introduction to Agri Entrepreneurship

Unit 1: Concept of Agri Entrepreneurship: Objectives, Introduction to Agri Entrepreneurship, Entrepreneurial Development Models, Successful Models in Agri Entrepreneurship, Intrapreneur, Development of Women Entrepreneurship with reference to SHGs, Social Entrepreneurship.

Unit 2: Creativity, Innovation and Agri Entrepreneur: Inventions and Innovation, The Environment and Process of Creativity, Creativity and the Entrepreneur, Innovative Approaches to Agri Entrepreneurship, Business Incubation, Steps and Procedure to start a new business, Business Opportunities in Agriculture and Allied Sectors.

Block III: Support System for Agri Entrepreneurship

Unit 1: Sources of Financing, Structure and Government Policy Support: Estimating Financial Requirements, Preparation of Detail Project Report, Project Appraisal, Sources of Long-Term Financing, Working Capital Financing, Venture Capitalist, Finance from Banking Institutions, Industrial Policy Resolutions in India, Incentives and Subsidies, Schemes for Incentives, Government Organisations like SIDO, DIC, KVIC, NSIC, SIDBI, NABARD and their role, Sick Industries and their Up gradation policy measures.

Practical

Planning projects, feasibility studies, use of monitoring and evaluation techniques, network analysis and review of case studies.

References

- ARORA R AND SOOD SK. *Fundamentals of Entrepreneurship and Small Business Management.* Kalyani Publishers, Ludhiana.
- DESAI V. 2016. *Business Planning and Entrepreneurial Management*, Himalaya Publishing House, Mumbai.
- RAMACHANDARAN K. *Managing a New Business Successfully.* Global Business Press, New Delhi.
- SHUKLA MB. *Entrepreneurship and Small Business Management.* Kitab Mahal, New Delhi.
- DANDEKAR VM AND SHARMA VK. 2016. *Agri-Business and Entrepreneurship Development.* Manglam Publications, New Delhi.
- ZIMMERER TW, SCARBOROUGH NM. *Essentials of Entrepreneurship and small Business Management,* 5thEdition, PHI Learning Pvt Ltd
- PANIGRAHI SR AND SINGH B. 2017. *Agro Entrepreneurship.* Scientific Publishers(India)

ABM 543 AGRIBUSINESS ENVIRONMENT AND POLICY (2+0)

Objective

To expose the students to the environment in which the agri-business is conducted.

Theory

Block I: Agribusiness in India

Unit1: Agribusiness (AB) - Meaning, definition of Agribusiness by different authors, emergence of AB, need, importance, scope of AB, Dimensions of Agribusiness, Agribusiness - Farm supplies, agricultural services, economic services, Potential in Agribusiness education, career opportunities in AB.

Unit 2: Subsystems of Agribusiness system, linkages among sub-sectors of the Agribusiness.

Block II: Economic Reforms affecting Agribusiness

Unit 1: Economic reforms- liberalization, privatization and globalization specifically affecting Agribusiness, Integrated Agribusiness Development Policy-2011 and Karnataka Agribusiness & Food Processing Policy-2015.

Unit 2: WTO Agreement on Agriculture and its compliances, changes in policies and regulations related to the sub sectors of agribusiness and its impact on agribusiness in India.

Block III: Emerging Trends in Agribusiness

Unit1: Emerging trends in farm supplies, farm production, agricultural finance, agro processing, reforms in agri output markets: private markets, contract farming, futures trading in agri commodities and e-NAM, etc. Pricing of agricultural outputs, public distribution system, imports and exports.

Unit2: International trade, emerging trends in production, processing, marketing and exports; with specific reference to agro-industries. Agro-based industries-Meaning, types-agro produce processing industries, Agro-produce manufacturing units, Agro-service centres, advantages and limitations of agro-industries, E- commerce, E-agribusiness - India prospective and global scenario.

Unit3: Importance of food safety and quality management in agribusiness; Environmental issues including carbon markets.

Unit4: SWOT analysis, Break- even analysis- assumption and application in agribusiness, appropriate solving problem, Factor share – concepts and methods, Six-sigma – concept, past, present and future, Cost of wrong decisions in using inputs.

