UNIVERSITY OF AGRICULTURAL SCIENCES
BANGALORE

Course Syllabus
for
Master's Degree Programme

SEMESTER SYSTEM

2020-21

DIRECTORATE OF POST GRADUATE STUDIES
University of Agricultural Sciences
Bangalore

Edited and Published by

DEAN OF POST GRADUATE STUDIES

University of Agricultural Sciences

Bangalore

CONTENTS

AGRICULTURAL ECONOMICS

Course No.	Title	Credits
AEC 501	Micro Economic Theory and Applications	1+1
AEC 502	Macro Economic Policy Analysis	2+0
AEC 503	Institutional Economics and Evolution of Economic Thought	1+1
AEC 504	Agricultural Production Economics	1+1
AEC 505 AMC 503	Agricultural Marketing and Price Analysis	1+1
AEC 506	Research Methodology for Social Sciences	1+1
AEC 507 AMC 507 AST 518	Econometrics	1+1
AEC 508 AMC 512 AST 520	Optimization Techniques	1+1
AEC 509 AMC 505	Agricultural Finance and Project Management	1+1
AEC 510 EVS 504	Natural Resource and Environmental Economics	1+1
AEC 511	International Economics	1+1
AEC 512	Agricultural Policy Analysis	2+0
AEC 513	Intellectual Property Management	1+0
AEC 514 AMC 513	Commodity Futures Trading	2+0
AEC 515	Mathematical Economics	1+1
AEC 516	Economic Development and Policy	1+1
AEC 571	Qualifying Examination	2
AEC 581	Seminar	2
AEC 591	Research	16

AEC 501 ***Micro Economic Theory and Applications*** **(1+1)**

Theory

Theory of Consumer Behaviour – Cardinal Utility Approach and Ordinal Utility Approach. Income effect and substitution effect - Applications of Indifference curve approach. Revealed Preference Hypothesis, Consumer surplus, Derivation of Demand curve, Elasticity of demand. Theory of Production – Production functions, Returns to scale and economies of scale, Technical progress. Theory of Costs – Cost curves – Profit maximization and cost minimization. Derivation of supply curve, Law of Supply, Producers' surplus. Market Equilibrium – Behavior of Firms in Competitive Markets – Perfect Competition, Effect of Taxation and Subsidies on market equilibrium, Monopoly, Monopolistic Competition, Oligopoly. Theory of Factor Markets. General Equilibrium Theory, Welfare Economics – Pareto Optimality – Social welfare criteria – Social Welfare functions.

Practical

Numerical exercises in utility functions – graphical and algebraical expositions. Numerical exercises in demand functions – graphical and algebraical exposition of different types of price-demand relationships and empirical demand functions. Production functions – diagrammatic and algebraical exposition with empirical applications of production functions. Numerical exercises in supply functions – graphical and algebraical exposition of different types of price-supply relations, empirical supply functions and lagged supply response functions. Elasticities – diagrammatic and algebraical expositions of demand and supply elasticities and their applications. Market equilibrium models – exercises on price and output determination under different market situations

AEC 502 ***Macro Economic Policy Analysis*** **(2+0)**

Theory

Nature and Scope of Macro Economics – Methodology and Keynesian Concepts, National Income – Concepts and measurement, Classical Theory of Employment and Say's Law, Modern Theory of Employment and Effective Demand. Consumption function- Investment and savings, Concept of Multiplier and Accelerator, Output and Employment, Rate of interest – Classical, Neo classical and Keynesian versions. Classical theory Vs Keynesian theory – Unemployment and Full employment. Money – classical theories of Money. Keynesian theory of money and Friedman Restatement theory of money. Supply of Money – Demand for Money Inflation: Nature, Effects and control. IS & LM frame work – General Equilibrium of product and money markets. Monetary policy & Fiscal policy- Effectiveness of Monetary and Fiscal policy. Central banking. Business cycles, Balance of Payment – Foreign Exchange Rate determination.

AEC 503 ***Institutional Economics and Evolution of Economic Thought*** **(1+1)**

Theory

Old and New Institutional Economics – Institutional Economics Vs Neo- classical Economics. Definition of institutions – Distinction between institutions and organizations – Institutional evolution, Institutional change and economic performance – National and international economic institutions. Transaction costs and the allocation of resources. Transaction costs and efficiency. Asymmetric information – Moral hazard and Principal-Agent problem. 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. Economic analysis of property rights – property rights regimes – Private property – State property – Common Property Resources (CPRs) – public goods and club goods. Coase Theorem. Special features

of institutional arrangements in agriculture – Transaction costs in agriculture – Co-operatives, Case Studies – Theories of agrarian institutions – Tenancy institutions. Approaches for the study of history of economic thought – Absolutist *vs*. Relativist approaches – Evolution of Economic Thought *vs*. Economic History. Ancient economic thought – medieval economic thought – mercantilism – physiocracy – Forerunners of Classical Political Economy. Development of Classical Thoughts (Adam Smith, Robert Malthus and David Ricardo) – Critics of Classical Thoughts-Socialist critics – Socialist and Marxian Economic Ideas – Austrian School of Thought – Origins of Formal Microeconomic Analysis – William Stanley Jevons, Cournot and Dupont.

Practical

Exercises on case studies, problem solving and empirical analysis.

AEC 504 ***Agricultural Production Economics*** **(1+1)**

Theory

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, specifications, estimation and interpretation of commonly used production functions. Factors of production, classification, interdependence, and factor substitution-Determination of optimal levels of production and factor application-Optimal factor combination – least cost combination of production; theory of product choice- selection of optimal product combination. Cost functions and cost curves 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. Types of technical change-economic analysis of technical

change and adoption and measurement, Efficiency Measures applied in agricultural production-Technical, Allocative and Economic efficiencies. Yield Gap analysis- concepts- types and measurement. Nature and sources of risk, modelling and coping strategies.

Practical

Different forms of production functions- specifications, estimation and interpretation of production functions- returns to scale, factor shares, elasticity of production. Physical optima vs economic optima, least cost combination, optimal product choice. Cost function estimation, interpretation, estimation of yield gap, incorporation of technology in production functions, measuring returns to scale, estimation of cost of production in perennials.

AEC 505 / AMC 503 ***Agricultural Marketing and Price Analysis*** **(1+1)**

Theory

Problems in Agricultural Marketing. Market intermediaries and their role – Need for regulation in the present context. Marketing Efficiency – Structure, conduct and performance analysis, Vertical and Horizontal integration – Integration over space, time and form – Vertical co-ordination. APMC (Regulated Markets) – Direct marketing. Contract farming and Retailing, Supply Chain Management – Value chain Analysis, State trading, Warehousing and other Government agencies – Performance and Strategies. Role of Information and Communication Technologies (ICT) in marketing of agricultural commodities, Market research and Market information service. Spatial and temporal price relationship – Price policy and Economic development, non–price instruments. Introduction to Commodity, markets and future trading–Basics of commodity futures–operation mechanism of Commodity markets –Price discovery, Hedging, Speculation. Role of Government in promoting commodity trading and regulatory measures.

Practical

Supply and demand elasticities for Agricultural commodities. Marketable & Marketed surplus estimation, Price spread and marketing efficiency. Market structure – Concentration and analysis. 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.

AEC 506 ***Research Methodology for Social Sciences*** **(1+1)**

Theory

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. Hypothesis – meaning – characteristics – types of hypothesis – review of literature – setting of Objective and hypotheses – testing of hypothesis. 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. Research design and techniques including accounting method – Types of research design. Mailed questionnaire and interview schedule – structured, unstructured, open ended and closed-ended questions. Scaling Preparation of schedule. Data collection – assessment of data needs – sources of data collection – discussion of different situations. Techniques problems in measurement of variables in agriculture. – methods of conducting survey – Reconnaissance survey and Pre testing. Interviewing techniques and field problems coding, editing,

tabulation, validation of data. Tools of analysis participatory rural appraisal, rapid rural appraisal – data processing. Interpretation of results – Preparing research report / 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.

AEC 507 / AMC 507 / AST 518 ***Econometrics*** **(1+1)**

Theory

Introduction – relationship between economic theory, mathematical economics, models and econometrics, methodology of econometrics- regression analysis. 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. Violation of assumptions – identification, consequences and remedies for Multicollinearity, heteroscedasticity, autocorrelation – data problems and remedial approaches – model misspecification. Use of dummy variables, limited dependent variables – specification, estimation and interpretation. Simultaneous equation models, structural equations, reduced form equations, identification and approaches to estimation.

Practical

Single equation two variable model specification and estimation – hypothesis testing-transformation of functional forms and OLS application-estimation of multiple regression model – hypothesis testing and correcting specification errors – testing and managing Multicollinearity – testing and managing heteroscedasticity – testing and managing autocorrelation – estimation of regressions with dummy variables – estimation of regression with limited dependent variable – identification of equations in simultaneous equation systems.

AEC 508 / AMC 512 / AST 520 ***Optimization Techniques*** **(1+1)**

Theory

Optimization and decision-making, concepts in decision making, mathematical basis underlying optimization models. Introduction to linear programming, uses of LP in different fields, formulation of farm and non-farm problems as linear programming models, graphic solution to LP problems. Simplex Method: Concept of simplex method, solving profit maximization and cost minimization problems. Problem of degeneracy, infeasible and unbounded solutions, Primal and dual concepts. Extension of Linear Programming models: Variable resource and price programming, transportation problems, recursive programming, dynamic programming, integer programming, goal programming Concept of non-linear programming models. Game theory- Concepts of game theory, two person zero sum game, saddle point, solution to mixed strategies, graphic method, inventory management. PERT, simulation and queuing theory.

Practical

Graphical and algebraic formulation of linear programming models. Solving of maximization and minimization problems by simplex method. Formulation of the LP problems for typical farm situations. Transportation problems, Game theory problems. Use of computers for solving optimization problems.

AEC 509 / AMC 505 ***Agricultural Finance and Project Management*** **(1+1)**

Theory

Role and importance of Agricultural Finance. Credit flow to rural/priority sector. Agricultural lending – Direct and Indirect Financing – Financing through Co-operatives, 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. Lending to farmers – The concept of 3 C's, 7 P's and 3 R's of credit. Estimation of repaying capacity and risk bearing ability of borrowers and appraisal of credit proposals. Credit inclusion – credit widening and credit deepening. 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 financial performance of farm/firm. 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 – BC ratio, NPV and IRR. Supervision, monitoring and evaluation phases in appraising agricultural investment projects. 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 schemes.

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.

AEC 510 / EVS 504 ***Natural Resource and Environmental Economics*** **(1+1)**

Theory

Features of Natural Resource and Environmental Economics, Classification of NRs, - Renewable, Non renewable and Environmental resources. Property rights: private, open access and common property resources; Economy – Environment interaction. The Material Balance principle, Entropy law, Resources Scarcity, Limits to Growth . Measuring and mitigating natural resource scarcity – Malthusian and Recardian scarcity. Non- renewable resources. The theory of mine depletion, profit maximisation. Gray model. Economic growth and depletable resource use; resource rent and intergenerational equity-Hotelling model, Solow-Harwick's Rule. Renewable resources: A model of the fishery, the bionomic equilibrium, maximum sustainable yield. Optimum harvest under open access/common property and private property regimes – Collective action, Forestry: optimal rotation period, pricing and valuation of forest products-NTFPs, Bio-diversity-as resources, resiliency and insurance for productive system; Land Degradation – environmental and economic impacts, nutrients, soil flora and fauna: Water-surface and ground water, optimal and sustainable use, quality of water, depletion and policies, water markets; Land-use, rent and value, emerging land markets; Air and open space, assimilative capacity, Sources and types of pollution – air, water, solid waste. Externalities – types, transaction costs – Coase's theorem and its critique. Economic instruments – pollution charges, Pigovian tax, tradable permits. Indirect instruments – environmental regulation and legislations in India. Economics of pollution control, pollution and its impact on agriculture. Agro-chemicals and externalities. Definition and conditions for sustainable development. Economic analysis of

sustainable development, productivity, equity and sustainability and their trade offs in natural resource use. Market failure, Policy failure and state intervention in natural resources management. Time and SD, discount rates and resource allocation, measurement of SD, National accounting and the Green GNP approach, Environment Accounting, Environment and trade, environment and population-carrying capacity of earth. Environmental Kuznet's curve. Sustainable agriculture: Definition and scope, Agro-ecosystem analysis, green revolution, organic and natural farming systems; policy failures-taxing and subsidies for agriculture. Review and exercise on pricing and optimum use of water, forestry resources, degradation of soil and water, agro-chemicals and externalities.

Practical

Exhaustible resource management –optimum rate of extraction. Renewable resource management – optimum harvest of Forestry/fishery. Exercise on pollution abatement, Concepts in valuing the environment. Total economic valuation of forestry-Hedonic price method, Travel cost method, Contingent valuation method. Discount rate in natural resource management. Environment impact assessment. Visit to Pollution Control Board. Tank rehabilitation: Costs and benefits.

AEC 511 ***International Economics*** **(1+1)**

Theory

Scope and Significance of International Economics – Classical theory of International Trade; Protectionism v/s Free Trade; The role of trade- General Equilibrium in a Closed Economy (Autarky Equilibrium) – Equilibrium in a Simple Open Economy – Possibility of World Trade – Gains of Free Trade and Trade Equilibrium. Tariff, Producer Subsidy, Export Subsidy, Import Quota and Export Voluntary Restraints- The Case of Small Country and Large Country. Ricardian Model of Trade-Specific Factors Model- Heckscher – Ohlin Model – Gravity theory model. Trade Creation and Trade Diversion – Offer Curve – Export Supply. Elasticity and Import Demand Elasticity –

Comparative Advantage and Absolute Advantage. Official Exchange Rate and Shadow Exchange Rate – Walra's Law and Terms of Trade – Trade Blocks. Regional Trade Agreements. IMF, World Bank, IDA, IFC, ADB, UNCTAD – International Trade agreements – Uruguay Round – GATT – WTO.

Practical

Review of empirical studies on 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.

AEC 512 ***Agricultural Policy Analysis*** **(2+0)**

Theory

Development Economics – Scope and Importance – Economic development and economic growth – divergence in concept and approach – Indicators and Measurement of Economic Development – GNP as a measure of economic growth – New Measures of Welfare – NEW and MEW – PQLI – HDI – Green GNP – Criteria for under development – Obstacles to economic development – Economic and Non-Economic factors of economic growth. Economic development – meaning, stages of economic development, determinants of economic growth. Theories of economic growth – Ricardian growth model – The Harrod – Domar Model – The Neo classical Model of Growth – The Kaldor Model – Optimal Economic Growth – Recent Experiences of developing country economies in transition – Role of state in economic development – Government measures to promote economic development. Introduction to development planning. Role of agriculture in

economic / rural development – theories of agricultural development – Population and food supply – need for sound agricultural policies – resource policies – credit policies – input and product marketing policies – price policies. Development issues, poverty, inequality, unemployment and environmental degradation – Models of Agricultural Development – Induced Innovation Model – policy options for sustainable agricultural development. Globalization and the relevance of development policy analysis – Arguments for and against protection. Role of protection in Developing Countries. WTO – Agreement on Agriculture – Contradictions of free trade – proponents and opponents policies in vulnerable sectors like agriculture – Lessons for developing countries.

AEC 513 ***Intellectual Property Management*** **(1+0)**

Theory

World Trade Organization- Agreement on Agriculture (AoA) and Intellectual property rights (IPR) – Importance of Intellectual property management-IPR and Economic growth-IPR and biodiversity – Major areas of concern in intellectual property management – Technology transfer and commercialization- Forms of different intellectual properties generated by agricultural research. Discovery versus invention-patentability of biological inventions- method of agriculture and horticulture- procedure for patent protection: preparatory work, Record keeping. Writing a patent document, filing the patent document-types of patent applications-patent application under the Patent cooperation treaty (PCT). Plant genetic resources-importance and conservation- Sui Generic system- Plant Varieties Protection and Farmers Rights Act-registration of extinct varieties- Registration and protection of New Varieties/Hybrids/Essentiality derived varieties – Dispute prevention and settlement of Farmers' Rights. Trademark-Geographical indications of goods and commodities –copy rights-designs-biodiversity protection- Economic implications of Sanitary and Phytosanitary measures. Procedures for

commercialization of technology –Valuation, costs and pricing of technologies-Licensing and implementation of Intellectual Properties-Procedures for commercialization –Exclusive and non exclusive marketing rights-Research exception and benefit sharing.

AEC 514 / AMC 513 ***Commodity Futures Trading*** **(2+0)**

Theory

History and Evolution of commodity markets – Terms and concepts: spot, forward and futures Markets – factors influencing spot and future markets. Transaction and settlement – delivery mechanism – role of different agents – trading strategies – potential impact of interest rate, Foreign Exchange, FDI in Commodity Markets. Risk in commodity trading, importance and need for risk management measures – managing market price risk: hedging, options, speculation, arbitrage, swaps – pricing and their features. Speculatory mechanism in commodity futures. Important global and Indian commodity exchanges – contracts traded – special features –Regulation of Indian commodity exchanges – FMC and its role. Criticism of the future markets in agriculture in a country like India. Fundamental Vs 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.

AEC 515 ***Mathematical Economics*** **(1+1)**

Theory

Nature, scope and significance of mathematical economics; difference between mathematical economics, econometrics and quantitative techniques. Linear functions and their applications in demand and supply analysis; partial and general equilibrium. National income models – estimation of equilibrium level using simultaneous equations, Cramer's rule, matrix inversion. Leontief input output models – derivation of Leontief inverse matrix and interpretation of column/row multiplier and

applications. Estimation of slope and elasticity. Curvilinear demand and supply functions. Application of maxima, minima to MR, MC functions, profit maximization, effect of tax and subsidy on profit of firm. Partial differentiation applications, maximizing and minimizing for two variables, total differentials, applications, implicit differentiation, Output maximization subject to cost constraint, application of Lagrange multiplier, Integration, economic applications of integrals, economic dynamics, consumer's surplus, producer's surplus, Differential equations, dynamics of market price, dynamic stability of equilibrium, Cobweb model, time path of equilibrium.

Practical

Estimating equilibrium prices and quantities in different types of markets using linear and curvilinear demand and supply equations in partial equilibrium conditions. Demonstration of use of quadratic function rule, use of Cramer's rule, matrix inversion in finding solutions in partial and general equilibrium situations. Solving Leontief inverse matrix and interpreting column multiplier. Estimating maxima – minima in cost functions, partial differentiation. Estimating maxima – minima in revenue and profit functions, partial differentiation. Estimating maxima – minima subject to constraints, application of Lagrange multipliers to least cost combination of factors and most profitable combination of enterprises, partial differentiation. Application of integration in economic dynamics, definite and indefinite integrals, finding equilibrium path of variables. Difference equations and applications to market equilibrium, deviations from equilibrium.

AEC 516 ***Economic Development and Policy*** **(1+1)**

Theory

Nature of Development Economics, Why Study Development Economics–Present development challenges. Objectives of Development: Rise in real per capita income (poverty removal), distributive justice, full employment, balance

of payments equilibrium, balanced regional development, environment conservation.

Meaning and measurement of economic development: Traditional economic measures – Difference between economic growth and economic development – Criteria for measuring (indicators of) economic development – Recent approaches to measure development – The New Economic View of Development – Sen's "Capability" Approach – Development and Happiness – Three Core Values of Development – The Central Role of Women –The Three Objectives of Development – Millennium Development Goals – Income and non-income measures – Concepts of PPP, PQLI, NEW (New Economic Welfare), MRW (Measurement of Economic Welfare), HDI, Green GNP, GNH, GPI, GCP, sustainable development, inclusive growth.

Concept, characteristics, causes of underdevelopment. Vicious circle of poverty – Nelson's low-level income trap – Meaning and facets of poverty and inequality, Measurement of poverty and inequality – Head-Count ratio and Poverty Gap ratio, MPI, Lorenze curve, Gini index, Palma ratio – policy options for alleviating poverty – Kuznet's inverted U-hypothesis.

Factors determining economic development – Economic factors: Capital formation and economic growth – Sources of capital for economic growth –Savings, investment, capital-output ratio. Taxation, deficit financing, foreign aid and FDI. Investment criteria in economic development. Resource Allocation in Developing

Countries: The Market Mechanism and the Role of the State – Project Appraisal, Social Cost-benefit Analysis and Shadow prices.

Population dynamics and economic development – theory of demographic transition, Micro-economic theory of household fertility. Human capital and economic development – Demographic dividend and developing countries.

Technological change and economic development – Meaning and types of technical progress – Measuring contribution of technical progress to economic growth – Hicks', Harrod's and Solow's classifications of technical change.

Theories of economic growth – Classical theory and neo-classical theories, Marx's, Schumpeter's and Rostow's theories of stages of economic growth. Growth models – Harrod-Domar, Neo-Classical growth models of Meade, Joan Robinson, Kaldor, Solow and Tobin. Kaldor's and Verdoorn's laws of growth, Other latest growth models

Strategies for economic development – Big-push theory and critical minimum effort strategies – Balanced and unbalanced growth strategies – Role of agriculture in economic development – Nurkse-Ranis-Fei-Jorgenson theory of surplus labour and development. Nurkse's theory of capital formation through disguised unemployment – Dualism and development – Technological and sociological dualism – Todaro's model of rural-urban migration and economic growth.

Practicals

Trade and development – Trade strategies for development: inward looking and outward looking – Trade as an 'engine' of growth.

Spread effect or 'trickle-down theory. Backwash effects of trade: Myrdal-Singer theory.

Prebisch's centre-periphery theory – Dependency theory of underdevelopment – Bhagwati's theory of immisersing growth.

WTO and developing countries – Financing of balance of payments deficits, FDI and MNCs, foreign portfolio investments and developing countries –

Role of IMF and the World Bank – Stabilization and structural adjustment programmes.

Development problems of Indian economy – Fundamentals of Indian economy – Five-year plans: Wage-goods, Mahalanobis and Rao-Manmohan models.

Political economy of recent economic reforms in India.

Managing an open developing economy: Fiscal balance, inflation control, exchange rate stability and balance of payments equilibrium in the context of development.

Phenomenon of middle-income trap and the way out.

Development strategies in India; five-year plans and agriculture; land reforms;

Share tenancy theory; institutions and development; agricultural growth analysis-determinants of agricultural growth and their measurements; features of planning in capitalist, socialist and mixed economies;

Role of infrastructure and technological change; agricultural policy analysis and reforms – input and output price policy;

Rural and irrigation infrastructure; credit policy, *etc.*; policies and programmes for development of agro-industry, dairy and fisheries; measurement of poverty and poverty alleviation programmes.

Agricultural Development and Policy: Role of agriculture in economic development; economic growth and development; present development challenges; theories of development;

Role of economic, technological social, political and environmental factors; nature, sources and impact of technological change; agricultural development in Asia; poverty, inequality and development

Role of International assistance (Grants, aids, loans, *etc*.) in economic development and its implications on socio political systems of nations

Use of MS Excel in analyzing growth theory and modelling exercises

Visits to Institutions such as ISEC, ISI, Panchayath Raj.

AGRICULTURAL ENTOMOLOGY

Course No.	Title	Credits
AET 501	Insect Morphology	1+1
AET 502	Insect Anatomy, Physiology and Nutrition	2+1
AET 503	Principles of Taxonomy	2+0
AET 504	Classification of Insects	1+2
AET 505	Insect Ecology	1+1
AET 506	Insect Pathology	1+1
AET 507	Biological Control of Crop Pests and Weeds	1+1
AET 508	Toxicology of Insecticides	1+1
AET 509	Plant Resistance to Insects	1+1
AET 510	Principles of Integrated Pest Management	1+1
AET 511	Pests of Filed Crops	1+1
AET 512	Pests of Horticultural and Plantaton Crops	1+1
AET 513	Storage Entomology	1+1
AET 514	Insect Vectors of Plant Viruses and other Pathogens	1+1
AET 515	General Acarology	1+1
AET 516	Soil Arthropods and their Management	1+1
AET 517	Vertebrate Pest Management	1+1
AET 518	Techniques in Plant Protection	0+1
AET 519	Commercial Entomology	1+1
AET 520	Plant Quarantine	2+0
AET 521	Forest Entomology	1+1
AET 522	Vermiculture and Vermicomposting	1+1
AET 571	Qualifying Examination	2
AET 581	Seminar	2
AET 591	Research	16

AET 501 ***Insect Morphology*** **(1+1)**

Theory

Principles, utility and relevance: insect body wall structure, cuticular outgrowths, colouration and special integumentary structures in insects, body tagmata, sclerites and segmentation. Head- origin, structure and modification; types of mouthparts and antennae, 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; Embryonic and post-embryonic development; types of metamorphosis. Insect sense organs (mechano-, photo- and chemoreceptors).