References

- BARNARD FL, AKRIDGE JT, DOOLEY FL, FOLTZ JC AND YEAGER EA. 2012. *Agribusiness Management*, Routledge, 4th Edition

- ASWATHAPPA K. 2014. *Essentials of Business Environment*. Himalaya Publ.
- FRANCIS CHERUNILAM 2003. *Business Environment*. Himalaya Publ.
- KODEKODI GK AND VISWANATHAN B. 2009. *Agril. Development, Rural Institution & Economic Policy*, Oxford.

ABM 544 AGRI BUSINESS LAWS AND ETHICS (2+0)

Objective

The objective of this course is to expose the learner to various ethical issues and laws affecting business. Focus will be on understanding provisions of various business laws with reference to agriculture and also ethical practices to conduct the business properly.

Theory

Block I: Indian Legal System

Unit 1: Introduction to Indian legal system, The Indian Contract Act-1872: Contract meaning, types of contract, essentials of a valid contract, offer and acceptance, capacity to contract, free consent, performance of contract.

Unit-2: Law of Negotiable Instruments: Promissory Notes, Bills of Exchange, Cheques and Bank Drafts, Endorsements, Law of Sale of Goods, Sales of Goods Act-1930-: Sale and agreement to sale, types of goods, Transfer of property in goods, mode of delivery of goods, performance of contract of sales, rights of an unpaid seller.

Unit 3: Companies Act – 2003: incorporation, commencement of business, types of companies, management of company, Memorandum of Association and Articles of Association, prospectus, winding of companies.

Block II: Regulatory Environment for Agri Business

Unit 1: Essential Commodities Act, Consumer Protection Act, RTI Act. Competition Act-2002, Regulatory environment for International Business.

Block III: Business Ethics

Unit 1: Nature and importance of ethics and moral standards; corporations and social responsibilities, scope and purpose of business ethics; Ethics in business functional areas; industrial espionage; solving ethical problems; governance mechanism. implementing business ethics in a global economy.

References

- MATHUR SB. 2010. *Business Law.* Tata McGraw Hill Edn. Pvt Ltd.
- GULSHAN SS AND KAPOOR GK. 2003. *Business Law including Company Law*. 10th Ed. NewAge Publ.
- KAPOOR ND. 2005. *Business Law*. S. Chand & Sons.
- TUTEJA SK. 2005. *Business Law for Managers*. S. Chand & Sons.
- TULSIAN PC AND TULSIAN B. 2015. *Business Law*. TMH, New Delhi.
- SINGH AVTAR. 2017. *Contract and Specific Relief,* Eastern Book Company; Twelfth edition
- PATHAK A. 2015. *Legal Aspects of Business.* McGraw Hill Education. 6th Edition

List of Common Courses

Course Code	Course Title	Credit Hours	To be offered by faculty
CMC 501	Library and Information Services	1(0+1)	Library
CMC 502	Technical Writing and Communications Skills	1(0+1)	Respective Department and Agri. Extension Education Department
CMC 503	Intellectual Property and its Management in Agriculture	1(1+0)	Agricultural Economics and Genetics & Plant Breeding Department
CMC 504	Basic Concepts in Laboratory Techniques	1(0+1)	Respective Departments and clubbed in outstation
CMC 505	Agricultural Research, Research Ethics and Rural Development Programmes	1(1+0)	Respective Departments and Agri. Extension Education Department
CMC 506*	Agri-export in India	1(1+0)	IABM
CMC 507*	Agricultural Service Management	1(1+0)	Respective Departments
CMC 508*	Bio Safety and Bio Containment	1(1+0)	Plant Biotechnology Department
CMC 509*	Food safety and Quality Assurance	1(1+0)	Food Science & Nutrition Department
CMC 510*	Agro-ecology and Environment	1(1+0)	Forestry & Environmental Science Department

* Courses designed by UASB

CMC 501 LIBRARY AND INFORMATION SERVICES (0+1)

(To be offered by Library Faculty)

Objective

To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines *etc.)* of information search.

Practical

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; e-resources access methods. Plagiarism; Digital Library; Reference Tools; Research Metrics.

CMC 502 TECHNICAL WRITING AND COMMUNICATIONS SKILLS (0+1)

(To be offered by Respective Departments and Agricultural Extension Education)

Objective

To equip the students/scholars with skills to write dissertations, research papers, etc. To equip the students/scholars with skills to communicate and articulate in English (verbal as well as writing).

Practical Technical Writing –

Various forms of scientific writings- theses, technical papers, reviews, manuals, *etc;* Various parts of thesis and research

communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion); Writing of abstracts, summaries, précis, citations etc.; commonly used abbreviations in the theses and research communications; illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations; Writing of numbers and dates in scientific write-ups; Editing and proof-reading; Writing of a review article. Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks); Error analysis (Common errors); Concord; Collocation; Phonetic symbols and transcription; Accentual pattern: Weak forms in connected speech: Participation in group discussion: Facing an interview; presentation of scientific papers.

CMC 503 INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE (1+0)

(To be offered by Genetics & Plant Breeding / Agricultural Economics Faculty)

Objective

The main objective of this course is to equip students and stakeholders with knowledge of intellectual property rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy.

Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant

Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement

CMC 504 BASIC CONCEPTS IN LABORATORY TECHNIQUES (0+1)

(To be offered by Respective Departments / Clubbed in Outstation)

Objective

To acquaint the students about the basics of commonly used techniques in laboratory.

Practical

Safety measures while in Lab; Handling of chemical substances; Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets; washing, drying and sterilization of glassware; Drying of solvents/chemicals. Weighing and preparation of solutions of different strengths and their dilution; Handling techniques of solutions; Preparation of different agro-chemical doses in field and pot applications; Preparation of solutions of acids; Neutralization of acid and bases; Preparation of buffers of different strengths and pH values. Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sand bath, water bath, oil bath; Electric wiring and earthing. Preparation of media and methods of sterilization; Seed viability testing, testing of pollen viability; Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taxonomy.

CMC 505 AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES (1+0)

(To be offered by Respective Departments and Agricultural Extension Education)

Objective

To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research ethics, and rural development programmes and policies of Government.

Theory

UNIT I: History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

UNIT II: Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT III: Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

CMC 506 AGRI EXPORT IN INDIA 1+0)

(To be offered by faculty from Institute of Agri-Business Management / Agricultural Marketing, Co-operation and Business Management of UASB)

Objective

To acquaint the students about the Agri-Export in India.

Theory

Role of exports in the development of economy - Export potential of Indian agricultural commodities. Theories of international trade. India's Agricultural trade scenario and implications of changing agricultural export basket. Agri Export policy of India – Objectives and

Policy Framework. Role of export promoting agencies in various agricultural commodities– APEDA, MPEDA, Coffee board, Spice board *etc.* Identification and evaluation of export potential products - Export potential assessment methods – Understanding the potential of GI tags, ethnic agricultural products, organic products, production competencies, geographical advantages etc. Export documentation and procedures undertaken for various agricultural products. Export documentation and procedures undertaken for various agricultural products. Understanding Quarantine, SPS measures, traceability systems, Country restrictions, political environment for export promotion of various agricultural products. Export Assistance schemes Trade Infrastructure for Export Scheme (TIES), Market Access Initiatives (MAI)Scheme, Merchandise Exports from India Scheme (MEIS)and Incentives in India under various schemes – Infrastructural requirements for export promotion (SEZ, pack houses, dock).Domestic support measures of trade (Tariff and Non-Tariff measures) – Understanding WTO trading system – WTO structure. Exclusive financial products for exporters- Role of EXIM bank. Risk management of exports. Quality management for conformance of international standards - Role of Conformity Assessment bodies (ISO, CODEX, USDA, HACCP, AGMARK standards and procedure, Fair trade etc.) – SOP for exports, packaging standards. Technological interventions in promoting traceability, trackability, Origin etc... (Block chain, GI tags, GPS trackers etc..). Key Challenges of Indian agri exports and measures to address them – Sensitization, capacity building programmes, role of branding and market promotion activities. Success stories of exporters like MAHAGRAPES.

CMC 507 AGRICULTURE SERVICE MANAGEMENT (1+0)

(To be offered by Respective Department)

Objective

To acquaint the students about the Agricultural Service Management which various agencies are carrying out.

Theory

Scope and nature of Agricultural systems services. Types agriculture and allied service. Custom hiring service centres (CHSCs). Agri clinic and its management, input suppliers, banking services, Insurance, Plant health clinic, soil and water testing laboratories, Agri-tourism, Farmers to farmers training to trainers (ToT). electronic solution for agriculture problems (e-SAP), Ground water dowsing, Nursery service management, Weathered based advisory services, Irrigation services, Post harvesting and processing services.