Practical

Study of insect segmentation, various tagmata and their appendages; preparation of permanent mounts of different body parts and their appendages of taxonomic importance including male and female genitalia. Sense organs.

AET 502 ***Insect Anatomy, Physiology and Nutrition*** **(2+1)**

Theory

Scope and importance of insect anatomy and physiology. Structure, modification and physiology of different systems- digestive, circulatory, respiratory, excretory, nervous, sensory, reproductive, musculature, endocrine and exocrine glands. Thermodynamics; physiology of integument, moulting; growth, metamorphosis and diapause. 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; artificial diets; Bioluminescence.

Practical

Dissection of different insects to study comparative anatomical details of different systems; preparation of permanent mounts of internal systems; chromatographic analysis of free

amino acids of haemolymph; determination of chitin in insect cuticle; examination of insect haemocytes; determination of respiratory quotient; preparation and evaluation of various diets; consumption, utilization and digestion of natural and artificial diets.

AET 503 ***Principles of Taxonomy*** **(2+0)**

Theory

Introduction to history and principles of systematics and importance. Levels and functions of systematics. Identification, purpose, methods character matrix, taxonomic keys. Descriptions-subjects of descriptions, characters, nature of characters, analogy vs homology, parallel vs convergent evolution, intraspecific variation in characters, polythetic and polymorphic taxa, sexual dimorphism. Classification of animals: Schools of classification- Phenetics, Cladistics and Evolutionary classification. Components of Biological Classification: Hierarchy, Rank, Category and Taxon. Species concepts, cryptic, sibling and etho-species, intra-specific categories. Introduction to numerical, biological and cytogenetica taxonomy. Nomenclature: Common vs Scientific names. International Code of Zoological Nomenclature, criteria for availability of names, validity of names. Categories of names under consideration of ICZN. Publications, Principles of priority, and homonymy, synonymy, type concept in zoological nomenclature. Speciation, anagenesis v/s cladogenesis, allopatric, sympatric and parapatric processes.

AET 504 ***Classification of Insects*** **(1+2)**

Theory

Brief evolutionary history of Insects- introduction to phylogeny of insects and major Classification of Superclass Hexapoda – Classes – Ellipura (Collembola, Protura), Diplura and Insecta-Orders contained. 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. 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.

AET 505 ***Insect Ecology*** **(1+1)**

Theory

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 Casual 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, Systems approach to ecology. 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. 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. Prey-predator interactions- Basic model- Lotka-Volterra Model, Volterra's principle. Functional and numerical response. Defense mechanisms against predators/parasitoids- Evolution of mimicry, colouration, concept of predator satiation; evolution of life history strategies. 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, Concept of diversity- the Wallacian view. Assessment of diversity. Diversity-stability debate, relevance to pest management. Pest management as applied ecology.

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 some 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.

AET 506 ***Insect Pathology*** **(1+1)**

Theory

History of insect pathology, infection of insects by bacteria, fungi, viruses, protozoa, rickettsiae, spiroplasma and nematodes. Epizootiology, symptomatology and etiology of diseases caused by the above and the factors controlling these. Defense mechanisms in insects against pathogens. Examples of successful instances of exploitation of pathogens for pest management and mass production techniques of pathogens. Safety and registration of microbial pesticides. Use of insect pathogens in integrated management of insect pests.

Practical

Familiarization with equipment used in insect pathology laboratory. Identification of different groups of insect pathogens and symptoms of infection. Isolation, culturing and testing pathogenicity of different groups of pathogens. Testing Koch's postulates. Estimation of pathogen load. Extraction of pathogens from live organisms and soil. Bioassays to determine median lethal doses.

AET 507 ***Biological Control of Crop Pests and Weeds*** **(1+1)**

Theory

History, principles and scope of biological control; important groups of parasitoids, predators and pathogens; principles of classical biological control- importation, augmentation and conservation. 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. Mass production of quality biocontrol agents-techniques, formulations, economics, field release/application and evaluation. Successful biological control projects, analysis,

trends and future possibilities of biological control. Importation of natural enemies- Quarantine regulations, biotechnology in biological control. Semiochemicals in biological control.

Practical

Identification of common natural enemies of crop pests (parasitoids, predators, microbes) and weed killers. Visits (only where logistically feasible) 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.

AET 508 ***Toxicology of Insecticides*** **(1+1)**

Theory

Definition and scope of insecticide toxicology; history of chemical control; pesticide use and pesticide industry in India. Classification of insecticides and acaricides based on mode of entry, mode of action and chemical nature. Structure and mode of action of organochlorines, organophosphates, carbamates, pyrethroids, tertiary amines, neonicotinoids, oxadiazines, phenyl pyrozoles, insect growth regulators, microbials, botanicals, new promising compounds, *etc*. Principles of toxicology; evaluation of insecticide toxicity; joint action of insecticides- synergism, potentiation and antagonism; factors affecting toxicity of insecticides; insecticide compatibility, selectivity and phytotoxicity. Insecticide metabolism; pest resistance to insecticides; mechanisms and types of resistance; insecticide resistance management and pest resurgence. Insecticide residues, their significance and environmental implications. Insecticide Act, registration and quality control of insecticides; safe use of insecticides; diagnosis and treatment of insecticide poisoning.

Practical

Insecticide formulations and mixtures; quality control of pesticide formulations; laboratory and field evaluation of bioefficacy of insecticides; bioassay techniques; probit analysis; evaluation of insecticide toxicity and joint action. Toxicity to beneficial insects. Pesticide appliances. Working out doses and concentrations of pesticides; visit to toxicology laboratories. Good laboratory practices.

AET 509 ***Plant Resistance to Insects*** **(1+1)**

Theory

History and importance of resistance, principles, classification, components, types and mechanisms of resistance. Insect-host plant relationships; theories and basis of host plant selection in phytophagous insects. Chemical ecology, tritrophic relations, volatiles and secondary plant substances; basis of resistance. Induced resistance - acquired and induced systemic resistance. Factors affecting plant resistance including biotypes and measures to combat them. 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. 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.

AET 510 ***Principles of Integrated Pest Management*** **(1+1)**

Theory

History and origin, definition and evolution of various related terminologies. Concept and philosophy, ecological principles, economic threshold concept, and economic consideration. Tools of pest management and their integration-legislative, cultural, physical and mechanical methods; pest survey and surveillance, forecasting, types of surveys including remote sensing methods, factors affecting surveys; political, social and legal implications of IPM; pest risk analysis; pesticide risk analysis; cost-benefit ratios and partial budgeting; case studies of successful IPM programmes.

Practical

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. Computation of EIL and ETL; crop modeling; designing and implementing IPM system.

AET 511 ***Pests of Field Crops*** **(1+1)**

Theory

Systematic position, identification, distribution, host-range, bionomics, nature and extent of damage, seasonal abundance and management of insect and mite pests and vectors. Insect pests of cereals and millets and their management. Polyphagous pests: grasshoppers, locusts, termites, white grubs, hairy caterpillars, and non-insect pests (mites, birds, rodents, snails, slugs, *etc.*). Insect pests of pulses, tobacco, oilseeds and their management. Insect pests of fibre crops, forages, 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.

AET 512 ***Pests of Horticultural and Plantation*** **(1+1)**

Crops

Theory

Systematic position, identification, distribution, host range, bionomics and seasonal abundance, nature and extent of damage and management of insect pests of various crops. Fruit Crops- mango, guava, banana, jack, papaya, pomegranate, litchi, grapes, *ber*, fig, citrus, *aonla*, pineapple, apple, peach and other temperate fruits. Vegetable crops- tomato, potato, radish, carrot, beetroot, cole crops, French beans, chow-chow, brinjal, okra, all gourds, gherkin, drumstick, leafy vegetables *etc*. Plantation crops- coffee, tea, rubber, coconut, arecanut, cashew, cocoa *etc*.; Spices and Condiments-pepper, cardamom, clove, nutmeg, chillies, turmeric, ginger, beetlevine *etc*. Ornamental, medicinal and aromatic plants and pests in polyhouses/protected cultivation.

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.

AET 513 ***Storage Entomology*** **(1+1)**

Theory

Introduction, history of storage entomology, concepts of storage entomology and significance of insect pests. Post-harvest losses *in toto vis- vis* total production of food grains in India. Scientific and socio-economic factors responsible for grain losses. 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 fungi and 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. 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., improved and modern storage structures in current usage. Ideal seeds and commodities' storage conditions. 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. 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 insect infestation in stored food grains; 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).

AET 514 ***Insect Vectors of Plant Viruses and Other Pathogens*** **(1+1)**

Theory

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. Transmission of plant

viruses and fungal pathogens. Relation between viruses and their vectors. Transmission of plant viruses byaphids,whiteflies, mealy bugs and thrips. Transmission of mycoplasma and bacteria by leafhoppers and planthoppers. 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.

AET 515 ***General Acarology*** **(1+1)**

Theory

History of Acarology; importance of mites as a group; habitat, collection and preservation of mites. Introduction to morphology and biology of mites and ticks. Broad classification- major orders and important families of Acari including diagnostic characteristics. 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.

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.

AET 516 ***Soil Arthropods and their Management*** **(1+1)**

Theory

Soil arthropods and their classification, habitats and their identification. Estimation of populations; sampling and extraction methods. Role of soil arthropods in detritus feeding, litter breakdown and humus formation. Soil arthropods as bio-indicators of habitat qualities. Effect of soil arthropod activity on soil properties. Harmful and beneficial soil arthropods and their management, interrelationship among arthropods and other soil invertebrates and soil microorganisms. Anthropogenic effects on soil arthropods.

Practical

Sampling, extraction methods and identification of various types of soil fauna; estimation and assessment of soil arthropod population; techniques and culturing soil invertebrates.

AET 517 ***Vertebrate Pest Management*** **(1+1)**

Theory

Vertebrate pests of different crops; biology of vertebrate pests such as rodents, birds and other mammals. Biology of beneficial birds. Population dynamics and assessment, patterns of pest damage and assessment, roosting and nesting systems in birds. 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, bioassays (LD50 studies), equipments and educative programmes.

Practical

Identification of important rodent and other vertebrate pests of agriculture, food preference and hoarding, social behaviour, damage assessment, field survey, population estimation, control operation and preventive methods.

AET 518 ***Techniques in Plant Protection*** **(0+1)**

Practical

Pest control equipments, principles, operation, maintenance, selection, application of pesticides and biocontrol agents, seed dressing, soaking, root-dip treatment, dusting, spraying, application through irrigation water. Soil sterilization, solarization, deep ploughing, flooding, techniques to check the spread of pests through seed, bulbs, corms, cuttings and cut flowers. Use of light, transmission and scanning electron microscopy. Protein isolation from the pest and host plant and its quantification using spectrophotometer and molecular weight determination using SDS/PAGE. Use of tissue culture techniques in plant protection. Computer application for predicting/ forecasting pest attack and identification.

AET 519 ***Commercial Entomology*** **(1+1)**

Theory

Bee keeping- General colony management during different seasons. Seasonal management. Managing colonies for honey production and pollination. Artificial queen rearing. Pests and diseases of honey bees. Bee poisoning. Production and marketing of quality honey and value added honey products. Establishment and maintenance of apiaries. Study of different species of silkworms, characteristic features, moriculture, silk and its uses, pests and diseases of silkworms, rearing and management of silkworms. Lac insect- natural enemies and their management. Economic and public health importance of insect pests in human habitation and habitats, biology, damage and control of mosquitoes, houseflies, bed bugs, ants, termites, cockroaches, flies, silverfish, head and body lice, carpet beetles, cloth moths, crickets, wasps, house dust mites, insect pests of cattle, poultry, pet animals and their management. Principles and methods of pest management in residential places and public buildings, insecticides for domestic use and their safety, pre- and post construction termite proofing of buildings, appliances for domestic pest control. Rodent control methods. Organic methods of domestic pest management.

Practical

Assessing pest status in dwellings (labs, canteen or hostel), implementation of pest control against flies, mosquitoes, bed bugs, cockroaches and rodents. Pre- and post-construction termite proofing methods, control of silverfishes in the library. Visit to poultry units and assessing pest status in poultries. Evaluation of commercially available domestic insect pest control products through bioassays. Identification of honey bee species, bee castes and special adaptations, identification and handling of bee-keeping equipments. Handling of honey bees-hive and frame inspection. Honey extraction and processing methods of hive products extraction. Preparation of bee-keeping projects for funding. Visit to bee nursery and commercial apiaries. Silkworm rearing and management. Lac host and crop management technology and processing of lac. Products and bye-products of lac.

AET 520 ***Plant Quarantine*** **(2+0)**

Theory

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. Plant protection organization in India. Acts related to registration of pesticides and transgenics. History of quarantine legislations, PQ Order 2003. Environmental Acts, Industrial registration; APEDA, Import and Export of bio-control agents. Identification of pest/disease free areas; contamination of food with toxicants, 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. WTO regulations; non-tariff barriers; Pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; Sanitary and Phytosanitary measures.

AET 521 ***Forest Entomology*** **(1+1)**

Theory

Insects in relation to forests interacting environmental or habitat factors. Role of insects in Nutrient cycling in forest ecosystems. History and importance of forest Entomology in India. Classification of forest insect pests. Factors responsible for outbreak of forest pests. Survey methodology for forest pests. Bioecology, nature of damage, distribution and management strategies of important insect pests of timber and fruit yielding species of natural forests and plantations. Timber Pests and their management. Non –insect pests of forest trees. Principles and concepts of forest pest management.

Practical

Study of insect damage and Sign categories. Identification of immature and adult stages of important insect pests of forest plants, plantation trees and timber. Visits to forest areas and forest plantations, timber Depots.

AET 522 ***Vermiculture and Vermicomposting*** **(1+1)**

Theory

Vermiculture-definition and scope. Classification of earthworms up to families/ important genera. Earthworm distribution. Earthworm activity on soil properties. Physico – chemical and biological properties. Reproductive patterns and earthworm biomass production. Earthworms and soil microorganisms. Vermicomposting. Definition and scope. Selection of earthworm species. Bioresources for vermicomposting. Structural designs and methodology. Factors influencing the process. Properties of vermicompost – compost enrichment. Vermi wash. Definition. Methodology for extraction, chemical composition and application. Vermmeal – definition and scope. Preparation and utility. Role of earthworms in sustainable agriculture. Earthworms as bio-concentrators and bio-indicators. Earthworms in human welfare.

Practical

Important key characters for earthworm identification. External and anatomical characters. Preparation of waste mix for vermicomposting. Comparative study on growth rate and population increase in different waste mix. Physico- chemical analyses of vermicompost. Microbial assay in vermicompost and earthworm gut. Vermiwash preparation. Effect of vermiwash and vermicompost on seed germination and plant growth. Laboratory observations on burrowing and feeding activity of earthworms. Visits to vermicomposting facilities in Karnataka.

AGRICULTURAL EXTENSION

Course No.	Title	Credits
AEX 501	Development Perspectives of Extension Education	1+1
AEX 502	Development Communication and Information Management	1+1
AEX 503	Diffusion and Adoption of Innovations	1+1
AEX 504	Research Methods in Behavioural Science	1+1
AEX 505	E-Extension	1+1
AEX 506	Entrepreneurship Development and Management in Extension	1+1
AEX 507	Human Resource Development (HRD)	1+1
AEX 508	Visual Communication	1+1
AEX 509	Participatory Methods for Technology Development and Transfer	1+1
AEX 510	Gener Sensitization for Development	1+1
AEX 511	Perspectives of Distance Education	1+1
AEX 512	Market Led Extension Management	1+1
AEX 513	Advances in Rural Sociology	1+1
AEX 514	Principles of Test Construction	1+1
AEX 571	Qualifying Examination	2
AEX 581	Seminar	2
AEX 591	Research	16

AEX 501 ***Development Perspectives of Extension Education*** **(1+1)**

Theory

Extension Education – Meaning, objectives, concepts, principles and philosophy, critical analysis of definitions – Extension Education as a Profession – Adult Education and Distance Education. Pioneering Extension efforts and their implications in Indian Agricultural Extension – Analysis of

Extension systems of ICAR and SAU – State Departments Extension system and NGOs – Role of Extension in Agricultural University. Poverty Alleviation Programmes – SGSY, SGRY, PMGSY, DPAP, DDP, CAPART – Employment Generation Programmes – NREGP, Women Development Programmes – ICDS, MSY, RMK, Problems in Rural Development. Current Approaches in Extension: Decentralised Decision Making, Bottom up Planning, Farming System Approach, Farming Situation Based Extension, Market – Led – Extension, Farm Field School, ATIC, Kisan Call Centres, NAIP.

Practical

Visit to Gram Panchayat to study on-going Rural Development Programmes, Visit to KVK, NGO and Extension centers of State Agricultural University and State Departments, Bottom up planning, Report preparation and presentations.

AEX 502 ***Development Communication and Information Management*** **(1+1)**

Theory

Communication process – concept, elements and their characteristics – Models and theories of communication – Communication skills– fidelity of communication, communication competence and empathy, communication effectiveness and credibility, feedback in communication, social networks and Development communication – Barriers in communication, Message – Meaning, dimensions of a message, characteristics of a good message, Message treatment and effectiveness, distortion of message. Methods of communication – Meaning and functions, classification. Forms of communication – Oral and written communication, Non-verbal communication, interpersonal communication, organizational communication. Key communicators – Meaning, characteristics and their role in development. Media in communication – Role of mass media in dissemination of farm technology, Effect of media mix for Rural People. Modern communication media – Electronic video, Tele Text, Tele conference, Computer Assisted Instruction, Computer technology and its implications.

Agricultural Journalism as a means of mass communication, Its form and role in rural development, Basics of writing – News stories, feature articles, magazine articles, farm bulletins and folders. Techniques of collection of materials for news stories and feature articles; Rewriting Art of clear writing, Readability and comprehension testing procedures; photo journalism, communicating with pictures, Radio and TV Journalism, Techniques of writing scripts for Radio and TV.

Practical

Exercises on Communication credibility, empathy, competence and communication skills. Visit to Press, Radio, AIR, Doordarshan, Press Trust of India, Tele Conference centre. Writing future articles, script writing for Radio, Script writing for TV, Measuring readability by using different formulae. Visiting progressive farmers to develop success stories.

AEX 503 ***Diffusion and Adoption of Innovations*** **(1+1)**

Theory

Diffusion – concept and meaning, elements; traditions of research on diffusion; the generation of innovations; innovation-development process; tracing the innovation-development process, converting research into practice. 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. Adopter categories – Innovativeness and adopter categories, adopter categories as ideal types, characteristics of adopter categories; Perceived attributes of Innovation and their rate of adoption, factors influencing rate of adoption. Diffusion effect and concept of over adoption, 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; Types of innovation-decisions – Optional, Collective and Authority and contingent innovation decisions; Consequences of Innovation-Decisions – Desirable or Undesirable, direct or

indirect, anticipated or unanticipated consequences; Decision making – meaning, theories, process, steps, factors influencing decision making.

Practical

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.

AEX 504 ***Research Methods in Behavioural Science*** **(1+1)**

Theory

Research – Meaning, importance, characteristics. Behavioural sciences research – Meaning, concept and problems in behavioural sciences research. Types and methods of Research – Fundamental, Applied and Action research, Exploratory, Descriptive, Diagnostic, Evaluation, Experimental, Analytical, Historical, Survey and Case Study. Review of literature – Need, Search Procedure, Sources of literature, Planning the review work. Research problem – Selection and Formulation of research problem and guiding principles in the choice of research problem, Factors and criteria in selection of research problem, statement of research problem and development of theoretical orientation of the research problem. Objectives – Meaning, types and criteria for judging the objectives. Concept and Construct – Meaning, role of concepts in research and Conceptual frame work development in research. Variable – Meaning, types and their role in research. Definition – Meaning, characteristics of workable definitions, types and their role in research. Hypothesis – Meaning, importance and functions of hypothesis in research, Types of hypothesis, linkages, sources, problems in formulation and criteria for judging a workable hypothesis. Measurement – Meaning, postulates and levels of measurement, Use of

appropriate statistics at different levels of measurement, criteria for judging the measuring instrument and importance of measurement in research. Validity – Meaning and methods of testing. Reliability – Meaning and methods of testing. Sampling – Universe, Sample and Sampling-Meaning, basis for sampling, advantages and limitations, size and factors affecting the size of the sample and sampling errors – Methods of elimination and minimizing, Maximincon Principle, Sampling – Types of sampling and sampling procedures. Research Designs – Meaning, purpose and criteria for research design, Types, advantages and limitations of each design. Experimental design – Advantages and limitations. Data Collection devices - Interview – Meaning, purpose, types, techniques of interviewing and advantages and limitations. Enquiry forms and Schedules – Meaning, types of questions used, steps in construction and advantages and limitations in its use. Questionnaires – Meaning, difference between schedule and questionnaire, types of questions to be used, pre – testing of the questionnaires or schedules and advantages and limitations. Check lists – Meaning, steps in construction, advantages and limitations in its use. Rating scales – Meaning, types, limits in construction, advantages and limitations in its use. Observation – Meaning, types, tips in observation, advantages and limitations in its use. Case studies – Meaning, types, steps in conducting, advantages and limitations in its use. Social survey – Meaning, objectives, types and steps in conducting, advantages and limitations. Data processing – Meaning, coding, preparation of master code sheet, analysis and tabulation of data, Statistical Package for Social Sciences (SPSS) choosing appropriate statistics for data analysis based on the level of measurement of variables. Report writing – Meaning, guidelines to be followed in scientific report writing, References in reporting.

Practical

Selection and formulation of research problem - Formulation of objectivesand hypothesis-Selection of variables based on objectives-Developing the conceptual framework of research. Operationally defining the selected variables-

Development of data collection devices.-Testing the validity and reliability of the data collection instruments.- Pre-testing of the data collection instrument-Techniques of interviewing and collection of data using the data collection instruments-Data processing, hands on experiences on SPSS, coding, tabulation and analysis. Formulation of secondary tables based on objectives of research. Writing report, Writing of thesis and research articles-Presentation of reports.

AEX 505 ***E-Extension*** **(1+1)**

Theory

ICTs- Concept, definition, tools and application in extension education. Reorganizing the extension efforts using ICTs, advantages, limitations and opportunities. ICTs projects, case studies in India and developing world. Different approaches (models) to ICTs. ICT use in field of extension- Expert systems on selected crops and enterprises; Self learning CDs on package of practices, diseases and pest management, Agricultural web sites and portals related crop production and marketing *etc*. Community Radio, Web, Tele, and Video conferencing. Computer Aided Extension. Knowledge management, Information kiosks, Multimedia. Online, Offline Extension. Tools-Mobile technologies, e-learning concepts. ICT Extension approaches-pre-requisites, information and science needs of farming community. Need integration. Human resource information. Intermediaries. Basic e-extension training issues. ICT enabled extension pluralism. Emerging issues in ICT.

Practical

Agril.content analysis of ICT Projects. Handling of ICT tools. Designing extension content. Online extension service. Project work on ICT enabled extension. Creation of extension blogs. Visit to ICT extension projects.

AEX 506 ***Entrepreneurship Development and Management in Extension*** **(1+1)**

Theory

Entrepreneurship – Concept, characteristics, Approaches, Theories, Need for enterprises development. Agri – entrepreneurship – Concept, characteristics, Nature and importance for sustainable Livelihoods. Traits of entrepreneurs – Risk taking, Leadership, Decision making, Planning, Organising, Coordinating and Marketing, Types of Entrepreneurs. Stages of establishing enterprise – Identification of sound enterprise, steps to be considered in setting up an enterprise, feasibility report, product selection, risk and market analysis, legal requirements. Project Management and Appraisal – Market, Technical, Financial, Social Appraisal of Projects. Micro enterprises – Profitable Agri enterprises in India – Agro Processing, KVIC industries. Micro financing – meaning, Sources of Finance, Banks, Small scale industries development organizations. Marketing for enterprises – Concept, planning for marketing, target marketing, Competition, market survey and strategies, Product sales and promotion. Gender issues in entrepreneurship development – Understanding gender and subordination of women, Gender as a development tool, Policy approaches for women entrepreneurship development. Success and Failure stories for enterprises – Issues relating to success and failure of enterprises – Personal, Production, Finance, Social, Marketing. Management – Meaning, concept, nature and importance, Approaches to management, Levels of management, Qualities and skills of a manager. Extension Management – Meaning, Concept, Importance, Principles of management, Classification of Functions of Management. Planning – Concept, Nature, Importance, Types, Making planning effective. Change Management – factors, process and procedures. Decision making – Concept, Types of decisions, Styles and techniques of decision making, Steps in DM Process, Guidelines for making effective decisions. Organizing – Meaning of Organization, Concept, Principles, Organizational Structure, Span of Management, Departmentalization, Authority and responsibility, Delegation and decentralization, line and staff relations. Coordination –

Concept, Need, Types, Techniques of Coordination. Interpersonal relations in the organization. Staffing – Need and importance, Manpower planning, Recruitment, Selection, Placement and Orientation, Training and Development – Performance appraisal – Meaning, Concept, Methods. Direction – Concept, Principles, Requirements of effective direction, Giving orders, Techniques of direction. Leadership – Concept, Characteristics, Functions, Approaches to leadership, Leadership styles. Organizational Communication – Concept, Process, Types, Net Works, Barriers to Communication. Managing work motivation – Concept, Motivation and Performance, Approaches to motivation. Supervision – Meaning, Responsibilities, Qualities and functions of supervision, Essentials of effective supervision. Managerial Control – Nature, Process, Types, Techniques of Control, Budgeting, Observation, PERT and CPM, MIS.

Practical

Field visit to Successful enterprises-Study of Characteristics of Successful entrepreneurs Development of Project Proposal - Case Studies of Success / Failure enterprises-Exercise on Market Survey-Field visit to Financial institutions-Simulated exercise to understand management process-Field visit to extension organizations to understand the functions of management -Group exercise on development of short term and long term plan Simulated exercise on techniques of decision making-Designing organizational structure -Group activity on leadership development skills.

AEX 507 ***Human Resource Development (HRD)*** **(1+1)**

Theory

Human Resource Development – Definition, Meaning, Importance, Scope and Need for HRD; Conceptual frame work, inter disciplinary approach, function systems and case studies in HRD; HRD Interventions – Different Experiences; Selection, Development & Growth- Selection, Recruitment, Induction Staff Training and Development, Career planning; Social and

Organizational Culture: Indian environment perspective on cultural process and social structure, society in transition; Organizational and Managerial values and ethics, organizational commitment; Motivation productivity - job description – analysis and evaluation; Performance Appraisal. Human Resource management: Collective bargaining, Negotiation skills; Human Resource Accounting (HRA): What is HRA? Why HRA? Information Management for HRA and Measurement in HRA; Intra personal processes: Collective behaviour, learning, and perception; Stress and coping mechanisms; Inter-Personal Process, Helping Process – communication and Feedback and interpersonal styles; Group & Inter group process: group information and group processes; Organizational communication, Team building Process and functioning, Conflict management, Collaboration and Competition; HRD & Supervisors: Task Analysis; Capacity Building – Counseling and Mentoring; Role of a Professional Manager: Task of Professional Manager – Responsibility of Professional Manager; Managerial skills and Soft Stills required for Extension workers; Decision Making: Decision Making models, Management by Objectives; Behavioural Dynamics :Leadership styles – Group dynamics. Training – Meaning, determining training need and development strategies – Training types, models, methods and evaluation; Facilities for training – Trainers training – techniques for trainees participation; Research studies in training extension personnel; Main issues in HRD: HRD culture and climate – organizing for HRD – emerging trends and Prospective.

Practical

Visit to different training organizations to review ongoing activities & facilities; Analysis of Training methods followed by training institutions for farmers and extension workers Studies on evaluation of training programmes; Study of HRD in organization in terms of performance, organizational development, employees welfare and improving quality of work life and Human resource information, Presentation of reports.

AEX 508 ***Visual Communication*** **(1+1)**

Theory

Role of visuals & graphics in Communication. Characteristics of visuals & graphics. Functions of visuals and graphics. Theories of visual perception. Classification and selection of visuals. Designing message for visuals, Graphic formats and devices. Presentation of Scientific data. Principles and procuction of low cost visuals. Photographs- reprographic visuals. PC based visuals. Degitized video material in multimedia production. Designing visuals for print and TV and video. Pre-testing and evaluation of visuals. Scanning of visuals.

Practical

Preparation of low cost projected and Non-Projected visuals. Designing and layout of charts, posters, flash cards, *etc*. Power point presentations. Generating computer aided presentation graphics. Scanning and evaluation of visuals.

AEX 509 ***Participatory Methods for Technology Development and Transfer*** **(1+1)**

Theory

Participatory extension – Importance, key features, principles and process of participatory approaches; Different participatory approaches (RRA, PRA, PLA, AEA, PALM, PAR, PAME, ESRE, FPR) and successful models. Participatory tools and techniques. Space Related Methods : village map (social & resource), mobility services and opportunities map and transect; Time related methods : time line, trend analysis, seasonal diagram. Daily activity schedule, dream map; Relation oriented methods : cause and effect diagram (problem tree), impact – diagram, well being ranking method, Venn diagram, matrix ranking, livelihood analysis. Preparation of action plans, concept and action plan preparation; Participatory technology development and dissemination; Participatory planning and management, phases and steps in planning and implementation aspects; Process monitoring, participatory evaluation.

Practical

Simulated exercises on space related methods, time related method and relation oriented methods; Documentation of PTD and dissemination; Preparation of action plan; Participatory monitoring and evaluation of developmental programmes.

AEX 510 ***Gender Sensitization for Development*** **(1+1)**

Theory

Gender concepts, issues and challenges in development; Gender roles, gender balance, status, need and scope; Gender analysis tools and techniques. National policy for empowerment of women since independence; Developmental programmes for women; Gender mainstreaming in agriculture and allied sectors – need and relevance; Gender budgeting – A tool for empowering women. Women empowerment – Dimensions; Women empowerment through SHG approach; Women entrepreneurship and its role in economic development; Public Private Partnership for the economic empowerment of women; Building rural institution for women empowerment; Women human rights ; Action plans for gender mainstreaming.

Practical

Visits to rural institutions of women for studying in the rural institutions engaged in Women empowerment; Visits to entrepreneurial unit of women for studying the ways and means of establishing entrepreneurship units for Women and their development and also SWOT analysis of the Unit; Visit to Center for women development - NIRD to study the different activities related to projects and research on gender; Visit to gender cell, Office of the Commissioner and Director of Agriculture, Hyderabad, to study the mainstreaming of gender concerns and gender budget of the department.

AEX 511 ***Perspectives of Distance Education*** **(1+1)**

Theory

Distance Education – Introduction Meaning, Concept, Philosophy and its work ethics, characteristics of Distance Education – Evolution and Historical view of Distance Education

– theory Methodology, and Epistemology. Dimensions of Distance Education, Scope and difficulties. Open Education – Non-formal Education, Continuing Education, Education by correspondence. Forms and systems of Distance and Open Education, Modes of Teaching and Learning in Distance Education, Methods of Distance Education, Significance of Distance Education in Teacher Education. Planning Distance Education – A Systems Approach Student Learning – Course Planning, The target groups – Barriers to learning in Distance Education – Planning and Management of Networked Learning. Educational Technology is Distance Education Application of information and Educational Technologies in Distance Education, Development of Course and Course material, Management of resources, processes, Forms of Instructional material in Distance Education and Media Development and Production in Distance Education - Video Classroom Strategy in Distance Education – Strategies for maximizing the reach – services to students, programme Evaluation - performance indicators and Quality Assessment.

Practical

Visit to the University which is implementing the Distance Education Programmes. Detailed Study of their programme in relation to Educational Technology, Methodology, Curriculum Development, Evaluation and Assessment. Exercise on development of curriculum for Distance Education exclusively for farming community.

AEX 512 ***Market Led Extension Management*** **(1+1)**

Theory

Agricultural extension at cross roads; Changing scenario of agricultural extension at the national level; Market led extension – emerging perspectives; Market led extension – issues and challenges; Dimensions of market led extension. Agricultural marketing an overview; Development of a marketing plan, pricing concepts and pricing strategy; Consumer behaviour; Marketing communication and promotional strategies; The marketing research process; Agricultural trade liberalization and

its impact; International marketing opportunities; Implications of AOA, TRIPS and IPRs agreements on agriculture; Agreement on SPS and TBT - an over view; Commodity features marketing. Public private linkages in market led extension; Role of SHG in market led extension; Contact farming – a viable approach to meet market challenges; IT enabled approaches for market led extension and communication; Weather service and crop modeling – An effective tool in market led extension.

Practical

Identification and analysis of different marketing sources for agricultural commodities. Development of strategy for an effective market intelligence system; Development of suitable marketing plan to suite rural situation; Visit to APEDA, Rythu Bazaars to study the processes and procedures related to market-led extension.

AEX 513 ***Advances in Rural Sociology*** **(1+1)**

Theory

Sociology and Rural Sociology: Meaning, Definition, Origin and development, scope and Importance of Rural Sociology for agricultural extension. Basic Concepts in Rural Sociology: Society, community, Institution, Social Organization, culture and Social structure. Indian Rural Community: meaning, important characteristics, differences between Rural and Urban communities. Rural Social Groups: meaning, definition, characteristics and classification. Rural Social Institutions: Family: meaning, definition, features, types, functions and trends. Cooperatives: meaning, types and development functions. Panchayati Raj Institutions: meaning, background, structure and development functions. Leadership: meaning, definition, types and development functions. Rural Social Stratification: meaning, definition, bases, theories and types – social class: agrarian class structure; and caste system Rural Social Control: meaning, definition, objectives, types – formal and informal social controls. Rural Social Change: meaning,definition, features, factors and impediments.

Practical

Current topics relevant to Indian Rural Community will be discussed. Assignments on topics of importance to rural life and development will be given to the students and such topics will be presented by them.

AEX 514 ***Principles of Test Construction*** **(1+1)**

Theory

Definition of test and purpose of testing. Comparison of different levels of measurement – nominal, ordinal, interval and ratio scales. Distinction between measurement and evaluation. Characteristics of a good test-standard conditions, consistency, validity, scores, norms and practicality. Test construction – a schematic model. Steps in test construction – specification of purpose, operational definitions, test plans, test formats, item writing, item tryout, item analysis, assembling the test, standardizing, administration and scoring, establishing reliability, validity and norms. Procedures for item analysis and scoring and establishing reliability, validity and norms. Psychometric scaling techniques – the method of rank order, paired comparison and rating scales.

Practical

Exercises on item analysis and computing derived scores and norms. Computing different reliability and validity coefficients. Deriving scale values by rank order, paired comparison and rating techniques.

AGRICULTURAL MARKETING AND CO-OPERATION

Course No.	Title	Credits
AMC 501	Marketing Management and Strategy	2+0
AMC 502	Techniques in Marketing Research	1+1
AMC 503 AEC 505	Agricultural Marketing and Price Analysis	1+1
AMC 504	Agricultural Trade Policy	1+1
AMC 505 AEC 509	Agricultural Finance and Project Management	1+1
AMC 506	Agricultural Business Management	1+1
AMC 507 AEC 507	Econometrics	1+1
AMC 508	Management of Cooperatives	2+0
AMC 509	International Business	2+0
AMC 510	Agricultural and Food Marketing	2+1
AMC 511	Grading and Quality Control in Agricultural and Food Industry	1+1
AMC 512 AEC 508	Optimization Technique	1+1
AMC 513 AEC 514	Commodity Futures Trading	2+0
AMC 571	Qualifying Examination	2
AMC 581	Seminar	2
AMC 591	Research	16

AMC 501 ***Marketing Management and Strategy*** **(2+0)**

Theory

Marketing, the management perspective – tasks and philosophies of marketing management. The strategic management and marketing process. Marketing systems and

organization – Key concepts in the systems approach, macro marketing system, the industry system. Marketing Planning – Planning prerequisites, developing the long-run marketing strategy, developing the marketing mix, finalizing the plan, designing marketing tactics, communication, implementation and monitoring. Market segmentation – consumer market, non-consumer market, segments and segmentation strategy. Market measurement and forecasting – determinants of demand – measurement of demand and market potentiality, sales forecasting methods. Marketing Strategy – product strategy, pricing strategy, channel strategy, physical distribution strategy and promotion strategy. Marketing control – Nature and importance of marketing control, annual plan control, profitability control, efficiency control and strategic control.

AMC 502 ***Techniques in Marketing Research*** **(1+1)**

Theory

Mathematical tools and their application in marketing – maximization and minimization procedures. Distribution and assignment model – spatial equilibrium model – simplex solutions. Analytical and operational framework for solving problems of location, transportation, media selection, distribution of salesman. Consumer behaviour models – regression analysis. Market segmentation techniques – Discriminant analysis, factor analysis, cluster analysis, Bayesian classificatory procedures. Inventory decisions, waiting line model, game theory, pricing decisions – breakeven analysis, PERT/CPM techniques. Market structure analysis – Markov chain – Market system analysis – simulation.

Practical

Maximization and problem formulation. Solving Linear programming problem using Simplex technique. Consumer behaviour models – Regression analysis. Discriminent, factor and cluster analysis using SPSS package. Game theory problems. Market structure analysis – Markov chain. Waiting line and Inventory Models.

AMC 503 / AEC 505 ***Agricultural Marketing and Price Analysis*** **(1+1)**

Theory

Problems in Agricultural Marketing. Market intermediaries and their role – Need for regulation in the present context – Marketing Efficiency – Structure, conduct and Performance analysis – Vertical and Horizontal integration – Integration over space, time and form – Vertical co-ordination. APMC (Regulated Markets) – Direct marketing. Contract Farming and Retailing – Supply Chain Management – Value chain Analysis - State trading, warehousing and other Government agencies – Performance and Strategies. Role of Information and Communication Technologies (ICT) in marketing of agricultural commodities – Market research – Market information service. Spatial and temporal price relationship – Price policy and economic development, non–price instruments. Introduction to Commodities markets and future trading – Basics of commodity futures – operation Mechanism of Commodity markets – Price discovery, Hedging, Speculation. Role of Government in promoting commodity trading and regulatory measures.

Practical

Supply and demand elasticities for Agricultural commodities. Marketable & Marketed surplus estimation, Price spread and marketing efficiency. Market structure - Concentration and analysis. 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.

AMC 504 ***Agricultural Trade Policy*** **(1+1)**

Theory

Historical development of trade and international economic relations. Domestic Trade and International Trade. Theories of international trade – classical theory and its refinement – terms of trade – theory of exchange rates – balance of trade and balance of payments. Economic integration- Theory of commercial policy-tariffs and quotas – regional economic co-operation – EEC-GATT – UNCTAD. MNCs, joint ventures, state trading, inter-government negotiation and co-operation. Trade policies of the economically developed nations, India's import and export policy with special reference to Agricultural Commodities – International Commodity Agreements- WTO, its objectives, functions and impact on Indian agriculture trade and other trade related issues.

Practical

Discussion on important trade policy issues of current importance. Discussion on the assignments of students on trade issues with special emphasis on WTO. Visit to important institutions and trading organizations such as APEDA, KAPPEC, Commodity boards like Coffee Board, Tobacco Board, Central Silk Board *etc*., and discussion on the same.

AMC 505 / AEC 509 ***Agricultural Finance and Project Management*** **(1+1)**

Theory

Role and Importance of Agricultural Finance. Credit flow to rural/priority sector. Agricultural lending – Direct and Indirect Financing - Financing through Co-operatives, 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. lending to farmers – The concept of 3 C's, 7 P's and 3 R's of credit. Estimation of credit repaying capacity and risk bearing ability of borrowers and appraisal of credit proposals. Credit inclusions – credit widening and credit deepening. 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. 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 – BC ratio, NPV and IRR. Supervision, monitoring and evaluation phases in appraising agricultural investment projects. 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.

Practical

Demand and supply of institutional agricultural credit and Overdues 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.

AMC 506 ***Agricultural Business Management*** **(1+1)**

Theory

Concept of Agril-Business – important – dimensions – Management – Meaning – Scope – Objectives. Planning – organization – coordinating – controlling management responsibility – Approaches to management – Firm growth – Personnel management tools – Public relations – Financial records as management tools – Capitalization of a business – business policies and laws. Characteristics of business enterprises and entrepreneurship – staffing the business – producing the

product or service – marketing the product – profit planning and control.

Practicals

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.

AMC 507 / AEC 507 ***Econometrics*** **(1+1)**

Theory

Introduction – relationship between economic theory, mathematical economics, models and econometrics, methodology of econometrics- regression analysis. 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. Violation of assumptions – identification, consequences and remedies for multicollinearity, heteroscedasticity, autocorrelation – data problems and remedial approaches - model misspecification. Use of dummy variables- limited dependent variables – specification, estimation and interpretation. Simultaneous equation models – structural equations – reduced form equations - identification and approaches to estimation.

Practical

Single equation, two variable model specification and estimation – hypotheses testing-transformation of functional forms and OLS application-estimation of multiple regression model - hypothesis testing and correcting specification errors - testing and managing Multicollinearity - testing and managing heteroscedasticity - testing and managing autocorrelation - estimation of regressions with dummy variables - estimation of regression with limited dependent variable - identification of equations in simultaneous equation systems.

AMC 508 ***Management of Co-operatives*** **(2+0)**

Theory

Nature of a Cooperative organizations - An overview of Cooperative theory - cooperative Firms in theory and practice - distinctive features of cooperative ownership - Cooperative schools of thought - Principles of Cooperation - Cooperative legal system - The Concept and Classifications of Agricultural cooperatives - redesigning cooperative boundaries - Emergence of new models - Capital and Cooperatives - current issues in cooperatives finance - Management of cooperative enterprises - Issue in Cooperative Management - Cooperative Governance : Models and Tensions - corporate governance in cooperative enterprises - Preconditions for successful cooperative ventures - Cooperatives, state and political economy - current political environment and its effects on cooperatives - Performance and impact of Cooperatives - future of cooperatives.

AMC 509 ***International Business*** **(2+0)**

Theory

Introduction-Evolution-Nature of international business-Scope - Stages of internationalization- international business approaches-Theories of International Business- Competitive Advantage of Global Business- Problems of International Business- Competitive advantage in a global setting. International Business Environment-Introduction- social and cultural environment- Technological environment- Economic environment- Political environment. Modes of entering international business-International business analysis-Modes of entry: exporting, licensing, franchising, contract manufacturing, management contracts, turnkey projects, foreign direct investment, alliances like mergers and acquisitions, joint ventures- Comparison of Different modes of entry- Functional alliances- Managing conflict Situations- Break up of Alliances. Globalization-Introduction- Meaning and Definition- Features-Stages of Globalization- Globalization of markets, production, investment and technology- Globalization Advantages and Disadvantages- methods of Globalization- essential conditions

for globalization – Globalization and India. multinational corporations-definition- distinction among IC, MNC, GC and TNC- Factors Contributing for the Growth of MNCs- Advantages and disadvantages of MNCs- Control over MNCs- Organization design and structure of MNCs, Relationship between headquarters and subsidiaries- MNCs in India- The Indianisation of transnational. Foreign direct investment- Introduction- foreign direct investment in the world economy- Trends in FDI-The direction of FDI-The source of FDI- The form of FDI: Acquisitions versus Green Field Investments- Horizontal foreign direct investment- Vertical foreign direct investment- Focus on Managerial Implications.

AMC 510 ***Agricultural and Food Marketing*** **(2+1)**

Theory

Definition and concept, role of marketing in economic development, classification of markets. Approaches to study marketing system-functional-institutional-commodity and structural approaches. Marketing channels and price spread. Marketing Efficiency-Technical and Economic Efficiency. Evaluation of marketing efficiency-structure-conduct and performance, marketing margin and price spread, market integration method. Analysis of marketing systems for a) food grains b) commercial crops c) horticultural crops d) livestock and animal products, and f) agricultural inputs.

Food consumption and marketing – Food preferences, consumption and expenditure patterns, demographics of food consumption – Food processing and manufacturing – Innovations and branding in food manufacturing, the structure of food manufacturing industry, location of food processing and problems of food processors. Food wholesaling and retailing – Food wholesaling, food retailing, competition and pricing in food retailing, the food service market. Government and institutional role in agricultural and food marketing – Market legislation and regulation, Commodity boards and corporations, Marketing co-operatives.

Practical

Identification of Marketing Channels and Analysis of Price Spread. Evaluation of Marketing Efficiency – Temporal efficiency, Spatial efficiency and Structure – Conduct – Performance Analysis. Market integration studies – Performance evaluation of Marketing Boards, Co-operatives and other Marketing parastatals.

AMC 511 ***Grading and Quality Control in Agricultural and Food Industry*** **(1+1)**

Theory

Standardization and grading – meaning scope and importance. Institutions related to standardization and grading. ISO (International organization for standardization). Bureau of Indian standards, Directorate of Marketing and Inspection, Objectives and functions and their role in standardization. Grading of food grains, pulses, commercial crops, oilseeds, spices, horticultural produce, fruits and vegetables. Grading of livestock, poultry, fisheries. Food adulteration and food poisoning and detection, food hygiene. Sanitary and phytosanitory measures. Quality management, quality parameters, quality specifications. Total quality management.

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.

AMC 512 / AEC 508 ***Optimization Techniques*** **(1+1)**

Theory

Optimization and decision-making-Concepts in decision making, Mathematical basis underlying optimization models, introduction to linear programming, uses of LP in different fields, Formulation of farm and nonfarm problems as linear programming models, graphic solution to LP problems. Simplex method: solving profit maximization and cost minimization problems. Problem of degeneracy, infeasible and unbounded solutions, primal and dual concepts. Extension of linear programming models: Variable resource and price programming, transportation problems, recursive programming, dynamic programming, integer programming, goal programming concept of non-linear programming models. Game theory -Concepts of game theory, two person zero sum game, saddle point, solution to mixed strategies, graphic method, inventory management. PERT, simulation and queuing theory.

Practical

Graphical and algebraic formulation of linear programming models. Solving of maximization and minimization problems by simplex method. Formulation of the LP problems for typical farm situations. Transportation problems, Game theory problems. Use of computers for solving optimization problems.

AMC 513 / AEC 514 ***Commodity Futures Trading*** **(2+0)**

Theory

History and Evolution of commodity markets – Terms and concepts: Spot, forward and futures markets – factors influencing spot and future markets. Transaction and settlement – delivery mechanism - role of different agents - trading strategies - potential impact of interest rate, Foreign Exchange, FDI in Commodity Markets. Risk in commodity trading, importance and need for risk management measures - managing market price

risk: hedging, options, speculation, arbitrage, swaps - pricing and their features. Speculatory mechanism in commodity futures. Important global and Indian commodity exchanges - contracts traded – special features -Regulation of Indian commodity exchanges – FMC/ SEBI and its role. Criticism of the future markets in agriculture country like India. Fundamental Vs 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.

AGRICULTURAL MICROBIOLOGY

Course No.	Title	Credits
AMB 501 / PBT 517	Principles of Microbiology	1+1
AMB 502	Microbial Taxonomy	1+1
AMB 503	Cytology and Morphology of Microorganisms	1+1
AMB 504 / SAC 505	Soil Microbiology and Bio-chemistry	1+1
AMB 505	Microbiological Techniques	0+2
AMB 506	Microbial Physiology and Metabolism	1+1
AMB 507	Microbial Genetics	1+1
AMB 508	Microbial Biotechnology	1+1
AMB 509	Food and Dairy Microbiology	1+1
AMB 510	Environmental Microbiology	1+1
AMB 511	Industrial Microbiology	1+1
AMB 512	Biofertilizer Technology	1+1
AMB 513	Autotrophic Microorganisms	1+1
AMB 514	Insect Microbiology	1+1
AMB 515	Bacteriophages	1+1
AMB 571	Qualifying Examination	2
AMB 581	Seminar	2
AMB 591	Research	16

AMB 501 / PBT 517 ***Principles of Microbiology*** **(1+1)**

Theory

Development of Microbiology in 18th and 19th century. Morphology, structure and function of prokaryotic and eukaryotic cell. Archea. Classification of prokaryotes – Basic principles and techniques used in bacterial classification.