CMC 508 BIOSAFETY AND BIO-CONTAINMENT (1+0)

(To be offered by Plant Biotechnology)

Objective

To acquaint the students about the Biosafety and Bio-Containment in the field of Agricultural Research.

Theory

Transgenics – their handling by public and private Institutes, Protocols to be followed under DBT guidelines, infrastructure needed; Regulatory issues; Cartagena protocols; Risk assessment for development of resistance in pests; Toxicological aspects, gene escape, GURTS and Bioethics.

CMC 509 FOOD SAFETY AND QUALITY ASSURANCE (1+0)

(To be offered by Food Science & Nutrition)

Objective

To acquaint the students about the importance in Food Safety and its quality assurance.

Theory

Unit I: Introduction to food safety

— Concept and meaning of food safety

— Types of hazards: Physical, Chemical, Biological

Unit II: Food contamination, food spoilage and food borne illness.

— Types of contaminants: Natural toxins: Pesticide residues

— Classification of food on the basis of shelf life.

— Factors responsible for food spoilage

— Bactrial and viral infections: Parasitic infestations

— Food allergies, Control of Food-borne illnesses

Unit III: Food preservation

— Basic principles of Food preservation methods of Food preservation

— Food additives, Quality control of raw and processed foods

Unit IV: Food Hygiene and sanitation

— Purchase and storage of food

— Sanitary procedures while preparing, holding and serving and displaying of food

— Cleaning procedures: Pest control

— Hazards of water contamination and water quality standards

— Storage and disposal of waste

- Food adulteration

— Food packing, nutrition labelling

Unit V: Personal hygiene and safety at work place

— Personal sanitary practices

— Sanitation training and education to food workers

Unit VI: Food Safety Management system:

— Good practices: PRPs, GAPs, GHP, GMP, SSOP, HACCP, TQM and ISO series

— Food laws and standards: FSSAI, AGMARK, BIS, CAC

Unit VII: Recent concerns

— Genetically modified foods

— Use of nanotechnology in food safety

— Opportunities of artificial intelligence and machine learning in food industries.

CMC 510 AGRO-ECOLOGY AND ENVIRONMENT (1+0)

(To be offered by Forestry & Environmental Science)

Objective

To acquaint the students about the role of Agro-Ecology and Environment in the field of Agriculture.

Theory

Block 1: Agro-ecology, food systems, and interdisciplinary

Unit 1 - The ecology of sustainable food systems, the science of sustainable agriculture, Differences between industrial and sustainable agriculture. Ecosystem functions relevant to agriculture.

Unit 2 - Agro-ecology - Science of sustainable agriculture: The crop plant and abiotic factors of the environment, resources and destructors: light, soil, water, minerals, wind, fire. Biotic factors of the environment. Conventional and alternative cropping systems. An overview concerning different cropping systems, their advantages and disadvantages. Species interaction in crop communities.

Block 2: Chemicals in agriculture: Health, productivity and Environment

Unit 1 - The alternatives to chemical control in agriculture, and the importance of healthy soil. Ecosystem Services to agriculture in an overview: Soil fertility and formation, role of biochar in soil fertility, nutrient cycling and retention, root growth and interaction with soils. Water provision and purification, Genetic diversity and Climate regulation, pollination and biological pest control. Ecosystem disservices to agriculture in an overview: pests damage, competition for water, competition for pollination.

Unit 2 - Sustainable management of Agro-Biodiversity: Farmers seed systems and participatory breeding, On farm conservation and management of agro-biodiversity. Value chains of traditional/ underutilized species.

Unit 3 - Global context for Agro-biodiversity management: Global change and agro-biodiversity, impact of climate change on agro-biodiversity, policies for agro-biodiversity conservation and use.

Block3: Agro-resources and farmers

Unit 1 - Genetic resources for food and agriculture: Introduction and definition of Agro-biodiversity and food security, Processes shaping agro-biodiversity, status and trends of agro-biodiversity, conservation of agro-biodiversity. Use of natural biodiversity.

Unit 2 - Connecting agriculture and farmers to nature conservation: Healthy inputs, cultivation practices and soil health, Pollination & crop productivity, pollution and health. Involving the farmers in research and its design, towards sustainable agriculture.