Evolutionary relationship among prokaryotes. Phylogenetic and numerical taxonomy. Study of major groups of bacteria belonging to Gracilicutes, Firmicutes, Tanericutes and Mendosicutes. Viruses – morphology, classification of plant, animal and bacterial viruses. Immune response – specific and non-specific resistance. Normal microflora of man body; some common bacterial and viral diseases of humans and animals.

Practical

Methods of isolation, purification and maintenance of microorganisms from different environments (air, water, soil, milk and food). Enrichment culture technique – isolation of asymbiotic, symbiotic nitrogen fixing bacteria. Isolation of photosynthetic bacteria. Use of selective media, and isolation of antibiotic producing microorganisms. Morphological, physiological and biochemical characterization of bacteria.

AMB 502 ***Microbial Taxonomy*** **(1+1)**

Theory

History of classification of microorganisms. Classification and the species concept. Nomenclature of microorganisms. Conventional bacterial taxonomy. Molecular taxonomy-GC ratios and DNA – DNA hybridization. Modern approaches to microbial taxonomy. Important RNA sequences in developing phylogenetic relationships. Phylogenetic probe. Universal phylogenetic tree. Phylogenetic tree of bacteria, archea and eukarya. Bergey's manual and taxonomy of prokaryotes. Recent classification of fungi, algae, protozoa and viruses. Prokaryotic diversity and taxonomy of representative groups of microorganisms-nitrogen fixing, endospore forming and chemolithotrophic, photosynthetic and plant pathogenic microorganisms.

Pratical

Examination of cell wall of Gram positive and Gram negative bacteria. Endospore formation and structure of flagella. Examination of types of fungi. Production of sclerotia, chlamydospores, and sporangia by fungi. Budding in yeasts.

Morphological differences among actinomycetes. Examination of different types of algae and protozoa. Observation of internal structures of eukaryotic organisms. Development of phylogenetic tree. Biochemical and cultural characters of selected genera of bacteria and fungi.

AMB 503 ***Cytology and Morphology of Microorganisms*** **(1+1)**

Theory

Cytology – development and historical background. Cytology of bacterial cell. Cell wall of bacteria, fungi and algae, Flagella of bacteria, fungi and protozoa. Fimbriae and pili, capsule, microcapsule and slime of bacteria . Outer layers of eucaryotes and procaryotes. Cytoplasmic inclusions, endospores, cysts and heterocysts of bacteria. Ribosomes, lysosome, glyoxysome and dictyosomes. Organization of genetic material in prokaryotes and eukaryotes. Morphology and cytology of fungi – vegetative structures fungi, fruiting bodies and spores. Structures of algae, protozoa, viruses, spirochaetes and rickettsiae.

Practical

Gram staining; Endospore staining; flagellar staining; Negative staining; Methods used in studying different types of fungi; Examination of different types of algae and protozoa. Study of biochemical and cultural characters for identification of agriculturally important microorganisms.

AMB 504 / SAC 505 ***Soil Microbiology and Bio-chemistry*** **(1+1)**

Theory

Soil biota, soil microbial ecology, types of organisms in different soils; soil microbial biomass; microbial interactions; unculturable soil biota. Microbiology and biochemistry of root-soil interface; phyllosphere; Soil enzymes-origin, activities and importance; soil characteristics influencing growth and activity of microflora. Microbial trans formations of nitrogen, phosphorus, sulphur, iron and manganese in soil; biochemical

composition and biodegradation of soil organic matter and crop residues, humus formation; cycles of important organic nutrients. Biodegradation of pesticides, organic wastes and their use for production of biogas and manures; biotic factors in soil development; microbial toxins in the soil. Preparation and preservation of farmyard manure, animal manures, rural and urban composts and vermicompost. Biofertilizers – definition, classification, specifications, method of production and role in crop production.

Practical

Determination of soil microbial population, Soil microbial biomass, 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 micro nutrients. Study of rhizosphere effect

AMB 505 ***Microbiological Techniques*** **(0+2)**

Practical

Use of Microscope; including phase contrast; Dark field, UV and Fluorescent microscopy- Photomicrography- Microscopic measurements of cells and study of microorganisms under microscopes. Staining techniques to examine the morphology of microorganisms; negative staining, Grams stain, acid fast stain, flagella stain, capsule stain *etc*. Formulation and preparation of media for culturing microorganisms, nutrient broth and agar media. Differential and selective media for bacteria, fungi, algae *etc*. Enrichment culture technique for specialized groups of bacteria. Methods of isolation of microorganisms; pour plate, dilution plate, tissue culture, anaerobic culture *etc*. Pure culture techniques and maintenance of stock cultures of various groups of microorganisms. – Principles and practices of manometry; Identification of microorganisms and examination of Koch's postulates in case of pathogens; Measurement of microbial activities-dehydrogenase activity, acid and alkaline

phosphatase activity; urease activity; Measurement of microbial biomass through estimation of microbial-C.

AMB 506 ***Microbial Physiology and Metabolism*** **(1+1)**

Theory

Structure, function, biosynthesis and assembly of various cellular components of prokaryotes. Archea and fungi. Transport of solutes across the membrane. Microbial growth. Cell cycle and cell division. EMP, HMP, ED, TCA pathways, Aerobic and anaerobic respiration. Fermentative metabolism. Biosynthesis of macromolecules. Regulation of microbial metabolism. Effect of chemicals and other environmental factors on growth. Morphogenesis and cellular differentiation. Important metabolic patterns in photoautotrophs, photoheterotrophs, chemoautotrophs and chemoheterotrophs.

Practical

Use of simple techniques in laboratory (Colorimetry, Centrifugation, Electrophoresis and GLC). Determination of viable and total number of cells. Measurement of cell size. Gross cellular composition of microbial cell. Growth – Factors affecting growth. Sporulation and spore germination in bacteria. Protoplasts formation. Induction and repression of enzymes.

AMB 507 ***Microbial Genetics*** **(1+1)**

Theory

Prokaryotic, eukaryotic and viral genome. Replication of Eukaryotic, Prokaryotic and Viral DNA. Structure, classification and replication of plasmids. Molecular basis of mutation. Biochemical genetics and gene mapping by recombination and complementation. Fine gene structure analysis. Fungal genetics. Gene transfer in bacteria through transformation, conjugation and transduction; Transposable elements. Gene cloning and gene sequencing. Impact of gene cloning on human welfare. Regulation of gene expression. Recent advances in DNA repair and mutagenesis, Genetic basis of Cancer and cell death.

Practical

Inactivation of microorganisms by different mutagens. Production, isolation and characterization of mutants. Determination of mutation rate. Isolation, and characterization of plasmids. Transfer of plasmid by conjugation, electroporation. Tetrad and random spore analysis.

AMB 508 ***Microbial Biotechnology*** **(1+1)**

Theory

Introduction, scope and historical development; Isolation, screening and genetic improvement of industrially important microorganisms. Types of fermentation systems; production of various primary and secondary metabolities, eg. Amino acids, organic acids, alcohols, enzymes organic solvents, antibiotics, *etc*. Process scale up steps: laboratory, pilot plant and industrial scales. Down stream processing; Over-production of metabolities; Bioreactor operations, process control. Fermented beverages; Production of single cell protein; Steroid transformation; Immobilization of cells/ enzymes; Silage production; Waste water treatment. Use of genetically-engineered microorganisms in biotechnology; Bioinsecticides, biofertilizers, *etc*. Microbiologically-produced food colours and flavours. Retting of flax.

Practical

Isolation of industrially important microorganisms, their maintenance and improvement. Production of industrial compounds such as alcohol, beer, citric acid, lactic acid and their recovery; Study of bio-reactors and their operation.

AMB 509 ***Food and Dairy Microbiology*** **(1+1)**

Theory

Introduction and scope; Food Microbiology – A many faceted science; Inter relationship of food microbiology with other sciences; Perspectives on food safety and Food Biotechnology. Factors of special significance in Food Microbiology – Principles influencing microbial growth in foods; Spores and their significance; Indicator organisms and

Microbiological criteria; Microbial spoilage of foods-meat, milk, fruits, vegetables and their products; Food poisoning and food-borne pathogenic bacteria. Food fermentation; Fermented dairy, vegetable, meat products; Preservatives and preservation methods – physical methods, chemical preservatives and natural antimicrobial compounds. Bacteriocins and their applications; Biologically based preservation systems and probiotic bacteria. Advanced techniques in detecting food-borne pathogens and toxins. Hurdle technology, Hazard Analysis and Critical Control Point (HACCP) systems in controlling microbiological hazards in foods.

Practical

Statutory, recommended and supplementary tests for microbiological analysis of various foods: Baby foods, canned foods, milk and dairy products, eggs, meat, vegetables, fruits, cereals, surfaces, containers and water.

AMB 510 ***Environmental Microbiology*** **(1+1)**

Theory

Scope of environmental microbiology. An overview of microbial niches in global environment and microbial activities. Microbiology of air, outdoor and indoor environment in relation to human, animal and plant health and economic activities. Microbiology of natural waters. Environmental pollution – Deleterious and beneficial role of microorganisms. Environmental microbiology in public health. Microorganisms in extreme environments, Environmental determinants that govern extreme environment- Air water interface, extreme of pH, Temperature, Salinity, Hydrostatic pressure. Microbial technology in pollution abatement, waste management and resource recovery in metal, petroleum and bioenergy fields. Biofuels. Global environmental problems. Microbial upgradation of fossil fuels and coal gas. Microbial interaction in rumen and gastro intestinal tract. Biodeterioration and Bioremediation. Biodegradation of xenobiotic compounds.

Practical

Analysis of natural waters, waste waters and organic waste in relation to water pollution assessment, pollution strength and resource quantification; 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.

AMB 511 ***Industrial Microbiology*** **(1+1)**

Theory

Biofermentor. Production of wine, beer, lactic acid, acetic acid (vinegar), citric acid, antibiotics, enzymes, vitamins, single cell proteins. Vaccines. Bioagents and Biopesticides. Bioplastics and biopolymers: Microorganisms involved in synthesis of biodegradable plastics, other pigments, Biosensors: Development of biosensors to detect food contamination and environment pollution. Biomining: Coal, mineral and gas formation, prospecting for deposits of crude, oil and gas, recovery of minerals from lowgrade ores.

Practical

Production of industrial compounds such as alcohol, beer, citric acid, lactic acid and their recovery. Detection of food-borne pathogens, pesticide degradation. Demonstration of biogas production. Production of biocontrol agents. Microbial analysis of processed foods.

AMB 512 ***Biofertilizer Technology*** **(1+1)**

Theory

Agriculturally important beneficial microorganisms – free living, symbiotic (rhizobial, actinorhizal) nodule formation, competitiveness and quantification of N_2 fixed, associative and endophytic nitrogen fixers including cyanobacteria, taxonomic classification, Phosphate solubilizing bacteria, fungi. Mycorrhiza. Potash solubilising / mobilizing microbes. Plant growth promoting rhizobacteria. Microbial biocontrol agents. Beneficial microorganisms for recycling of organic waste and composting, Bioremediators and other related microbes. Other

agriculturally important beneficial microorganisms – selection, establishment, competitiveness, crop productivity, soil and plant health. Large scale production of biofertilizers Different formulations of biofertilizers. Quality control of microbial inoculants. Marketing of biofertilizers .Methods of biofertilizer application .

Practical

Isolations of symbiotic, asymbiotic, associative nitrogen fixing bacteria. Development and production of efficient microorganisms, Determination of beneficial properties in important bacteria to be used as biofertilizer, Nitrogen fixing activity, P and K solubilization by microbes. Estimation of AM fungal spores and per cent infection in roots. Testing for Indole acetic acid (IAA), GA, Cytokinins and siderophore production by beneficial microorganisms. Biofertilizer production and quality control.

AMB 513 ***Autotrophic Microorganisms*** **(1+1)**

Theory

Evalution of autotrophic mode of nutrition. Obligate and facultative autotrophs. Photoautotrophs – cyanobacteria and photosynthetic bacteria. Cyanobacterial and algal fuels, Fine chemicals (restriction enzymes) and nutraceuticals from algae. Algae in pollution-as pollution indicators, eutrophication agents and role in Bioremediation.Chemoautotrophs – bacteria oxidizing ammonia, nitrite, sulphur, iron, hydrogen and carbon monoxide. Autotrophic mode of nutrition in archaebacteria – methane oxidizers. Autotrophic prokaryotes in extreme environments. Autotrophic and heterotrophic succession. Physiology and biochemistry of – carbon dioxide fixation, reducing power generation and ATP production in autotrophs. Factors influencing the activity and growth of autotrophic microorganisms in selected environments. Role of autotrophic microorganisms in agriculture and industry with reference to reclamation of alkali soils, phosphate solubilisation, production of single cell protein and microbial leaching of low grade ores.

Practical

Isolation and study of photo autotrophs and chemo autotrophs from selected eco systems. Study tour to SCP production units and ore leaching sites. Reclamation of alkali soils and phosphate solubilization by chemoautotrophes. Role of autotrophies in bio remediation of polluted eco system.

AMB 514 ***Insect Microbiology*** **(1+1)**

Theory

Historical developments, intracellular and extracellular microbiota. Relationships between bacteria, fungi, protozoa, nematodes and insects – symbiotic and parasitic. Microorganisms associated with beneficial and harmful insects. Symptomatology, diagnosis and control in case of beneficial insects. Strategies of defence in insects. Microbial insecticides – definition, selection, virulence, methods of mass culture, criteria to be considered in application, advantages, limitations and quality control. Compatibility of microbial and chemical insecticides. Biological control of major insect pests – problems and prospects.

Practical

Isolation and study of external, internal and intracellular microorganisms of healthy and diseased insects. Isolation and purification of nuclear polyhedra viruses and Bacillus sp. From insects. Determination of bactericidal property of insect haemolymph. Isolation of pathogenic microorganisms from insects. Determination of insecticidal property of bacterial and viral insect pathogens under laboratory conditions.

AMB 515 ***Bacteriophages*** **(1+1)**

Theory

Historical developments and classification of bacteriophages. Physiology, biochemistry, enzymology and molecular biology of phage bacterial interactions. Structure, functions and life cycles of different DNA, RNA, lytic and

lysogenic phages. Phages in the development of molecular biology and genetic engineering.

Practical

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 bursts. Induction of lambda. Complementation of T4 *rII* mutants *etc.*

AGRICULTURAL STATISTICS

Course No.	Title	Credits
AST 501	Statistical Methods for Applied Sciences	1+1
AST 502	Experimental Designs	1+1
AST 503	Sampling Techniques	2+1
AST 504	Applied Regression Analysis	2+1
AST 505	Data Analysis using Statistical Packages	1+2
AST 506	Probability Theory	1+1
AST 507	Statistical Methods	2+1
AST 508	Statistical Inference	2+1
AST 509	Multivariate Analysis	2+1
AST 510	Design of Experiments	2+1
AST 511	Sampling Techniques	2+1
AST 512 / BIM 512	Statistical Genetics	2+1
AST 513	Regression Analysis	2+1
AST 514	Statistical Computing	1+1
AST 515	Time Series Analysis	1+1
AST 516	Actuarial Statistics	2+0
AST 517	Bioinformatics	2+0
AST 518 AEC 507	Econometrics	1+1
AST 519	Statistical Quality Control	2+0
AST 520 AEC 508	Optimization Techniques	1+1
AST 521	Demography	2+0
AST 522	Statistical Methods for Life Sciences	2+0
AST 523	Statistical Ecology	2+0
AST 524	Non-Parametric Methods	1+1
AST 571	Qualifying Examination	2
AST 581	Seminar	2
AST 591	Research	16

Course No.	Title	Credits
MAT 501	Mathematical Methods for Applied Sciences	1+1
MAT 502	Mathematical Methods – I	2+1
MAT 503	Mathematical Methods – II	1+1
CSC 501	Data Warehousing and Data Mining	2+1
CSC 502	Introduction to Networking and Internet Applications	1+1
CSC 503	Object Oriented Analysis and Design	2+1
CSC 504	Data Structures Algorithms	2+1
CSC 505 / BIM 504	Database Management System	2+1
CSC 506	Web Technologies and Applications	1+1
CSC 507	Introduction to Computer Graphics	1+1
CSC 508	GIS and Remote Sensing Techniques	2+1
CSC 509	Bioinformatics Computing	2+1

AST 501 ***Statistical Methods for Applied Sciences*** **(1+1)**

Theory

Review of probability, Discrete and continuous probability distributions: Binomial, Poisson, Normal distribution, their applications and fitting of distributions. Sampling distribution-means and proportions, Standard error. Introduction to theory of estimation and confidence-intervals. Testing of Hypothesis, type –I and type–II errors. Tests of significance based on Normal, Student *t, F* distributions and Chi-square. Correlation and regression. Simple linear regression model, estimation of parameters, predicted values. Test of significance of correlation and regression coefficients. Coefficient of determination. Analysis of variance technique. One way analysis of variance. Two way analysis with one and multiple observations.

Practical

Solving problems on above topics.

AST 502 ***Experimental Designs*** **(1+1)**

Theory

Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control. Uniformity trials, size and shape of plots and blocks; Analysis of variance; Completely randomized design, randomized block design and Latin square design. Missing plot techniques in randomized block and Latin square designs; Factorial experiments, (symmetrical as well as asymmetrical). Orthogonality and partitioning of degrees of freedom, Confounding in symmetrical factorial experiments, Factorial experiments with control treatment. Split plot and strip plot designs; Analysis of covariance and variance stabilizing transformations

Practical

Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law; Analysis of data obtained from CRD, RBD, LSD; Analysis of factorial experiments without and with confounding; Analysis with missing data; Split plot and strip plot designs; Transformation of data.

AST 503 ***Sampling Techniques*** **(2+1)**

Theory

Concept of sampling, sample survey vs complete enumeration, planning of sample survey, sampling from a finite population. Simple random sampling, sampling for proportion, determination of sample size; Stratified sampling. Cluster sampling, PPS sampling, Multi-stage sampling, double sampling, systematic sampling; Use of auxiliary information at estimation as well as selection stages. Ratio and regression estimators.

Construction and analysis of survey designs, sampling and non-sampling errors; Preparation of questionnaire Non-sampling errors inverse sampling.

Practical

Random sampling use of random number tables, concepts of unbiasedness, variance, *etc*.; simple random sampling, determination of sample size; Exercises on sampling, stratified sampling, cluster sampling and systematic sampling; Estimation using ratio and regression estimators; Estimation using multistage design, double sampling and PPS sampling.

AST 504 ***Applied Regression Analysis*** **(2+1)**

Theory

Introduction to correlation analysis and its measures; Correlation from grouped data, Biserial correlation, Rank correlation; Testing of population correlation coefficients; Multiple and partial correlation coefficients and their testing. Regression analysis; Method of least squares for curve fitting; Testing of regression coefficients; Multiple and partial regressions. Problem of correlated errors; Auto correlation; Durbin Watson Statistics; Removal of auto correlation by transformation; Analysis of collinear data; Detection and correction of multicollinearity; Examining the multiple regression equation; Concept of weighted least squares; regression equation on grouped data; Various methods of selecting the best regression equation; regression approach applied to analysis of variance in one way classification. Heteroscedastic models, Concept of nonlinear regression and fitting of quadratic, exponential and power curves; Orthogonal polynomials.

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, multicollinearity; Fitting of quadratic, exponential and power curves, fitting of orthogonal polynomials.

AST 505 ***Data Analysis Using Statistical Packages*** **(1+2)**

Theory

Use of Software packages for: Summarization and tabulation of data; Descriptive statistics; Graphical representation of data, Exploratory data analysis. Fitting and testing the goodness of fit of discrete and continuous probability distributions; Testing of hypothesis based on large sample test statistics; Testing of hypothesis using chi-square, t and F statistics. Concept of analysis of variance and covariance of data for single factor, multi-factor, one-way and multi-classified experiments, contrast analysis, multiple comparisons, Analyzing crossed and nested classified designs. Analysis of mixed models; Estimation of variance components; Testing the significance of contrasts; Correlation and regression including multiple regression.

Practical

Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data. Robust Estimation, Testing linearity and normality assumption, Estimation of trimmed means *etc*., Cross tabulation of data including its statistics, cell display and table format and means for different sub-classifications; 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, pairwise comparisons; Multiway classified analysis of variance – cross-classification, nested classification, factorial set up, fixed effect models, random effect models, mixed effect models, estimation of variance components; Generalized linear models – analysis of unbalanced data sets, testing and significance of contrasts, Estimation of variance components in unbalanced data sets –

maximum likelihood, ANOVA, REML, MINQUE; Bivariate and partial correlation, Distances – to obtain a distance matrix, dissimilarity measures, similarity measures; Linear regression, Multiple regression, Regression plots, Variable selection, Regression statistics, Fitting of growth models – curve estimation models, examination of residuals.

AST 506 ***Probability Theory*** **(1+1)**

Theory

Basic concepts of probability. Elements of measure theory: class of sets, field, sigma field, minimal sigma field, Borel sigma 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. 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 case 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, cumulant generating function, probability generating function and statements of their properties. Conditional expectation and conditional variance. Characteristic function and its properties. Inversion and uniqueness theorems. Functions, which cannot be characteristic functions. Chebyshev, Markov, Cauchy-Schwartz, Jenson, Liapounov, holders and Minkowskys inequalities. Sequence of random variables and modes of convergence (convergence in distribution, in probability, almost surely, and quadratic mean) and their interrelations. Statement of Slutskys theorem. Borel Cantelli lemma and Borel 0-1 law. Laws of large numbers(WLLN), Bernoulli and Kintchins WLLN. Kolmogorov inequality,

Kolmogorovs SLLNs. Central Limit theorems: Demoviere-Laplace CLT, Lindberg Levy CLT, Liapounov CLT, Statement of Lindeberg-Feller CLT and simple applications. Definition of quantiles and statement of asymptotic distribution of sample quantiles. Classification of Stochastic Processes, Examples. Markov Chain and classification of states of Markov Chain.

Practical

Solving problems on above topics.

AST 507 ***Statistical Methods*** **(2+1)**

Theory

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. Concepts of compound, truncated and mixture distributions (definitions and examples). Pearsonian curves and its various types. Sampling distributions of sample mean and sample variance from Normal population, central and noncentral chi-Square, t and F distributions, their properties and inter relationships. 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. Sampling distribution of correlation coefficient, regression coefficient, correlation ratio, intra class correlation coefficient. Categorical data analysis – loglinear models, Association between attributes. Variance Stabilizing Transformations. Order statistics, distribution of r-th order statistics, joint distribution of several order statistics and their functions, marginal distributions of order statistics, distribution of range, median, *etc*.

Practical

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.

AST 508 ***Statistical Inference*** **(2+1)**

Theory

Concepts of point estimation: MSE, unbiasedness, consistency, efficiency and sufficiency. Statement of Neymans Factorization theorem with applications. MVUE, Rao-Blackwell theorem, completeness, Lehmann- Scheffe theorem. Fisher information, Cramer-Rao lower bound and its applications. Moments, minimum chi-square, least square and maximum likelihood methods of estimation and statements of their properties. Interval estimation-Confidence level, Confidence Interval (CI) using pivots and shortest length CI. CI for the parameters of Normal, Exponential, Binomial and Poisson distributions. Fundamental notions of hypothesis testing-statistical hypothesis, statistical test, critical region, types of errors, test function, randomized and nonrandomized 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, statement of asymptotic properties of LR tests with applications (including homogeneity of means and variances).Relation between confidence interval estimation and testing of hypothesis. Notions of sequential vs fixed sample size techniques. Walds SPRT for testing simple null hypothesis vs simple alternative. 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. 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. Kruskal Wallis and Friedmans tests. Spearmans rank correlation and Kendalls Tau tests for independence.

Practical

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

AST 509 ***Multivariate Analysis*** **(2+1)**

Theory

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. 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 lambda criterion and statement of its properties. Concepts of discriminant analysis, computation of linear discriminant function, classification between k (e" 2) multivariate normal populations based on LDF and Mahalanobis D^2. Principal Component Analysis, factor analysis (simple and multi factor models). Canonical variables and canonical correlations. Cluster analysis, similarities and dissimilarities, Hierarchical clustering. Single and Complete linkage methods. Path analysis and computation of path coefficients, introduction to multidimensional scaling, some theoretical results, similarities, metric and non metric scaling methods. Concepts of analysis of categorical data.

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.

AST 510 ***Design of Experiments*** **(2+1)**

Theory

Elements of linear estimation, Gauss Markoff Theorem, relationship between BLUEs and linear zero-functions. Aitkens transformation, test of hypothesis, analysis of variance, partitioning of degrees of freedom. Orthogonality, contrasts, mutually orthogonal contrasts, analysis of covariance; Basic principles of design of experiments, uniformity trials, size and shape of plots and blocks. Basic designs – completely randomized design, randomized complete block design and Latin square design; orthogonal Latin squares, mutually orthogonal Latin squares (MOLS), Youden square designs, Graeco Latin squares. 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, general analysis of block designs. Factorial experiments, confounding in symmetrical factorial experiments (2^n and 3^n series), partial and total confounding, fractional factorials, asymmetrical factorials. Designs for fitting response surface; 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, Youden square design; Analysis of data generated from a BIB design, lattice design, PBIB designs; 2^n, 3^n factorial experiments without and with confounding; Split and strip plot designs, repeated measurement design; Missing plot techniques, Analysis of covariance; Analysis of Groups of experiments, Analysis of clinical trial experiments. Sampling in field experiments.

AST 511 ***Sampling Techniques*** **(2+1)**

Theory

Sample survey vs courses survey, probability sampling, sample space, sampling design, sampling strategy; Inverse sampling; Determination of sample size; Confidence-interval; Simple random sampling, Estimation of population proportion, Stratified random sampling, Number of strata and optimum points of stratification. Ratio and regression methods of estimation, Cluster sampling, Systematic sampling, Multistage sampling with equal probability, Separate and combined ratio estimator, Double sampling, Successive sampling an two occasions. Non-sampling errors, sources and classification, Non-response in surveys, Imputation methods, Randomized response techniques, Response errors, interpenetrating sub-sampling. Sampling with varying probabilities with and without replacement, PPS sampling, Cumulative method and Lahiris 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, PPS systematic sampling, Multistage sampling with unequal probabilities, Self weighting design PPS sampling. Unbiased ratio and regression type estimators, Multivariate ratio and regression type of estimators, Design effect, Bernoulli and Poisson sampling.

Practical

Determination of sample size and selection of sample; Simple random sampling, Inverse sampling, Stratified random

sampling, Cluster sampling, systematic sampling; Ratio and regression methods of estimation; Double sampling, multi-stage sampling, Imputation methods; Randomized response techniques; Sampling with varying probabilities.

AST 512 / BIM 512 ***Statistical Genetics*** **(2+1)**

Theory

Physical basis of inheritance. Analysis of segregation, detection and estimation of linkage for qualitative characters. Amount of information about linkage, combined estimation, disturbed segregation. Gene and genotypic frequencies, Random mating and Hardy – Weinberg law, Application and extension of the equilibrium law, Fishers fundamental theorem of natural selection. Disequilibrium due to linkage for two pairs of genes, sex-linked genes, theory of path coefficients. 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. 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. 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. 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.

AST 513 ***Regression Analysis*** **(2+1)**

Theory

Simple and Multiple linear regressions: Least squares fit, Properties and examples. Polynomial regression: Use of orthogonal polynomials. Assumptions of regression; diagnostics and transformations; Examination of residuals – Studentized residuals, applications of residuals in detecting out- liers, identification of influential observations. Lack of fit, Pure error. Testing homoscedasticity and normality of errors, Durbin-Watson test. Use of R^2 for examining goodness of fit. Concepts of Least median of squares and its applications; Concept of multicollinearity, Analysis of multiple regression models, estimation and testing of regression parameters, sub-hypothesis testing, restricted estimation. Weighted least squares method: Properties, and examples. Box-Cox family of transformations. Use of dummy variables, Selection of variables: Forward selection, Backward elimination. Stepwise and Stagewise regressions. 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.

AST 514 ***Statistical Computing*** **(1+1)**

Theory

Introduction to statistical packages and computing: data types and structures, pattern recognition, classification, association rules, graphical methods. Data analysis principles and practice. ANOVA, regression and categorical data methods; model formulation, fitting, diagnostics and validation; Matrix computations in linear models. Analysis of discrete data. Numerical linear algebra, numerical optimization, graphical techniques, numerical approximations, numerical integration and Monte Carlo methods. Spatial statistics; spatial sampling; hierarchical modeling. Analysis of cohort studies, case-control studies and randomized clinical trials, 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; Categorical data analysis, analysis of discrete data, analysis of binary data; Numerical algorithms; Spatial modeling, cohort studies; Clinical trials, analysis of survival data; Handling missing data.

AST 515 ***Time Series Analysis*** **(1+1)**

Theory

Components of a time-series. Autocorrelation and Partial autocorrelation functions, Correlogram and periodogram analysis. Linear stationary models: Autoregressive, Moving average and Mixed processes. Linear non-stationary models: Autoregressive integrated moving average processes. Forecasting: Minimum mean square forecasts and their properties, Calculating and updating forecasts. Model identification: Objectives, 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 outliers detection.

AST 516 ***Actuarial Statistics*** **(2+0)**

Theory

Insurance and utility theory, models for individual claims and their sums, survival function, curtate future lifetime, force of mortality. Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables. 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. Distribution of aggregate claims, compound Poisson distribution and its applications. Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding. 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. 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. 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. 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.

AST 517 ***Bioinformatics*** **(2+0)**

Theory

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. Computing techniques: OS and Programming Languages Linux, perl, bioperl, cgi, MySQL, php, MyAdmin; 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. 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; 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, ClustalW, Phylogeny; Databases on SNPs; EM algorithm and other methods to discover common motifs in biosequences; Gene prediction based on Neural Networks, Genetic algorithms, Hidden Markov models. Computational analysis of protein sequence, structure and function; Design and Analysis of microarray experiments.

AST 518 / AEC 207 ***Econometrics*** **(1+1)**

Theory

Introduction – relationship between economic theory, mathematical economics, models and econometrics, methodology of econometrics- regression analysis. 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. Violation of assumptions – identification, consequences and remedies for Multicollinearity, heteroscedasticity, autocorrelation – data problems and remedial approaches – model misspecification. Use of dummy variables-limited dependent variables – specification, estimation and interpretation. Simultaneous equation models – structural equations reduced form equations – identification and approaches to estimation.

Practical

Single equation two variable model specification and estimation – hypothesis testing-transformation of functiona forms and OLS application-estimation of multiple regression model – hypothesis testing and correcting specification errors – testing and managing Multicollinearity – testing and managing heteroscedasticity – testing and managing autocorrelation – estimation of regressions with dummy variables – estimation of regression with limited dependent variable – identification of equations in simultaneous equation systems.

AST 519 ***Statistical Quality Control*** **(2+0)**

Theory

Introduction to Statistical Quality Control; Control Charts for Variables Mean, Standard deviation and Range charts; Statistical basis; Rational subgroups. Control charts for attributes- np, p and c charts. Fundamental concepts of acceptance, sampling plans, single, double and sequential sampling plans for attributes inspection. Sampling inspection tables for selection of single and double sampling plans.

AST 520 / AEC 508 ***Optimization Techniques*** **(1+1)**

Theory

Optimization and decision-making-Concepts in decision making, Mathematical basis underlying optimization models, introduction to linear programming, uses of LP in different fields, Formulation of farm and nonfarm problems as linear programming models, graphic solution to LP problems. Simplex Method: Concept of simplex method, solving profit maximization and cost minimization problems. Problem of degeneracy, infeasible and unbounded solutions, Primal and dual concepts. Extension of Linear Programming models: Variable resource and price programming, transportation problems, recursive programming, dynamic programming, integer programming, goal programming Concept of non-linear programming models. Game theory - Concepts of game theory, two person zero sum game, saddle point, solution to mixed strategies, graphic method, inventory management. PERT, simulation and queuing theory.

Practical

Graphical and algebraic formulation of linear programming models. Solving of maximization and minimization problems by simplex method. Formulation of the LP problems for typical

farm situations. Transportation problems, Game theory problems. Use of computers for solving optimization problems.

AST 521 ***Demography*** **(2+0)**

Theory

Introduction to vital statistics, crude and standard mortality and morbidity rates, Estimation of mortality, Measures of fertility and mortality, period and cohort measures. Life tables and their applications, methods of construction of abridged life tables, Increment-Decrement Life Tables. 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. 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.

AST 522 ***Statistical Methods for Life Sciences*** **(2+0)**

Theory

Proportions and counts, contingency tables, logistic regression models, Poisson regression and log-linear models, models for polytomous data and generalized linear models. 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 nonparametric 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). 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. 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 biostatistical analysis techniques with emphasis on data applications. Newton, scoring, and EM algorithms for maximization; smoothing methods; bootstrapping; trees and neural networks; clustering; isotonic regression; Markov chain Monte Carlo methods.

AST 523 ***Statistical Ecology*** **(2+0)**

Theory

Ecological data, Ecological sampling; Spatial pattern analysis: Distribution methods, Quadrant-variance methods, Distance methods. Species-abundance relations: Distribution models, Diversity indices; Species affinity: Niche-overlap indices, interspecific association, interspecific covariation. UNIT III Community classification: Resemblance functions, Association analysis, Cluster analysis; Community Ordination: Polar Ordination, Principal Component Analysis, Correspondence analysis, Nonlinear ordination. Community interpretation: Classification Interpretation and Ordination Interpretation.

AST 524 ***Non-parametric Methods*** **(1+1)**

Theory

Parametric V/s Non-parametric tests. Assumptions underlying non-parametric tests. Scales of measurements, merits and demerits. Power efficiency of tests. One sample tests: binomial, chi-square, Kolmogorov-Smirnov and run test. Two related sample tests: McNemar test, Sign test and Matched pair sign-rank test. Two independent sample tests: Fisher's Exact probability test, Chi-square test, K-related samples tests: Cochran's test Friedman's two-way ANOVA by ranks, K-

independent sample tests: Chi-square test, Median test Kruskal-wallis one way ANOVA by ranks. Measures of association: Spearman's rank correlation, Kendal's coefficient of correlation, phi coefficient, canners is co efficiencies kendars coefficient of contingency, coefficient of concordance.

Practical

Solving problems on above topics.

MAT 501 ***Mathematical Methods for Applied Sciences*** **(1+1)**

Theory

Variables and functions; limit and continuity. Specific functions. Differentiation: theorems of differentiation, differentiation of logarithmic, trigonometric, exponential and inverse functions, function of a function, derivative of higher order, partial derivatives. Application of derivatives in agricultural research; determination of points of inflexion, maxima and minima in optimization, *etc*. Singular points, Asymptotics and tracing of curves. Integration as a reverse process of differentiation, methods of integration, reduction formulae, definite integral; Applications of integration in agricultural research with special reference to economics and genetics, engineering, *etc*. 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, application of determinants and matrices in solution of equation for economic analysis. Rank of a matrix. Set theory -set operations, finite and infinite sets, operations of set, function defined in terms of sets. Venn diagrams, pictorial representations

Practical

Solving problems on above topics.

MAT 502 ***Mathematical Methods – I*** **(2+1)**

Theory

Real Analysis: Convergence and divergence of infinite series, use of comparison tests –Dalemberts Ratio – test, Cauchys nth root test, Raabes test, Kummers test, Gauss test. Absolute and conditional convergence. Riemann integration, concept of Lebesgue integration, power series, Fourier, Laplace and Laplace –Steiltjes transformation, multiple integrals. Calculus: Limit and continuity, differentiation of functions, successive differentiation, partial differentiation, mean value theorems, Taylor and Maclaurins series. Application of derivatives, Lhospitals rule.

Integration of rational, irrational and trigonometric functions. Application of integration. Improper integrals, Beta and Gamma functions. Dirichlet's and Liville's integrals. Differential equation: Differential equations of first order, linear differential equations of higher order with constant coefficient. Numerical Analysis: Simple interpolation, Divided differences, Numerical differentiation and integration.

Practical

Solving problems on the above topics

MAT 503 ***Mathematical Methods – II*** **(1+1)**

Theory

Linear Algebra: Group, ring, field and vector spaces, Sub-spaces, basis, Gram Schmidts orthogonalization, Galois field – Fermats theorem and primitive elements. Linear transformations. Graph theory: Concepts and applications. Matrix Algebra: Basic terminology, linear independence and dependence of vectors. Row and column spaces, Echelon form. Determinants, rank and inverse of matrices. Special matrices idempotent, symmetric, orthogonal. Eigen values and eigen vectors. Spectral decomposition of matrices. Unitary, Similar, Hadamard, Circulant, Helmerts 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. Generalized inverses, Moore-Penrose inverse, Applications of g-inverse. Spectral decomposition of matrices, Inverse and Generalized inverse of partitioned matrices, Differentiation and integration of matrices, Quadratic forms.

Practical

Solving problems on above topic.

CSC 501 ***Data Warehousing and Date Mining*** **(2+1)**

Theory

Concepts and Principles of data warehousing; Data warehousing architecture. System process architecture; data warehousing design database schema . Partitioning strategy; Aggregations; Data marts; Data management; Data warehousing process. Introduction to Data mining; to neural networks , fuzzy logics . Data pre-processing and cleaning. Data visualization techniques decision tree, Association rules; Clustering and Classification models and exploratory data analysis data mining techniques. Performance evaluation. Finding patterns and rules. Predictive and descriptive modeling. Issues relating to large data sets applications to web mining bioinformatics. Introduction.

Practical

Data warehousing design, selection of schema; normalization and re normalization; query plan strategy; performance tuning backup and recovery and data warehouse; Dynamic reporting and OLAP cubes; Data mining techniques; Neural networks, fuzzy logic, visualization techniques and decision trees.

CSC 502 ***Introduction to Networking and Internet Applications*** **(1+1)**

Theory

Networking fundamentals, types of networking, network topology; Introduction to File Transfer Protocol (FTP), Telnet, Simple Mail Transfer Protocol (SMTP). World Wide Web (WWW), working with Internet; Web pages, web sites, web servers; Web Applications. Hyper Text Markup Language (HTML), DHTML, web based application development.

Practical

Network and mail configuration; Using Network Services; Browsing of Internet; Creation of web pages; Creation of websites using HTML and Creation of websites using DHTML.

CSC 503 ***Object Oriented Analysis and Design*** **(2+1)**

Theory

Procedural abstraction, command and functional procedures. Data encapsulation – concepts of modules and interfaces; Data abstraction and types. Introduction to object orientation; History and evolution of object oriented languages; Object Oriented Programming (OOP) languages (e.g. C++ JAVA/C# *etc*.) – Abstract data types, classes, objects, object/message paradigm. Overloading, dynamic binding, parametric polymorphism. Inheritance: class and object inheritance, inheritance and dynamic binding, multiple inheritance. Object oriented software design; Generic and reusable classes.

Practical

Case studies using object oriented analysis and design (OOAD); Creation of classes with features – overloading, inheritance, data abstraction, polymorphism and Implementation of a case study.

CSC 504 ***Data Structures and Algorithms*** **(2+1)**

Theory

Representation of character, string and their manipulation. Linear list structure; Stacks; Queues; Heaps. Sorting algorithms; Searching algorithms. Representation and processing of linear linked lists; Multiple linked structures; Sparse arrays. Tree Structures: Representation of tree structures and different tree traversal algorithms. Graph and geometric algorithms.

Practical

Implementation of various types of structures – linked lists, doubly linked lists, circular linked lists, queue, dequeue, stack

and tree; String processing; Searching and sorting techniques; Graph and geometric algorithms and Case studies.

CSC 505 / BIM 504 ***Database Management System*** **(2+1)**

Theory

Database system – Operational Data, Characteristics of database approach, architecture. Overview of DBMS; Data associations – Entities, Attributes and Associations, Relationship among Entities, Representation of Associations and Relationship, Data Model classification. Entity Relationship model; Relational Data Structure- Relations, Domains and Attributes, Relational Algebra and Operations, Retrieval Operations. Relational Database Design – Anomalies in a Database, Normalization theory, and Normal forms; Query processing. Distributed Databases- concepts, architecture, design; Structured Query Language (SQL) – Data Definition Language (DDL), Data Manipulation Language (DML). PL/SQL – Stored procedure, Database triggers; Relational Data Base Management Package.

Practical

E-R diagram construction; SQL – Command Syntax, Data types, DDL Statements, DML Statements, integrity constraints; Triggers, creating stored procedures/ functions; Normalization of database and Case study on a database design and implementation.

CSC 506 ***Web Technologies and Applications*** **(1+1)**

Theory

Survey of contemporary Internet Technologies – Role, use and implementation of current tools. Application Layer Services and protocols – Domain name services, network management protocol, electronic mail and file transfer protocol. World Wide Web, Web pages, Web Sites, Web Servers; Intranet and Extranet Concepts; Web Application Architectures. Hyper Text Markup Language (HTML); Building static and dynamic web pages.

Scripting Languages – Client side and server side scripting; Interaction with database. Latest trends in programming on the emerging technologies relating to web based software development.

Practical

Designing static website with features like tables, hyperlink among pages, pictures, frames and layers; Client side scripting for user interface validation; Server side scripting for database interaction; and Designing of a information system.

CSC 507 ***Introduction to Computer Graphics*** **(1+1)**

Theory

Introduction, Application of Graphics, Elements of Graphics Workstation, Graphics I/P Devices; Development of computer graphics: Basic graphics system and standards. Raster scan and random scan graphics; Continual refresh and storages displays; Display processors and character generators; Colour display techniques. Frame buffer and bit operations, Concepts in raster graphics; Points, Lines and Curves; Scan conversion; Line-drawing algorithms; Circle and ellipse generation; Polygon filling; Conic-section generation. Antialiasing; Two-dimensional viewing: Basic transformations; Co- ordinate systems; Windowing and clipping; Segments; Interactive picture-construction techniques; Interactive input/output devices. Three-dimensional concepts: 3-D representations and transformations; 3- D viewing; Algorithm for 3-D volumes, Spline curves and surfaces. Fractals; Quadtree and Octree data structures; Hidden line and surface rendering and animation.

Practical

Implementation of algorithms for drawing geometrical figures, rotation, charts; Pixel handling on screen; Clipping Line clipping Polygon Clipping, Windowing; Use of primitive transformations and/ or their combinations; Implementation of 3D Object Representation and Fractal programming and animation.

CSC 508 ***GIS and Remote Sensing Techniques*** **(2+1)**

Theory

Introduction to Geographical Information System (GIS); Introduction maps and spatial information, components of a GIS; GIS Internals – data representation raster and vector data structures and analysis techniques. Digital Elevation Models; Data input, verification, storage and output. Spatial modelling-manual and automatic digitizing process; Data errors in GIS; Classification methods-multivariate analysis and classification. Spatial interpolation; Current and potential uses of GIS in agricultural planning; Software components used in GIS; GIS in India. Physics of remote sensing, atmospheric effects and remote sensing sensors; Spectral signatures of earth surface features, spectral characteristics of vegetation, soil and water. Data acquisition system, satellite image acquisition; Data collections: preprocessing and data storage; Visual and digital image interpretation; Digital image processing.

Practical

Digitization of a map with the help of a digitizer; Map editing; Geo- referencing and map projections; Creation of attribute database and linking with spatial data; General analysis of the data with the help software; Applications of digital elevation models using GIS; Spatial interpolations using GIS; Visual interpretations of remote sensing data; Geometric corrections of remote sensing digital data; Methods for improving quality of digital data and Techniques of image classifications.

CSC 509 ***Bioinformatics Computing*** **(2+1)**

Theory

The Central Dogma, Review and Utilization of Biological Databases. Overview of Algorithms: Pattern Matching, Biological Motivation Nave Algorithm. Pre-processing: Suffix trees Time and Space Considerations. Approximate Pattern Matching: Sequence Comparisons, Dot Plots. Sequence

Alignment: Dynamic Programming, Global and Local Alignments Scoring Matrices, BLAST, FASTA Parameters. Similarity and Distance: PAM & BLOSUM matrices, Heuristic Approaches. Exhaustive Search Fragment Assembly: DNA Sequencing, Greedy Algorithms, Sequencing by Hybridization Fragment Assembly. Graph Algorithms, Overlap Graphs, and Hamiltonian Path Wrap-up.

Practical

Suffix trees: Time and Space Considerations; Approximate Pattern Matching: Sequence Comparisons, Dot Plots; Sequence Alignment: Dynamic Programming, Global and Local Alignments Scoring Matrices, BLAST, FASTA Parameters; Similarity and Distance: PAM & BLOSUM matrices, Heuristic Approaches and Exhaustive Search Fragment Assembly: DNA Sequencing, Greedy Algorithms, Sequencing by Hybridization Fragment Assembly, Graph Algorithms, Overlap Graphs, and Hamiltonian Path Wrap-up.

AGRONOMY

Course No.	Title	Credits
AGR 501	Modern Concepts in Crop Production	2+0
AGR 502	Principles and Practices of Soil Fertility and Nutrient Management	1+1
AGR 503	Principles and Practices of Weed Management	1+1
AGR 504	Principles and Practices of Water Management	1+1
AGR 505	Agrometeorology and Crop Weather Forecasting	2+1
AGR 506	Agronomy of Major Cereals and Pulses	1+1
AGR 507	Agronomy of Oilseed, Fibre and Sugar Crops	1+1
AGR 508	Agronomy of Medicinal, Aromatic and Under-utilized Crops	2+1
AGR 509	Agronomy of Fodder and Forage Crops	2+1
AGR 510	Dryland Farming	1+1
AGR 511	Cropping Systems	2+0
AGR 512	Principles and Practices of Organic Farming	1+1
AGR 513	Research Techniques in Agronomy	1+1
AGR 514	Crop Growth and Yield Analysis	1+1
AGR 571	Qualifying Examination	2
AGR 581	Seminar	2
AGR 591	Research	16

AGR 501 ***Modern Concepts in Crop Production*** **(2+0)**

Theory

Crop growth analysis in relation to environment; geo-ecological zones of India. Quantitative agro-biological principles and inverse yield nitrogen law; Mitscherlich yield equation, its interpretation and applicability; Baule unit. 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. Scientific principles of crop production; crop response production functions; concept of soil plant relations; yield and environmental stress. 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.

AGR 502 ***Principles and Practices of Soil Fertility and Nutrient Management*** **(1+1)**

Theory

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; Criteria of essentiality of nutrients; Essential plant nutrients – their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients. Preparation and use of farmyard manure, compost, green manures, vermicompost, biofertilizers and other organic concentrates their composition, availability and crop responses; recycling of organic wastes and residue management Commercial fertilizers; composition, relative fertilizer value and cost; crop response to different nutrients, residual effects and fertilizer use efficiency, fertilizer mixtures and grades; agronomic, chemical and physiological methods of increasing fertilizer use efficiency; nutrient interactions. Time and methods of manures and fertilizers application; foliar application and its concept; relative performance of organic and inorganic manures; economics of fertilizer use; integrated nutrient management; use of vermincompost and residue wastes in crops.

Practical

Determination of soil pH, ECe, organic C, total N, available N, P, K, S and selected micronutrients in soils and interpretation Determination of total N, P, K, S and selected micronutrients in plants and interpretation in plants Interpretation of interaction

effects and computation of economic and yield Optima Rapid tissue tests, soil testing kits as tools of soil fertility diagnosis, use of LCC and SPAD meter and pot culture studies using selected test crops for site specific nutrient management.

AGR 503 ***Principles and Practices of Weed Management*** **(1+1)**

Theory

Weed biology and ecology; Crop-weed competition including allelopathy; Weed indices Classification and characteristics of weeds; Principles and methods of weed control: prevention, physical, mechanical, cultural, biological including bio-herbicides, allelochemicals and chemical weed control. Herbicides-introduction and history of their development, Classification based on chemical, physiological application and selectivity; Mode and mechanism of action of herbicides Herbicide structure – activity relationship; Factors affecting the efficiency of herbicides; Herbicide formulations, herbicide mixtures; Herbicide resistance and management; Weed control through bio-herbicides; Myco-herbicides and allelochemicals; Degradation of herbicides in soil and plants; Herbicide resistance in weeds and crops. Herbicide rotation. Weed management in major crops and cropping systems; Parasitic weeds; Weed Shifts in cropping systems; Aquatic and perennial weed control, integrated weed management; 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, preparation of spray solutions of herbicides for high and low volume sprayers, use of various types of spray pumps and nozzles and cacluation of swath width, economics of weed control. Herbicides resistance analysis in plants and soil, Bioassay of herbicide resistance, calculation of herbicidal requirement.

AGR 504 ***Principles and Practices of Water Management*** **(1+1)**

Theory

Water and its role in plants; water resources of India, major irrigation projects, extent of area and crops irrigated in India and different states. Problelms of irrigated agriculture in India and Karnataka. Soil 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. Soil, plant and meteorological factors determining water needs of crops; scheduling, depth and methods of irrigation ,micro irrigation, system; fertigation; management of water in controlled environments and polyhouses. Methods to determine water requirement of crops. Water management of the crops and cropping systems; quality of irrigation water and management of saline water for irrigation; water use efficiency. 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. Principles and practices of drainage.

Practical

Measurement of soil water potential by using tensiometer, and pressure, plate and membrane apparatus, Study of sprinkler irrigation system. Soil-moisture characteristics curves, Study of drip irrigation system, water flow measurements using different devices, Working out of crop W.R. Determination of irrigation requirements. Study on on farm development structures. Calculation of irrigation efficiency. Determination of infiltration rate. Determination of saturated / unsaturated hydraulic conductivity. Visit to CADA.

AGR 505 ***Agrometeorology and Crop Weather Forecasting*** **(2+1)**

Theory

Agro meteorology - aim, scope and development in relation to crop environment; composition of atmosphere, distribution of atmospheric pressure and wind. Characteristics of

solar radiation; energy balance of atmosphere system; radiation distribution in plant canopies, radiation utilization by field crops; photosynthesis and efficiency of radiation utilization by field crops; energy budget of plant canopies; environmental temperature: soil, air and canopy temperature. Temperature profile in air, soil, crop canopies; soil and air temperature effects on plant processes; environmental moisture and evaporation: measures of atmospheric temperature and relative humidity, vapor pressure and their relationships; evapo-transpiration and meteorological factors determining evapotranspiration. Modification of plant environment: artificial rain making, heat transfer, controlling heat load, heat trapping and shading; protection from cold, sensible and latent heat flux, controlling soil moisture; monsoon and their origin, characteristics of monsoon; onset, progress and withdrawal of monsoon; weather hazards, drought monitoring and planning for mitigation. Weather forecasting in India – short, medium and long range; aerospace science and weather forecasting; benefits of weather services to agriculture, remote sensing; application in agriculture and its present status in India; atmospheric pollution and its effect on climate and crop production; climate change and its impact on agriculture.

Practical

Visit to agro-meteorological observatory to record sun-shine hours, wind velocity, wind direction, relative humidity, soil and air temperature, evaporation, precipitation and atmospheric pressure; Measurement of solar radiation outside and within plant canopy; Measurement/estimation of evapo-transpiration by various methods; Measurement/estimation of soil water balance; Rainfall variability analysis; Determination of heat-unit requirement for different crops; Measurement of crop canopy temperature; Measurement of soil temperatures at different depths; Remote sensing and familiarization with agro-advisory service bulletins; Study of synoptic charts and weather reports, working principle of automatic weather station; Visit to solar observatory.

AGR 506 ***Agronomy of Major Cereals and Pulses*** **(1+1)**

Theory

Origin and history, area and production, distribution, classification, improved varieties, adaptability, climate, soil, water and cultural requirements, nutrition, quality components, industrial uses and the main and by-products, handling and processing of the produce for maximum production of *Rabi cereals*: a) Wheat b) Sorghum, *Kharif cereals*: a) Rice b) Sorghum c) Bajra d) Maize Finger millet and f) Small millets, *Rabi pulses*: a) Chickpea b) Peas, *Kharif pulses* : a) Pigeonpea b) Mungbean c) Urdbean d) Cowpea e) Horsegram.

Practical

Analysis of area, production and productivity of cereals, millets and pulses in Karnataka, India and world. 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 (CER, CGR, RGR, NAR, LAD), aggressiveness, relative crowding coefficient, monetary yield advantage and ATER of prominent intercropping systems of different crops.). Estimation of protein content in pulses, Planning and layout of field experiments. Establishment of cereals, millets and pulses in crop museum. Judging of physiological maturity in different crops. Intercultural operations in different crops. Determination of cost of cultivation of different crops, Working out harvest index of various crops. Study of seed production techniques in various crops. Visit of field experiments on cultural, fertilizer, weed control and water management aspects. Visit to nearby taluks for identification of constraints in crop production.

AGR 507 ***Agronomy of Oilseed, Fibre and Sugar Crops*** **(1+1)**

Theory

Origin and history, area and production, classification, improved varieties, adaptability, climate, soil, water and cultural requirements, nutrition quality component, handling and

processing of the produce for maximum production of : Rabi oilseeds – Rapeseed and mustard, linseed, *etc.*, Kharif oilseeds - Groundnut, sesame, castor, sunflower, soybean *etc*., Fiber crops - Cotton, jute, sunhemp *etc*., Sugar crops – Sugar-beet and sugarcane.

Practical

Planning and layout of field experiments, Cutting of sugarcane setts, its treatment and methods of sowing, tying and propping of sugarcane, Determination of cane maturity and calculation on purity percentage, recovery percentage and sucrose content in cane juice phonological studies at different growth stages of crop, Intercultural operations in different crops, Cotton seed treatment. 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 fibre of different fibre crops, Study of seed production techniques in various crops, Visit to field experiments on cultural, fertilizer, weed control and watermanagement aspects, Visit to nearby villages for identification of constraints in crop production, Visit to AICRP on different oilseed crops, Visit to VC farm Mandya, CTRI, Hunsur and CTRL, Nagpur / Mumbai Visit to sugar factory and oil mills.

AGR 508 ***Agronomy of Medicinal, Aromatic and Under-utilized Crops*** **(2+1)**

Theory

Importance of medicinal and aromatic plants in human health, national economy and related industries, classification of medicinal and aromatic plants according to botanical haracteristics and uses. Climate and soil requirements; cultural practices; yield and important constituents of medicinal plants (Isabgol, Rauwolfia, Poppy, *Aloe vera*, Satavar, Stevia, Safed Musli, Kalmegh, Asaphoetida, *Nux vomica*, Rosadle, *etc.*).

Climate and soil requirements; cultural practices; yield and important constituents of aromatic plants (Citronella, Palmarosa, Mentha, Basil, Lemon grass, Rose, Patchouli, Geranium *etc*.). Climate and soil requirements; cultural practices; yield of under-utilized crops (Rice bean, Lathyrus, Sesbania, Clusterbean, French bean, Fenugreek, Grain Amaranth, Coffee, Tea and Tobacco).

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.

AGR 509 ***Agronomy of Fodder and Forage Crops*** **(2+1)**

Theory

Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important fodder crops like maize, jowar, *bajra*, *guar*, cowpea, oats, barley, berseem, *senji*, lucerne, *etc*. Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important forage crops/grasses like, napier grass, *Panicum*, *Cenchrus*, *Dicanthu mumpennisetum*, *etc*. Year-round fodder production and management, preservation and utilization of forage and pasture crops. Grass covers of India, problems and management of grasslands. Silvipastural systems. 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. Economics of forage cultivation uses and seed production techniques.

Practical

Farm operations in raising fodder crops; Canopy measurement, yield and quality estimation, *viz*. crude protein;

NDF, ADF, lignin, silica, cellulose *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.

AGR 510 ***Dryland Farming*** **(1+1)**

Theory

Definition, concept and characteristics of dry land farming; dry land versus rainfed farming; significance and dimensions of dry land farming in Indian agriculture. Modification of plant environment: artificial rain making, heat transfer, controlling heat load, heat trapping and shading; protection from cold, sensible and latent heat flux, controlling soil moisture; monsoon and their origin, characteristics of monsoon; onset, progress and withdrawal of monsoon; weather hazards, drought monitoring and planning for mitigation. Weather forecasting in India – short, medium and long range; aerospace science and weather forecasting; benefits of weather services to agriculture, remote sensing; application in agriculture and its present status in India; atmospheric pollution and its effect on climate and crop production; climate change and its impact on agriculture. Soil and climatic parameters with special emphasis on rainfall characteristics; constraints limiting crop production in dry land areas; characterization of environment for water availability. Types of drought, stress physiology and resistance to drought, adaptation of crop plants to drought, drought managment strategies; preparation of appropriate crop plans for dry land areas; mid contingent plan for aberrant weather conditions. 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); anti-transpirants; soil and crop management techniques, seeding and efficient fertilizer use. Concept of watershed, principles, identification of watershed, delineation, prioritization, characterization, watershed planning and implementation, resource management , problems, approach and components.

Practical

Seed treatment, seed germination and crop establishment in relation to soil moisture contents, Moisture stress effects and recovery behavior of important crops, Measurement/estimation of soil water balance, Rainfall variability analysis, Estimation of moisture index and aridity index, Remote sensing and familiarization with agro-advisory service bulletins, Spray of anti-transpirants and their effect on crops, Collection and interpretation of data for water balance equations for ACZ of Karnataka, Rain water budgeting, Water use efficiency, Preparation of crop plans for different drought conditions, Study of field experiments relevant to dryland farming, Map reading - Watershed delineation, Visit to dryland research stations and watershed projects

AGR 511 ***Cropping Systems*** **(2+0)**

Theory

Cropping systems: definition, indices and their importance: management of physical resources, soil and water management in cropping systems; assessment of land use, Overview of cropping systems of India. Concept of sustainability in cropping systems and farming systems, scope, objectives and constraints ; production potential under monoculture cropping, multiple cropping, alley cropping sequential cropping and cropping and intercropping , mechanism of yield advantage in intercropping systems. Above and below ground interactions and allelopathic effects; competition relations; multi-storeyed cropping and yield stability in intercropping, role of non-monetary inputs and low cost technologies; Yield stability in cropping systems. Crop diversification – objectives and relevance to sustainability; role of organic matter in maintenance of soil fertility; crop residue management; nutrient use efficiency in intensive and extensive cropping system. Plant ideotypes cropping systems, crop architecture. Latest research trends in system approach towards sustainability; Study of different sustainable cropping systems of agro-ecological zones of India.

AGR 512 ***Principles and Practices of Organic Farming*** **(1+1)**

Theory

Organic farming – concept and definition, its relevance to India and global agriculture and future prospects; land and water management – land use, minimum tillage; shelter zones, hedges, pasture management, agro-industry. Organic farming and water use efficiency; soil fertility, nutrient recycling, organic residues, organic manure, composting, soil biota and decomposition of organic residues, earthworms and vermicompost, green manures and bio fertilizers. Nutrient release pattern in different organics. Improved Farming system model, crop rotations, multiple and relay cropping systems, intercropping in relation to maintenance of soil productivity. Control of weeds, diseases, and insect pest management, biological agents and pheromones, bio pesticides. Socio economic impacts; marketing and export potential; inspection, certification, labelling and accreditation procedures; organic farming and national economy.

Practical

Aerobic and anaerobic methods of making compost & manures and their evaluation, Making of vermi compost, Preparation of vermi-wash and its use, Preparation of liquid manures and their use. Study of green manure crops & their use in different ways, Preparation and use of bio fertilizers and bio pesticides, Laboratory analysis of manures, composts, liquid manures, vermi wash for their major nutrients, Visit to organic farm, visit to mechanical composting unit. Study of oil cakes and their use in different ways. Visit to Agro-foresty model farms. Estimation of litter biomass.

AGR 513 ***Research Techniques in Agronomy*** **(1+1)**

Theory

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. Research projects proposal, format and screening. Pitfalls in experiments. Field experimentation, Laboratory and pot culture experiments. Principles of field experimental designs, soil heterogeneity and measures of competitions under field

experimental conditions. Uniformity trials; 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; Presentation of data writing and reviewing of technical papers, participation in agronomic seminar and conferences, thesis writing Biometric observations of agronomic experiments, crop growth and development growth 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. Transformation of experimental data. Experimental design, CRD and RBD Latin square and factorial experiments. Confounding and splitplot designs Correlation and regression analysis, crop response curves, dynamics of crop growth and modeling,

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.

AGR 514 ***Crop Growth and Yield Analysis*** **(1+1)**

Theory

Crop growth and development, Growth expressions in plants. Growth measurements. History and development of important growth indices and forms of growth analysis in field crops. Genesis of crop yield, formation of yield components. Plant density and yield relationships in crops- density equations. The senescence of leaf, leaf area and leaf area duration, chlorophyll content, development of primordium, chloroplast and their relation to dry matter production and yield. Accumulation and distribution of dry matter- partition analysis of crop plants, contribution of each part to economic yield. Factors determining yields. Use of growth analysis technique to study variation in yield due to planting season, planting density, fertilizer treatment, other agronomic practices, light, temperature, water, growth substances, varietal differences. Crop response curves. Dynamics of crop growth and modeling.

Practical

Partitional analysis of dry matter production and accumulation in different crops. Patterns of nutrient contents and dry weight accumulation of whole plants (%) and in different parts. Dry matter accumulation (% of total) curves and their importance in crop growth and development of the plant. Methods of measuring leaf area and estimation of leaf production constant (factor) in different crops. Estimation of leaf area and leaf angle at different profiles in different crops. Estimation of dry matter production (g/plant) and accumulation (% to total). Estimation of LA/plant (cm^2), Leaf area index (LAI) and leaf area duration (LAD, days). Estimation of Absolute growth rate (AGR, g/plant/day), Daily rate of DM production and relative growth rate (RGR, g/day). Estimation of leaf area ratio (LAR), Relative growth rate of leaf (RGRL), leaf weight ratio (LWR) and Specific leaf area (SLA). Computation of growth indices for the given primary data and presentation of these through tables and graphs. Estimation of Net assimilation rate (NAR, g/dm^2/day by Gregory's method (Ea) and whitehead and Myers cough's

method (E'a) and Crop growth rate (CGR, g/cm^2/ day). Study on light transmission and radiation measurements in relation to canopy analysis studies (Co- efficient of solar energy utilization). Estimation of chlorophyll content in different crops and relating them to growth and yield thorough chlorophyll index. Computation of biological yield, harvest index (HI), Grain to leaf ratio and dry matter efficiency (DME). Study of relationship between growth and yield components in expression of ultimate yield in different crops. Working out crop response curves. Working out crop growth – modeling.

APICULTURE

Course No.	Title	Credits
API 501	Bee Morphology and Anatomy	1+1
API 502	Biology of Honey Bees	1+1
API 503	Bee Physiology	1+1
API 504	Bee Ecology and Behaviour	1+1
API 505	Bee Toxicology	1+1
API 506	Bee Keeping and its Management	1+1
API 507	Honey and Bee Products	1+1
API 508	Bee Pollination and Crop Production	1+1
API 509	Bee Pests and Diseases	1+1
API 510	Non-Apis Pollinators	1+1
API 511	History, Development and Techniques of Bee Keeping	1+1
API 512	Classification and Systematics of Bees	1+1
API 513	Genetics and Breeding of Honey Bees	1+1
API 571	Qualifying Examination	2
API 581	Seminar	2
API 591	Research	16

API 501 ***Bee Morphology and Anatomy*** **(1+1)**

Theory

Integument structures, segmentation and modifications. Body regions, appendages and other structures with modifications and their importance. Distinguishing morphological characters of different castes of honey bee species. Structure and modifications of digestive, circulatory, excretory, respiratory, reproductive, sensory, nervous and glandular systems. Bee musculature. Approaches to cytology, karyology and embryology.

Practical

Studying the morphology 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 systems such as digestive, circulatory, reproductive, nervous and glandular system.

API 502 ***Biology of Honey Bees*** **(1+1)**

Theory

Evolution of honeybees, species of honeybees, their races and strains. Growth and development of different bee species and their castes. Biotic factors influencing growth and development, growth curves, role of nutrition on bee biology. Moulting and associated phenomenon. Polytheism and its basis, feeding response of honey bees. Sex and caste determination, nest architecture, regulatory mechanism of colony development. Reproduction-swarming, supersedure and mating. Abnormalities in honey bees.

Practical

Study of honey bee life cycle with special reference to hive bees; sex and caste determination; observation 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.

API 503 ***Bee Physiology*** **(1+1)**

Theory

Importance of physiology, functional details of various systems – digestive, excretory, respiratory, reproductive, circulatory, neural and sensory systems. Nutrition of larva and adult honey bee. Physiology of moulting. Endocrine and exocrine glands of bees. Honey bee pheromones - production, composition and importance.

Practical

Study of honey stomach and other functional regions of digestive system. Study of hemolymph and its composition. Study of glandular systems and its 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.

API 504 ***Bee Ecology and Behaviour*** **(1+1)**

Theory

Ecosystem-trophic structure. Nutrient cycling, growth curves, life tables, population regulation, dispersal and migration. Intra and interspecific interaction. Distribution and abundance of bee species. Evolution and degree of sociality in bees. Foraging, swarming, defense, robbing, homeostasis and migration behavior; activities of queen and drones; behaviour in queenless colony. Role of pheromones in social organization, handling, processing and storage of food. Factors affecting behaviour - seasonal changes, age and environmental factors. Communication through dancing.

Practical

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 workers in queenless and queen right colonies. Defensive behaviour of worker bees against various predators. Population estimation of bee colonies.

API 505 ***Bee Toxicology*** **(1+1)**

Theory

Toxicology - definition and scope. Insecticide classification, types of formulations, mode of action and structure activity relationship of major groups of insecticides. Insecticide

metabolism, penetration and distribution of insecticides, poisoning symptoms - remedies and prevention of insecticidal poisoning. Poisoning by plants - injury, detection and remedies. Weedicide poisoning, industrial poisoning, bee attractants and repellents. Pesticide residues in bee environment. Insecticide Acts, safe use of pesticides.

Practical

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.

API 506 ***Bee Keeping and its Management*** **(1+1)**

Theory

Starting of bee keeping, ideal location for apiary. Locating and hiving natural colonies. Colony examination and seasonal management. Swarming and its prevention, robbing and its prevention, absconding and its prevention. Methods of queen raring and instrumental insemination, dividing and uniting colonies, two queen management, package bees, migratory bee keeping, management for commercial honey production. Study of bee hives and other bee keeping equipments. Wild bee management.

Practical

Selection of ideal sites for apiary. Hiving natural colonies, handling of bee colonies, swarm catching. Study of robbing and its prevention. Swarming and its prevention. Dividing and uniting colonies. Feeding colonies with artificial food. 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

API 507 ***Honey and Bee Products*** **(1+1)**

Theory

Honey – categories and types, physical and chemical properties, harvesting, processing, storage and marketing of honey. Purity standard of honey, detection of adulteration, crystallization, fermentation and its prevention. Uses and value addition of honey; Composition, properties, production, processing, uses and marketing of other bee/hive products such as - Wax, pollen, propolis, royal jelly, bee venom.

Practical

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 bee keepers societies in Karnataka.

API 508 ***Bee Pollination and Crop Production*** **(1+1)**

Theory

Modes of pollination and its ecological significance. Assessment of pollination efficiency, pollination ecology, foraging behaviour of honey bees. Pollination of agricultural, horticultural, plantation and greenhouse crops. 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 in pollination. Pollination specialities.

Practical

Crop wise pollinator diversity, 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 submission.

API 509 ***Bee Pests and Diseases*** **(1+1)**

Theory

Natural enemies - classification, abundance and distribution. Biology and management of insect enemies. Honey bee diseases - bacterial, protozoan, viral, fungal - virulence, infection, epizootology, symptomatology, pathology and management. Mite and vertebrate pests and their management.

Practical

Collection and identification of bee pests. Examination of colonies affected by pests and diseases. Collection, isolation and identification of bee pathogens such as bacteria, fungi, virus, and protozoa. Studying the symptoms of various diseases. Preservation of honey bee pathogens in vitro. Study of acarine diseases and their management. Methods of pest and disease management

API 510 ***Non-Apis Pollinators*** **(1+1)**

Theory

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. Comparative morphological and anatomical studies of non-apis bees. Biology of specific non-apis bees. Evolution of pollinators- plant relationship. Commercial production of non-apis bees. Importance of other group of pollinators.

Practical

Study of taxonomic characters of non-apis bees and their identification using taxonomic keys. Collection and identification

of various non-apis insect pollinators. Study of pollinator competition on flowering plants. Study of nesting sites, foraging behavior and efficiency of non-apis pollinators; collection and submission of non-apis pollinators.

API 511 ***History, Development and Techniques of Bee Keeping*** **(1+1)**

Theory

History and Development of Apiculture in India and world from ancient to modern times. Eminent personalities involved and innovations in the development of bee keeping. Institutions involved in bee keeping in India and abroad. Research and training in bee keeping. Role of Government and other organizations in development of Apiculture.

Practical

Materials and techniques for collection, 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 Centers. Writing of research papers and thesis, proof reading, presentation of papers in scientific fora, use of audio-visual aids.

API 512 ***Classification and Systematics of Bees*** **(1+1)**

Theory

History of bee classification, Principles of bee classification, zoological nomenclature, concept of species, genera and other categories. Zoo-geography of honey bees. Phylogeny and evolution. Construction and use of taxonomic keys. Knowledge of the order - Hymenoptera and families, sub-families and tribes of Apoidea. Morphometrics and its importance in establishing ecotypes.

Practical

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. Submission of bee species.

API 513 ***Genetics and Breeding of Honey Bees*** **(1+1)**

Theory

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. Different methods of breeding and selection of queen. Breeding techniques - instrumental insemination, storage, transport and preservation of semen. Breeding for disease resistance, honey production, pollination, prolificity and other characters. Interspecific breeding and genomics of honeybees.

Practical

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*.

BIOINFORMATICS

Course No.	Title	Credits
BIM 501 / PBT 501	Principles of Biotechnology	1+1
BIM 502 / PBT 518	Introduction to Bioinformatics	1+1
BIM 503	Introduction to Computer Application	1+1
BIM 504 / CSC 505	Database Management System	2+1
BIM 505	Comparative Genomics	1+1
BIM 506	Phylogenetic Analysis	1+1
BIM 507	Biological Databases and Data Analysis	1+1
BIM 508	Advanced Bioinformatics	2+1
BIM 509	RNA / Protein Structure Prediction & Molecular Modelling	1+1
BIM 510	Techniques in Bioinformatics	0+2
BIM 511	Tools and Techniques for Biological Data Mining	1+2
BIM 512 / AST 512	Statistical Genetics	2+1
BIM 513	Advanced Techniques for Sequence and Structure Analysis	2+1
BIM 514	Advnced Programming in Bioinformatics	1+2
BIM 571	Qualifying Examination	2
BIM 581	Seminar	2
BIM 591	Research	16

BIM 501 / PBT 501 ***Principles of Biotechnology*** **(1+1)**

Theory

History, scope and importance; DNA structure, function and metabolism. DNA modifying enzymes and vectors; Methods of recombinant DNA technology; Nucleic acid hybridization; Gene libraries; PCR amplification; Plant and animal cell and tissue culture techniques and their applications. Molecular markers and their applications; DNA sequencing; Applications of gene cloning in basic and applied research; Genetic engineering and transgenics; Genomics, transcriptomics and proteomics. General application of biotechnology in Agriculture, Medicine, Animal husbandry; Environmental remediation, Energy production, Forensics; Public perception of biotechnology; Bio-safety and bioethics issues; Intellectual property rights in biotechnology.

Practical

Isolation of genomic and plasmid DNA, Gel electrophoresis techniques, Restriction enzyme digestion, ligation, transformation and screening of transformants, PCR and molecular marker analysis; Plant tissue culture: media preparation, cell and explant culture, regeneration and transformation.

BIM 502 / PBT 518 ***Introduction to Bioinformatics*** **(1+1)**

Theory

Introduction, biological databases – primary, secondary and structural; Protein and Gene Information Resources – PIR, SWISSPROT, PDB, genebank, DDBJ. Specialized genomic resources. DNA sequence analysis, cDNA libraries and EST, EST analysis, pairwise alignment techniques, database searching, multiple sequence alignment. Secondary database searching, building search protocol, computer aided drug design – basic principles, docking, QSAR. Analysis packages – commercial

databases and packages, GPL software for bioinformatics, web-based analysis tools.

Practical

Usage of NCBI resources, Retrival of sequence/structure from databases, Visualization of structures, Docking of ligand receptors, BLAST exercises.

BIM 503 ***Introduction to Computer Application*** **(1+1)**

Theory

Computer organization; Software - System software and Application software. Networking fundamentals, types of networking, network topology; File Transfer Protocol (FTP), Telnet, Simple Mail Transfer Protocol (SMTP). Internet basics; Hyper Text Markup Language (HTML). Web designing; Web servers. Image Processing with emphasis on biological systems.

Practical

Network and mail configuration; Using Network Services; Creation of web pages, Web Search logics, Search logics in internet data resources, Image processing and analysis

BIM 504 / CSC 505 ***Database Management System*** **(2+1)**

Theory

Database system - Operational Data, Characteristics of database approach, architecture. Overview of DBMS; Data associations - Entities, Attributes and Associations, Relationship among Entities, Representation of Associations and Relationship, Data Model classification. Entity Relationship model; Relational Data Structure- Relations, Domains and Attributes, Relational Algebra and Operations, Retrieval Operations. Relational Database Design - Anomalies in a Database, Normalization theory, and Normal forms; Query processing. Distributed Databases- concepts, architecture, design; Structured Query

Language (SQL) - Data Definition Language (DDL), Data Manipulation Language (DML). PL/SQL - Stored procedure, Database triggers; Relational Data Base Management Package.

Practical

E-R diagram construction; SQL - Command Syntax, Data types, DDL Statements, DML Statements, integrity constraints; Triggers, creating stored procedures/ functions; Normalization of database and Case study on a database design and implementation

BIM 505 ***Comparative Genomics*** **(1+1)**

Theory

Objective and Overview of Genome Comparisons; Genome Alignments: BLAST2, MUMmer, PipMaker, VISTA; Comparison of Gene Order; Comparative Genomics: Synteny among Prokaryotes and Eukaryotes; Comparative Genomics Databases: COG, VirGen, CORG, HOBACGEN, Homophila, XREFdb, Gramene; Single Nucleotide Polymorphisms: dbSNP and other SNP-related databases.

Practical

Querying comparative genomics resources.Query SNP and SNP-related databases.query the protein-protein interaction databases. Genomic sequences comparison using BLAST2, MegaBLAST and Discontiguous MegaBLAST, MUMmer, PipMaker, VISTA Artemis. Coparative genome studies using model prokaryotes and eukaryotes.

BIM 506 ***Phylogenetic Analysis*** **(1+1)**

Theory

Phylogenetic trees and their comparison: Definition and description, various types of trees; Consensus (strict, semi-strict, Adams, majority rule, Nelson); Data partitioning and combination. Tree to tree distances, similarity; Phylogenetic analysis algorithms: Maximum Parsimony, Distance-based: UPGMA, Transformed Distance, Neighbors-Relation, Neighbor-

Joining. Probabilistic models of evolution, Maximum likelihood algorithm ; Approaches for tree reconstruction: Character optimization; delayed and accelerated transformation, Reliability of trees, Bootstrap, jackknife, decay, randomization tests; Applications of phylogeny analyses: Comparison of Phylogenetic Trees obtained using DNA seq. Vs. protein seq. Vs. Full genomes. Need for addition of other properties towards total phylogenetic analysis, Comparative methods for detection of species / organism relationships, Gene duplication, Horizontal transfer, Domain evolution, Study of co-evolution: Plant-insect interactions. Hostparasite interactions, Viral evolution.

Practical

Preparation sequence data for phylogenetic analysis; Cluster analysis using oper source R. Phylogenetic analysis using MEGA, Phylip, *etc*.; Multiple sequence alignment using CLUSTALW. Understanding UPGMA, Neighbor-joining, Neighbor-relations & Transformed distance, Maximum Parsimony, Maximum likelihood; Use of Bootstrapping tool; Use of different tree types.
Suggested Readings:

BIM 507 ***Biological Databases and Data Analysis*** **(1+1)**

Theory

Nature of biological data; Overview of available biological data resources on the web; NCBI/EBI/EXPASY *etc*; Biological Databases: Nucleic acid sequence databases; GenBank/EMBL/DDBJ; Biological Databases: Protein sequence databases; PIR-PSD; SwissProt, UniProtKB, Metabolome databases; Database search engines: Entrez, SRS. Overview/concepts in sequence analysis; Pairwise sequence alignment algorithms:Needleman & Wunsch, Smith & waterman ; Scoring matrices for Nucleic acids and proteins: MDM, BLOSUM, CSW; Database Similarity Searches: BLAST, FASTA; Multiple sequence alignment: PRAS, CLUSTALW; Biological databases: Genome & genetic disorders. Genome

databases: Human, model organisms, microbes & viral: OMIM; Biological databases: structural databases: PDB, NDB, CCSD; Derived databases: Prosite, BLOCKS, Pfam/Prodom.

Practical

Nucleic acid sequence databases, Protein sequence databases, Database search engines, Database Similarity Searches, Multiple sequence alignment, Genome databases, Structural databases, Derived databases

BIM 508 ***Advanced Bioinformatics*** **(2+1)**

Theory

Genomic databases and analysis of high-throughput data sets, Analysis of DNA sequence, Sequence annotation, ESTs, SNPs. BLAST and related sequence comparison methods. 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. 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), 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.

BIM 509 ***RNA / Protein Structure Prediction & Molecular Modelling*** **(1+1)**

Theory

Structural data, databases and structure analysis: Exploring the Database searches on PDB and CSD, WHATIF Molecular visualization tools; Visualization of tertiary structures, quaternary structures, architectures and topologies of proteins and DNA using molecular visualization softwares such as RasMol, Cn3D, SPDBV,Chime, Mol4D, *etc*; Structure prediction tools and homology modeling: Prediction of secondary structures of proteins using different methods with analysis and interpretation of the results; Comparison of the performance of the different methods for various classes of proteins. (Fasman method, Garnier Osguthorpe Robson (GOR), Neural Network based; methods);NLP approach for secondary structure

prediction of RNA; Introduction to mfold and Vienna packages; Prediction of tertiary structures of proteins using Homology Modeling approach: SWISSMODEL, SWISS-PDB Viewer; Prediction of tertiary structures of proteins different methods for fold recognition along with analysis and interpretation of results (Threading techniques; Homology Modeling and abinitio methods). Molecular dynamics simulation and docking: Basic principles of theoretical modeling, Empirical force fields for biomolecular simulations, Energy minimization, Molecular dynamics, Monte Carlo simulation Peptide building (PYMOL / DStools).

Practicals:

Structural data, databases and structure analysis, Molecular visualization tools, Structure prediction tools and homology modeling, Molecular dynamics simulation and docking

BIM 510 ***Techniques in Bioinformatics**** **(0+2)**

Practical

Gene Information Resources: GenBank, EMBL, Protein Information Resources: Swiss-Prot, BLOCKS, Gene Prediction Tools: GENSCAN, GRAIL. Structural Databases: PDB, CSD, RELIBASE, REBASE, File Format Converter Tools: BABEL, ReadSeq, NCBI Resources. Visualization tools – RasMol, QMol, Swiss PDB, Pymol, Modelling Tools: MODELLER, SwissPDB, Geno3D, Docking Tools: Chimera, Dock, AutoDock, GRAMM, Hex, Argus Lab. Proteomics Tools: EXPASY, CDART, 3D-Structure Optimization Tools, Sequence Analysis Tools: BLAST, FASTA, EMBOSS, TCOFFEE, Phylogenetic Analysis Tools: Phylip, NTSYS, CLUSTALW/CLUSTALX, BIOEDIT.

BIM 511 ***Tools and Techniques for Biological Data Mining*** **(1+2)**

Theory

Introduction to data mining; Quality of Biological Data & Data Accuracy; General issues regarding Biological Databases; Data cleaning; Data processing; Data Integration; visual data mining; Literature mining, Data mining methods for protein

subcellular location; Genomic sequence data mining; Mining Genomic Sequence Data for homology, Mining regulatory region; Biological Network mining; Text mining and its applications in life science; Automated mining of disease specific protein; Metric Methods in Data Mining; Bidirectional Constraint Pushing in Frequent Pattern Mining; Mining Hyperclique Patterns; Pattern Discovery in Biosequences; Data mining and machine learning; Foundations for Machine learning Techniques: Hidden Markov Model, Neural Network, Bayesian modeling, The Cox-Jaynes Axiomes.

Practical

Data mining tools and techniques for identification of Biomarkers, Data mining of DNA micrarray, Gene annotation data mining, Biomarker discovery by nining glycomic and lipidomic data, Small molecule chemical sctructure data mining.

BIM 512 / AST 512 ***Statistical Genetics*** **(2+1)**

Theory

Physical basis of inheritance. Analysis of segregation, detection and estimation of linkage for qualitative characters. Amount of information about linkage, combined estimation, disturbed segregation. Gene and genotypic frequencies, Random mating and Hardy – Weinberg law, Application and extension of the equilibrium law, Fishers fundamental theorem of natural selection. Disequilibrium due to linkage for two pairs of genes, sex-linked genes, theory of path coefficients. 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. 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. 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. 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.

BIM 513 ***Advanced Techniques for Sequence and Structure Analysis*** **(2+1)**

Theory

Advanced Techniques for Sequence Analysis; Sequence Profiles: Derivation, Databases, Application, Gapped BLAST, PSI-BLAST, PHI-BLAST; Advanced Techniques for Structure Analysis: Molecular replacement method, Direct method & Fiber diffraction, Methods for Comparison of 3D structures; Application of the optimization techniques: Sequence Alignments, Prediction of Protein Structure, Docking Simulations; Advance techniques in Prediction of 3D Structure: Rossetta Stone Hidden Markov Model, Neural networks. Molecular Dynamics Simulations & Monte Carlo Methods: Electrostatics of biomolecules, Simulations of Bio-

macromolecular Structures in Water & membrane, Free energy perturbation method; Simulated Annealing: Multiple Sequence Alignments, Simulations of Bio-macromolecular Structures; Designing of molecules like drug, inhibitors using Structure based and ligand based docking methods.

Practical:

Advanced Techniques for Sequence Analysis, Molecular replacement method, Methods for Comparison of 3D structures, Optimization techniques: Sequence Alignments, Prediction of Protein Structure, Docking Simulations; Advance techniques in Prediction of 3D Structure.

BIM 514 ***Advanced Programming in Bioinformatics*** **(1+2)**

Theory

Common Gateway Interface (CGI); data submission; Basic steps in CGI programing; Perl and CGI; Basics of the Perl; Perl Strings and their types, scalar variables, Arrays, extract information from arrays, hash Array; Perl Functions; File Handling; Bash; Shell; Bash scripting: Numeric and string comparison, conditional statements, bash loops, bash arithmetic ; R Language: Basic data types, variable assignment, arithmetic with R, Vector creation, naming vector, vector selection, matrix, data frames, factors, lists;

Practical

The CGI.pm Module; Perl scripting for CGI; Simplest CGI Programs; Perl: Numerical Variables and operators, arrays, regular expression; programs using Bioperl: Transcription Translation reading frames, data retrieval from databases; R-Language: Micro array analysis, Cluster analysis, Sequence analysis, Annotation.

CROP PHYSIOLOGY

Course No.	Title	Credits
CPH 501	Principles of Plant Physiology – I Cell Organelles Water Relations and Mineral Nutrition	2+1
CPH 502	Principles of Plant Physiology – II Metabolic Processes and Growth Regulation	2+1
CPH 503	Plant Development Biology, Physiological and Molecular Basis	2+0
CPH 504	Physiological and Molecular Responses of Plants to Abiotic Stresses	2+1
CPH 505	Hormonal Regulation of Plant Growth and Development	2+1
CPH 506	Physiology of Growth, Yield and Modelling	1+1
CPH 507	Genome Organization in Higher Plants	2+0
CPH 508	Morphogenesis, Tissue Culture and Transformation	1+1
CPH 509	Physiology of Crop Plants – Specific Case Studies	2+0
CPH 510	Physiological and Molecular Aspects of Photosynthesis – Carbon and Nitrogen Assimilation	1+1
CPH 511	Physiology of Plant Nutrition	1+1
CPH 512	Experimental Techniques in Plant Physilogy	0+1
CPH 513	Physiology of Woody Plants	2+0
CPH 514	Physiology of Seed Growth and Development	1+1
CPH 515	Herbicide Physiology	1+1
CPH 516	Post Harvest Physiology of Fruits and Vegetables	1+1
CPH 571	Qualifying Examination	2
CPH 581	Seminar	2
CPH 591	Research	16

CPH 501 ***Principles of Plant Physiology - I*** **(2+1)**
Cell Organelles, Water Relations and Mineral Nutrition

Theory

Cell organelles and their physiological functions: structure and physiological functions of cell wall, cell inclusions. Cell membrane structure and functions. Water and its role in plants: properties and functions of water in the cell water relations-cell water terminology, water potential of plant cells. Mechanism of water uptake by roots transport in roots, movement of water in plants, water loss from plants – energy balance-solar energy input-energy dissipation at crop canopy level-evapotranspiration. Transpiration-Driving force for transpiration, plant factors influencing transpiration rate. Stomata, structure and function-mechanism of stomatal movement, antitranspirants. Physiology of water stress in plants: influence of water stress at cell, organ, plant and canopy levels. Indices for assessment of drought resistance. The role of mineral nutrients in plant metabolism: essential elements, classification based on function of elements in plants. Uptake of mineral elements in plants – Mechanisms of uptake – translocation of minerals in plants. Physiological and metabolic functions of mineral elements. Critical levels. Deficiency symptoms, nutrient deficiency and toxicity. Foliar nutrition.

Practical

Measurement of soil water status: theory and principle of pressure plate apparatus, neutron probe. Measurement of plant water status: Relative water content, water saturation deficits chardakov's test. Theory and principle of pressure bomb, hydraulic jack, psychrometer and osmometer. Measurement of transpiration rate: Measurement of vapour pressure deficits, theory and principle of porometry, diffusion porometer and steady state porometer, stomatal physiology, influence of ABA on stomatal closing. Mineral nutrients: Demonstration of energy requirement for ion uptake. Deficiency symptoms of nutrients.

CPH 502 ***Principles of Plant Physiology - II*** **(2+1)**
Metabolic Processes and
Growth Regulation

Theory

Photosynthesis, Translocation and the respiration as key processes regulating carbon metabolism and plant growth. Photosynthesis, its importance in bio productivity. Photochemical process – chloroplast, its structure, photochemical reactions, CO_2 reduction in Calvin cycle, supplementary pathway of C fixation in C_4 and CAM plants and its significance. Photorespiration and its relevance. Photosynthesis as a diffusive process, effect of environmental factors on photosynthetic rates. Synthesis of sucrose, starch, oligo and polysaccharides (composition of cell wall). Translocation of photosynthates and its importance in sink growth. Mitochondrial respiration, growth and maintenance respiration, cyanide resistant respiration and its significance. Nitrogen metabolism: inorganic nitrogen species (N_2, NO_3 and NH_3) and their reduction to amino acids, protein synthesis and nucleic acids. Lipid metabolism-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 mechanism. Growth and differentiation. Hormonal concept of growth and differentiation, plant growth hormones (Auxins, gibberellins, cytokinins, ABA, ethylene *etc*). biosynthesis of growth hormones, their metabolism and their physiological role synthetic growth regulators, growth retardants. Apical dominance, senescence, fruit growth abscission. Photo morphogenesis: Photo receptors, phytochrome. Cryptochrome, physiology of flowering photoperiodism and vernalization.

Practical

Radiant energy measurements, separation and quantification of chlorophylls, O_2 evolution during photosynthesis. Measurement of gas exchange parameters, conductance's, photosynthetic rate, photorespiration, 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.

CPH 503 ***Plant Development Biology, Physiological and Molecular Basis*** **(2+0)**

Theory

Basic Physiological and molecular processes concerning various faces of growth and development of plants. Plant Biodiversity, Concept of evolution in plants. General Aspects – Novel features of plant growth and development; Concept of plasticity in plant development; Analysing plant growth, seed germination and seedling growth – Mobilization of food reserves during seed germination; tropisms; hormonal control of seed germination and seedling growth. Shoot, Leaf and Root Development – Organization of shoot apical meristem (SAM); Control of cell division and cell to cell communication; Molecular analysis of SAM; Leaf development and differentiation; Organization of root apical meristem (RAM); Root hair and trichome development; Cell fate and lineages. Floral Induction and Development – Photoperiodism and its significance; Vernalization and hormonal control; Inflorescence and floral determination; Molecular genetics of floral development and floral organ differentiation; Sex determination. Seed Development and Dormancy – Embryo and endosperm development; Cell lineages during late embryo development; Molecular and genetic determinants; Seed maturation and dormancy. Senescence and Programmed Cell Death (PCD) – Senescence and its regulation; Hormonal and environmental control of senescence; PCD in the life cycle of plants. Light Control of Plant Development – Discovery of phytochromes and cryptochromes, their structure, biochemical properties and cellular distribution; Molecular mechanisms of light perception, signal transduction and gene regulation; Biological clocks and their genetic and molecular determinants. Embryonic Pattern Formation – Maternal gene effects; Zygotic gene effects; Homeotic gene effects in Drosophila; Embryogenesis and early

pattern formation in plants. Regeneration and totipotency; Organ differentiation and development; Cell lineages and developmental control genes in maize. Special Aspects of Plant Development and Differentiation – Pollen germination and pollen tube guidance; Phloem differentiation; Sex determination in plants; Self-incompatibility and its genetic control; Heterosis and apomixis.

CPH 504 ***Physiological and Molecular Responses of Plants to Abiotic Stresses*** **(2+1)**

Theory

Response of plants to abiotic stresses: Abiotic stresses affecting plant productivity. Basic principles of a crop improvement programme under stress, Interactions between biotic and abiotic stresses. Drought-characteristic features, Water potential in the soil-Plant air continuum. Development of water deficits, energy balance concept. Transpiration and its regulation – stomatal functions. Physiological processes affected by drought. Drought resistance mechanisms: Escape Dehydration postponement (Drought avoidance), Dehydration tolerance and characteristics of resurrection plants. Osmotic adjustment, Osmoprotectants, Stress proteins. Water use efficiency as a drought resistant trait. Molecular responses to water deficit: Stress perception, Expression of regulatory and functional genes and significance of gene products. Stress and hormones- ABA as a signaling molecule- Cytokinin as a negative signal. Oxidative stress: Reactive Oxygen Species (ROS). Role of scavenging systems (SOD, catalase *etc*.). High temperature stress: Tolerance mechanisms- role of membrane lipids in high temperature tolerance. Functions of HSP's. Chilling stress: Effects on physiological processes. Crucial role of membrane lipids. Salinity: Species variation in salt tolerance. Salinity effects at – Cellular and whole plant level, tolerance mechanisms. Salt tolerance in – Glycophytes and halophytes, Breeding for salt resistance. Heavy metal stress: Aluminium and cadmium toxicity in acid soils. Role of Phytochelatins (heavy metal binding proteins).

Practical

Measurement of water status of plants, determination of osmotic potential by vapour pressure and freezing point depression, Determination of soil water potential and content by psychrometry and other systems. Stress imposition and quantification, Stress – stomatal conductance. Canopy temperature as a reflection of transpiration and root activity, Water use efficiency, Determination at whole plant and single leaf level, Root- shoot signals-ABA and cytokinin effect on stomatal behavior, Heat tolerance and membrane integrity. Sullivans heat tolerance test, chilling tolerance-Galactolipase and free fatty acid levels as biochemical markers for chilling damage, Cold induced inactivation of O_2 evolution of chloroplasts- as a screening technique for chilling tolerance.

CPH 505 ***Hormonal Regulation of Plant Growth and Development*** **(2+1)**

Theory

Structure, function of plant growth regulator on growth and development of plant. Definition and classification of plant growth regulators- Hormones, endogenous growth substances and synthetic chemicals, Endogenous growth regulating substances other than hormones. triacontanol, Phenols – polyamines, jasmonates, concept of death hormone. Site of synthesis, biosynthetic pathways and metabolism and the influence on plant growth development of individual group of hormones- Auxins, Gibberilins, cytokinins, Abscisic acid and Ethylene, Brassinosteroids. Hormone mutants and transgenic plants in understanding role of hormones. Signal perception.transduction, and effect at functional gene level of different hormones- Auxins- cell elongation, Gibberellins - germination of dormant seeds, cytokinins- cell division. Retardation of senescence of plant parts, Abscisic acid-Stomatal closure and induction of drought resistance, Ethylene- fruit ripening. Interaction of hormones in regulation of plant growth and development processes. Rooting of cuttings-Flowering. Apical dominance, molecular aspects of control of reproductive growth and development. Synthetic growth regulators-

Classification, their effect on plant growth and development. practical utility in agriculture and horticulture.

Practical

Quantification of Hormones- Principles of bioassays, physico chemical techniques and immunoassay, Extraction of hormones from plant tissue. Auxins- bioassays- auxins effect on rooting of cuttings, abscission, apical dominance, Gibberellins-bioassays-GA effect on germination of dormant seeds, cytokinin-bioassays- estimation using immunoassay technique, cytokinin effect on apical dormance and senescence, ABA bioassays estimation using immunoassay technique. ABA effect on stomatal movement, Ethylene bioassays, estimation using physico chemical techniques- effect on breaking dormancy in sunflower and groundnut.

CPH 506 ***Physiology of Growth, Yield and Modelling*** **(1+1)**

Theory

Crop growth analysis and different yield prediction models. Crop growth analysis, key growth parameters. Analysis of factors limiting crop growth and productivity- the concept of rate limitation. Phenology- Growth stages, internal and external factors influencing flowering. Photoperiodic and thermo-periodic responses and the concept of Degree days and crop growth duration. Canopy architecture, light interception, energy use efficiency of different canopies. LAI, LAD. concept of optimum LAI. Source-sink relationships. Translocation of photosynthates and factors influencing transport of sucrose. Physiological and molecular control of sink activity – partitioning efficiency and harvest index. Plant growth analysis techniques, yield structure analysis, theoretical and actual yields. Plant ideotypes, Simple physiological yield models- Duncan's, Monteith's and Passioura's Crop growth models-empirical models testing and yield prediction.

Practical

Plant sampling for leaf area and biomass estimation; analysis of growth and yield parameters – LAD, NAR. CGR,

LAI, RGR, SLW, LAR, SLA partitioning efficiency HI, Measurement of light interception, light extinction coefficient, energy utilization efficiency based energy intercepted, and realized, Computer applications in plant physiology, crop productivity and modelling.

CPH 507 ***Genome Organization in Higher Plants*** **(2+0)**

Theory

Basic concept of genome organization in prokaryotic and eukaryotic system. Introduction: Basic discoveries in molecular genetics; basic concepts on genome organization and its replication in prokaryotic systems including cyanobacteria; genome organization in diploids, tetraploids, auto tetraploids and polyploids. Gene & gene expression: Diversity in DNA polymerases; control of plasmid copy number; Regulation of transcription in prokayotes; Promoters and terminators; Positive and negative control of transcription; Repression and activation-operon concept. Mitochondrial and chloroplastic genome organization and regulation of gene expression. Eukaryotic genome structure: Organization and replication; control of gene expression-transcription and post-transcriptional; promoter analysis; concept of cis elements; transcription factors, function and role of RNA polymerases. Genetic code and translation-deciphering the genetic code; Codon bias; tRNAs, ribosomes; Initiation and termination of translation; Translational and post-translational controls; Attenuation ; Suppressor tRNAs. Mobile genetic elements; Structure and function of transposable elements; Mechanism of transposition; Special features of retroptransposans; Repair and recombination.

CPH 508 ***Morphogenesis, Tissue Culture and Transformation*** **(1+1)**

Theory

Morphogenesis: The cellular basis of growth and morphogenesis cytodifferentiation. The cell cycle-cell division and cell organization, cell structure, tissue and organ differentiation. Control of cell division and differentiation in selected cell types, Introductory history, morphogenesis and

cellular totipotency. Introduction to in vitro methods : Terms and definitions, Use of growth regulators, Beginning of in vitro cultures in our country (ovary and ovule culture, in vitro pollination and fertilization), Embryo culture, embryo rescue after wide hybridization and its application, Endosperm culture and production of triploids. Introduction to the processes of embryogenesis and organogenesis and their practical applications: Clonal Multiplication of elite species (micropropagation) – axillary bud, shoot tip and meristem culture. Haploids and their applications. Somaclonal variations and applications. Introduction to protoplast isolation: Principles and applications. Testing of viability of isolated protoplast. Various steps in the regeneration of protoplast. Somatic hybridization – an introduction, Various methods for fusing protoplast, chemical and electrical. Use of makers for selection of hybrid cells. Practical applications of somatic hybridization (hybrids vs cybrids). Use of plant cells, protoplast and tissue culture for genetic manipulation of plant : Introdiuction to *A. tumefaciens*. Tumour formation on plants using *A. tumefaciens* (Monocots *vs* Dicots), Root – formation using *A. Rhizogenes*.

Practical

Tissue culture laboratory orientation, facilities required, glassware, stock preparation, media preparation, aseptic manipulation in tissue culture lab, explants preparation for aspetic inoculation. *In vitro* culture of different explants such as leaf, stem, shoot apex, cotyledonary nodes; Effect of explant age on propagation potential, Effect of growth regulators auxin, cytokinins and ethlyne on callus induction, organogenesis; Somatic embryogenesis, Effect of growth conditions such as temperature and photoperiod on organogenesis, Single – cell suspension cultures.

CPH 509 ***Physiology of Crop Plants – Specific Case Studies*** **(2+0)**

Theory

Physiological aspects of different crop plants. Crop physiological aspects of rice, wheat, maize, sorghum, millets,

sugarcane, pulses, oil seeds, cotton and potato Crops. Six to Eight Species could be chosen based on local importance. Crop specific topics. Seed dormancy, photoperiodic and thermoperiodic responses. Source-sink relationship, Yield structure and factors influencing yield, Nutrients and other resource requirements and crop specific features.

CPH 510 ***Physiological and Molecular Aspects of Photosynthesis – Carbon and Nitrogen Assimilation*** **(1+1)**

Theory

Physiological and molecular aspects of carbon reduction cycle and nitrogen assimilation. Photosynthesis- its significance in plant growth, development and bio productivity. Gaseous fluxes in atmosphere. Physiological and biochemical aspects: chloroplast structure development and replication, ultra structure of thylakoids, photo systems, mechanism of light absorption, chloroplast electron transport chain, Coupling factors and mechanisms of ATP synthesis, and concept of quantum yield. Photosynthetic carbon reduction cycle and its regulation. CO2 Concentration Mechanism (CCM) as a complementary strategy for carbon fixation. CCM in photosynthetic bacteria, micro algae, Submerged Aquatic Macrophages (SAM), C4, CAM and single celled C4 organisms, C3-C4 intermediates. Ecological significance of CCM. Rubisco structure, assembly and kinetics, photorespiration and its significance. Carbon fluxes between chloroplast and cytoplasm and Carbon fixation as a diffusive process, the concept of ra, rs and rm. Pi recycling, starch and sucrose synthesis and export. Concept of canopy photosynthesis, influence of environmental factors such as water stress, high light stress VPD *etc*. Molecular aspects: chloroplast genome organization, expression and regulation of plastid genes Genes regulating potential traits of photosynthesis, biotechnological approaches for improving photosynthetic rate and productivity – transgenics. Conceptual approaches of expressing C4 photosynthesis genes in C3 species. Photosynthesis and crop productivity, energy utilization efficiency by crops. Photo inhibition, photo oxidation, excitation energy dissipation

mechanisms, photochemical and non-photochemical quenching of chlorophyll fluorescence. Photosynthesis and transpiration interaction, significance of WUE, carbon isotope discrimination concept. Prospects of improving photo synthetic rate and productivity – potential traits of photosynthesis- biotechnological approaches. Nitrogen assimilation in photosynthesizing cells – NO_3 -, NO_2 - reduction, GS-GOGAT pathway. Photorespiration loss of Ammonia and its reassimilation and NUE.

Practical

Extraction and separation of plant pigments, Isolation of chloroplasts ETC reactions- O2 evolution, Determination of rubisco content (western and ELISA), activity and activation state, Enzymatic determination of starch and sucrose, Determination of photosynthetic rates –gas exchange. A, gs, Ci, A/gs, C/gs- intrinsic WUE by gas exchange rates. Light, CO_2, VPD response curves, Determination of photorespiration by gas exchange- (TPS, APS). Genotypic/species differences in photosynthetic rates. Measurement of radiation, Eu% light interception, Determination of NH_4 +, reduction of inorganic nitrogen species.

CPH 511 ***Physiology of Plant Nutrition*** **(1+1)**

Theory

Physiological and molecular aspects of carbon reduction cycle and nitrogen assimilation. Overview of essential mineral elements, kinetics of nutrient uptake by plants. Biological actions influencing nutrient availability near the root system. Nutrient uptake by root cells, long distance transport in plants and movement into developing grains. Nutrient transport from vegetative to reproductive organs during reproductive stage of growth and maturity. Molecular mechanism of ion uptake, ion transporters, specific examples of transporters for Nitrate, Phosphate, Potassium and other nutrients. Multiple transporters for a single ion and their functional regulation. Molecular physiology of micronutrient acquisition. Examples of genes encoding mineral ion transporters. Strategies plants adopt to acquire and transport minerals under deficient levels.

Physiological and molecular mechanisms underlying differential nutrient efficiency in crop genotypes, Examples of Phosphorous, Iron and Zinc efficient crop varieties. Breeding crop varieties for improved nutrient efficiency. Plant responses to mineral toxicity.

Practical

Physiological and biochemical changes in plants under nutrient sufficiency and deficiency levels. Quantification of pigment levels, enzyme activities.

CPH 512 ***Experimental Techniques in Plant Physiology*** **(0+1)**

Practical

Quantification of hormone – immunoassay/physico-chemical methods. WUE-determination of water use efficiency by gravimetric approach. Stable isotopes-use in physiological investigations. Use of isotope materials (potential photosynthesis/protein synthesis). Purification, quantification of RuBisCO by ELISA using polyclonal antibodies. Gas exchange technique, measurement of photosynthetic rates and dark respiration. Protein purification and isozyme analysis. Moisture / Termperature stress – methods to impose, quantification of the stress levels. Molecular aspects of stress response – stress responsive proteins, their expression – western and northern analysis. Stress measurement parameters (membrane integrity, chlorophyll stability index, osmolyte quantification, osmotic adjustment. TTC, *etc*.,). DNA extraction and determination of polymorphism-RAPD, RFLP, and AFLP. Real – time PCR, Flourimetry. RNA isolation. Reverse Northern. cDNA library. Fluorescence kinetics and their application in physiology.

CPH 513 ***Physiology of Woody Plants*** **(2+0)**

Theory

Growth and development of horticultural and plantation crop species. Juvenility, shoot growth, types of shoots. Patterns of shoot growth, cambial growth and its regulation. Physiological aspects of pruning and dwarfing. Growth measurements. Water relations of tree species. Water uptake and transport. Concepts of

transpiration ratio and water use efficiency. Sexual and asexual propagation. Root stock and scion interactions. Physiology of flowering in perennial species, photoperiodism and thermoperiodism. Physiological aspects of fruit crops, mango, banana, grapes, citrus, papaya and pineapple, *etc*. physiological aspect of plantation crops coffee, tea, cardamom, coconut, pepper. NB species could be chosen based on the local importance.

CPH 514 ***Physiology of Seed Growth and Development*** **(1+1)**

Theory

Structure of seeds and their storage resources. Seed developmental patterns and source of assimilates for seed development. Pathway of movement of assimilates in developing grains of monocots and dicots. Chemical composition of seeds. Storage of carbohydrates, proteins and fats in seeds. Storage chemistry including biosynthesis. Hydration of seeds, physiological processes. Seed respiration, mitochondrial activity. Mobilization of stored resource in seeds. Chemistry of oxidation of starch, proteins and fats. Utilization of breakdown products by embryonic axis. Control processes in mobilization of stored resources. Role of embryonic axis. Gibberllin and á-amylase and other hydrolytic activity. Seed maturation phase and desiccation damage. Role of LEA proteins. Seed viability. Physiology of seeds and means to prolong seed viability. Seed dormancy, types and regulation. Means to overcome seed dormancy.

Practical

Determination of seed storage proteins. Sink drawing ability of ovules, empty ovule technique. Alpha –amylase activity in germinating seeds. Role of GA in inducing á-amylase activity. Role of embryo in GA induced á-amylase activity. Protease and lipase activity in germinating seeds. Seed viability test and accelerated ageing test. Seed hardening/ osmotic priming of seeds. Estimation of seed respiration rates. Seed viability losses – membrane leakage.

CPH 515 ***Herbicide Physiology*** **(1+1)**

Theory

Introduction-Classification of herbicides. Absorption and translocation of soil and foliar applied herbicides. Physiological and biochemical effect of herbicides – effect on membrane structure and functions, on cell division and cell development. Nature of herbicide receptor proteins and their role in herbicide tolerance. Effect on chloroplast, photosynthesis, respiration, protein synthesis, synthesis of lipids. Molecular mechanisms of herbicide resistance in relation to chloroplast gene expression. Methods to increase the efficiency of soil and foliar applied herbicide – pH adjuvants, synergists. Antidotes. Case studies of different types of herbicides – growth regulating types, triazines, substituted ureas, chloroacetamides, substituted uracils. Thiocarbamates, nitriles, bipyridylium, unclassified groups, herbicide mixtures. Herbicide resistance – induction – taxonomic and biological consideration of herbicide resistance- nature of resistance to triazine – Breeding herbicide tolerant crop cultivars. Herbicide resistance in plant cell cultures – practical significance.

Practical

Bioassay for different herbicides. Influence of pH, adjuvants, contact angle, surface tension on penetration, absorption and translocation of herbicides. Quantification of herbicide potency, relative potency. Quantification of herbicide – herbicide interaction (synergistic, antagonistic and additive). Role of adjuvants on penetration, translocation, contact angle surface tension *etc*. effect of herbicide on electron transport in isolated chloroplast and mitochondria. Effect of herbicide on rate of photosynthesis in crop and weed plants.

CPH 516 ***Post Harvest Physiology of Fruits and Vegetables*** **(1+1)**

Theory

Senescence and ageing in plants. Ethylene-the senescence hormone, leaf senescence, chloroplast degradtions. Monocarpic plant senescence. Biochemistry and molecular biology of flower senescence. Gene expression during senescence. Concepts of physiological maturity of seeds – post harvest changes in biochemical constituents in field crops – loss of viability, loss of nutritive value (changes in fat deterioration *etc*). environmental factors influencing post-harvest deterioration of seeds. Post harvest physiological and biochemical changes during fruit ripening and storage. Senescence and post harvest of life and cut flowers. Hormonal and chemical control of post-harvest deterioration of fruits, vegetables and cut flowers and its significance during storage and transport. Regulation of fruit ripening at molecular level-Transgenic technology for improvement of shelf life.

Practical

Physiological maturity indices – colour, softness and size of harvested fruits – mango, banana, sapota, apple, papaya, citrus and guava. Changes in chlorophyll, storage protein, amino acids, membrane integrity during leaf senescence. Use of antiethylene agents on petal senescence and vascular plugging during flower senescence. Demonstration of ethylene and respiratory climactric in fruits. Estimation of chlorophyll, colouring pigments, respiration and ethylene evolution during development, maturity and ripening stages. Quantification of hydrolytic enzymes during ripening of fruits. Judging TSS, acidity in fruits, estimation of quality and weight loss of fruits and vegetables during storage. Estimation of sugars, vitamins, ascorbic acid and total phenolics.

ENVIRONMENTAL SCIENCE

Course No.	Title	Credits
EVS 501	Concepts of Environmental Science	1+1
EVS 502	Biodiversity and Conservation	1+1
EVS 503	Ecology and Environment	1+1
EVS 504 / AEC 510	Natural Resource and Environmental Economics	1+1
EVS 505	Remote Sensing and GIS Application in Biodiversity Conservation	1+1
EVS 506	Solid Waste Management	1+1
EVS 507	Principles of Environmental Impact Assessment	1+1
EVS 508	Environmental Analytical Techniques	1+1
EVS 509	Environmental Pollution	2+1
EVS 510	Environmental Policy, Law and International Conventions	2+0
EVS 511	Global Climate Change and Environment	2+0
EVS 512	Management of Degraded Ecosystems	1+1
EVS 513	Biological Resources – Assessment and Utilization	1+1
EVS 514 / PBT 519	Environmental Biotechnology	1+1
EVS 515	Structural and Functional Anatomy of Plant	1+1
EVS 516	Plant Taxonomy	1+1
EVS 517	Reproductive Biology and Ecology	1+1
EVS 518	Plant Tissue and Organ Culture	1+1
EVS 519	Histochemical Techniques	0+2
EVS 520	Botany of Bee Flora and Palynology	1+1
EVS 521	Floral Biology and Ecology	1+1
EVS 522	Environmental Engineering	1+1
EVS 571	Qualifying Examination	2
EVS 581	Seminar	2
EVS 591	Research	16

EVS 501 ***Concepts of Environmental Science*** **(1+1)**

Theory

Environment-definition and its relation to other disciplines - its relevance to human civilization, History. Ecosystems - types and biological components. Distribution and abundance of living organisms - interrelationship between environment, microbes, plant and animal systems - nutrition and metabolism, eco-system modeling. Environment and population, environmental problems and laws of nature - Environmental health - Environmental pollution - Air, Soil and Water pollution, Eco toxicology - environmental monitoring - bio indicators. Resources - Renewable and non - renewable resources, exploitation and conservation.

Practical

Study of terrestrial ecosystem, grassland ecosystem - a biotic factor and biotic factors in terrestrial ecosystem - flora and fauna – Aquatic ecosystems - biotic and a biotic factor. Visit to Forest to study Forest ecosystem - flora and fauna – biotic factors influencing forest ecosystem. Study of Air and Water pollution.

EVS 502 ***Biodiversity and Conservation*** **(1+1)**

Theory

Elements of Biodiversity - Measuring biodiversity - Species abundance - species diversity - number and difference - habitat distribution - Biodiversity through time - the fossil record - history of biodiversity - diversification - extinction -. Mapping biodiversity - Species -Area relationships - Local regional diversity relationships - Extremes of high and low diversity - Gradients in biodiversity - latitudinal, altitudinal and depth gradients in biodiversity - Importance of biodiversity - Use value. Maintaining biodiversity - the scale of human enterprise - The Convention on Biological Diversity. Why conservation - Objectives and general measures for conservation and sustainable use - *In situ* and *Ex situ* Conservation Tropical forests and their conservation - Deforestation -The pressure on wildlife -

conservation of species - species extinction - Genetic diversity in rare species - Conservation of ecosystems – Habitat conservation - Design and Maintenance of conservation areas - Conservation of the biosphere - Special projects for endangered species - Man and Biosphere programmes - Viable conservation.

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.

EVS 503 ***Ecology and Environment*** **(1+1)**

Theory

Habitat ecology, Systems ecology, Synecology, Autecology's, *etc*. - Biotic communities -Community structure and composition - Communities and Environment - structure and patterns in diversity – habitats and niches -. Basic population genetic principles, Evolutionary principles: Evolution and natural selection - definition of species - Populations -Growth, regulation and interaction - species interactions - Population consequence of selection - Species formation and evolution - allopatric, sympatric and parapatric species -species losses -population losses and declines. The shifting balance theory -Peripheral diversity - Static and changing patterns - Competition and community structure-Interspecific interactions and Intraspecific competition. Life tables and their use in population models - construction of life tables, Ecological Succession. Adaptation: Niche and Limiting factors-Habitat ecology. Behavioral 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, Lotka volterra models. Selection forces. Interspecific interactions.

EVS 504 / AEC 510 ***Natural Resource and Environmental Economics*** **(1+1)**

Theory

Features of Natural Resource and Environmental Economics, Classification of NRs, Renewable, Non renewable and Environmental resources, Property rights: private, open access and common property resources; Economy - Environment interaction – The Material Balance principle, Entropy law- Resources Scarcity - Limits to Growth - Measuring and mitigating natural resource scarcity – Malthusian and Recardian scarcity. Non-renewable resources; The theory of mine; depletion, profit maximisation; Gray model, economic models of oil extraction. Economic growth and depletable resource use; resource rent and intergenerational equity- Hotelling model Solow-Harwick's Rule. Renewable resources: A model of the fishery, the bionomic equilibrium, maximum sustainable yield. Optimum harvest under open access/common property and private property regimes. - Collective action, Forestry: optimal rotation period, pricing and valuation of forest products-NTFPs, Bio-diversity-as resources, sources of information, resiliency and insurance for productive system; Extinction of species/varieties. Land Degradation – environmental and economic impacts, nutrients, soil flora and fauna: Water-surface and ground water, optimal and sustainable use, quality of water, depletion and policies, water markets; Land-use, rent and value, emerging land markets; Air and open space, , assimilative capacity, recycling and ecological processes including the pests and disease control capacity of the environment. Sources and types of pollution - air, water, solid waste, externalities – types – transaction costs – Coase's theorem and its critique– economic instruments - pollution charges - Pigovian tax - tradable permits – indirect instruments - environmental regulation and legislations in India. Economics of pollution control, pollution and its impact on agriculture. Ago-chemicals and externalities. Definition and conditions for sustainable development, inter and intergenerational equity. Economic analysis of sustainable development, Economy-environmental models, productivity,

equity and sustainability and their trade offs in natural resource use. Market failure, Policy failure and state intervention in natural resources management. Time and SD, discount rates and resource allocation, measurement of SD, National accounting and the Green GNP approach, Environment Accounting, Environment and trade, environment and population-carrying capacity of earth. Environmental Kuznet's curve. International Environmental Issues – climate change – likely impacts - mitigation efforts and international treaties. Sustainable agriculture: Definition and scope, Agro-ecosystem analysis, green revolution, organic and natural farming systems; sustainable agricultural technologies, government interventions, policy failures-taxing and subsidies for agriculture. Review and exercise on pricing and optimum use of water, forestry resources degradation of soil and water, agro-chemicals and externalities.

Practical

Exhaustible resource management – optimum rate of oil extraction. Renewable resource management – optimum harvest of Forestry/fishery. Exercise on pollution abatement, Concepts in valuing the environment. Total economic valuation of forestry, Hedonic price method - Travel cost method - Contingent valuation method. Discount rate in natural resource management. Environment impact assessment. Visit to Pollution Control Board. Tank rehabilitation: Costs and benefits.

EVS 505 ***Remote Sensing and GIS Application in Biodiversity Conservation*** **(1+1)**

Theory

Introduction to remote sensing, electromagnetic spectrum-physics of remote sensing, effects of atmosphere, spectral reflections of earth objects. GPS- introduction basic principles, definition of map, computer assisted cartography, hardware requirements, types of data. Spatial and non-spatial data. Raster and Vector data conversion, Geographic information system analysis and modeling, digital counter modeling, errors, elimination. GIS software packages, capabilities, creating base maps, raster and vector conversions. Digitizing- linking data

files, tools for mapping and GIS. Use of GIS in policy and planning. Various platforms for data acquisitions, aerial photography, satellite sensors; optical, thermal and microwave. Different types of data products and their characteristics. Satellite data acquisitions. Storage and retrieval, 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 and GIS.

EVS 506 ***Solid Waste Management*** **(1+1)**

Theory

Solid waste: Definition – sources and types – characteristics and classification – collection and handling - processing and segregation. Treatment and disposal: physical, chemical and thermal treatment – incineration – types of incinerators – sanitary land fill-leach ate management - open dumping - soil and ground water contamination and management. Integrated eco-friendly recycling of solid wastes: Advantages and disadvantages of composting methods. Agricultural wastes: farm waste, plant residues, weeds; food processing wastes – vermicomposting – impact on agro-eco system. Domestic and municipal solid wastes: Night soil – characteristics, disposal techniques - impact on agro-eco system. Industrial waste management and their impact on eco-system: toxic wastes – classification – management – impact on human health and agro-eco system. Treatment and disposal of hospital waste. Recent advances in solid waste management.

Practical

Solid waste materials collection – characterization of different solid wastes – treatments and disposal methods. Visit to near by compost yard, open dumps and land fills - 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.

EVS 507 ***Principles of Environmental Impact Assessment*** **(1+1)**

Theory

Concept of environmental impact assessment – types of environmental impacts – natural impacts – impacts due to developmental activities – economic, environmental and ecological consequences of common property ecosystem degradation - current status of EIA – EIA in developed countries – steps and processes in EIA study – prediction and assessment of different environments – soil, air, water, noise – biological, socioeconomic and cultural appraisal of EIA – criteria for evaluating environment related projects – review of EIA – status of EIA in India – case studies for EIA – conflict between industrialization and environmental preservation – effect of global trade on environment – 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.

EVS 508 ***Environmental Analytical Techniques*** **(1+1)**

Theory

Environment & its importance – Study of physico-chemical and biological parameters. Instrumentations, Microscopy and microbiological techniques. Study of Water-Acidity, Alkalinity, hardness, TDS & EC, organic acids, phenolics, metals. BOD, COD. Study of carbon dioxide, methane, oxides of nitrogen, CFC and 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.

EVS 509 ***Environmental Pollution*** **(2+1)**

Theory

Sources of major air pollutants (SO_2, NO_2, O_3, Co); Effect of gaseous air pollutants on plants Effect and on animals; TSP and their effects on plants and animals, Air pollution tolerance index; Air quality standards; Euro standards; Air pollution control. Sources of water pollution; Classification of water pollutants; Water quality standards; Water pollution control; Marine pollution; Sources of soil pollution; Heavy metals: sources and effect on biological systems; Pesticides: sources and effect on biological systems; Detrimental effects of soil pollutants on soil micro biota: Ecological consequences; Soil pollution control. Sources and measurement of noise pollution; Noise pollution control Principles of air monitoring; Air sampling methods; Air sampling instruments and sampling operations; Methods of water sampling; Water sampling Instruments; 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 run off 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.

EVS 510 ***Environmental Policy, Law and International Conventions*** **(2+0)**

Theory

Goal, objectives and guiding principles of Environmental Education,programmes through formal and non-formal systems-Role of Environmental organization – Government and NGO's-Environmental Legislation-Environment policies of the government-Remedies for Environmental pollution. Environmental Legislation-Law relating to control of pollution-Water Act-1974-Air Act – 1981,Environmental protection Act, (1986) – rules and notifications made there under-Laws to prevent land and ground water pollution-Law relating to conservation of forest and wild life-Emergence of environmental standards. Any act and policies introduced from time to time. Visits to Forest Departments. Visit to Social organizations. Visit to Environmental Non- governmental organization.

EVS 511 ***Global Climate Change and Environment*** **(2+0)**

Theory

Issues on global climate change, Climate change and biodiversity, IPCC assessment on climate change and International conventions, El nino effect, Climatic fluctuations over India, climate change and global desertification process, Ongoing efforts on climate change research. Greenhouse gases - CO_2, CH_4, NOx, CFCs *etc*. greenhouse gases in atmosphere, global warming potential, source - sink ratios and atmospheric loading rates *etc*. Mitigation options of greenhouse gases. CO_2 enrichment studies and plant response, O_3 depletion and CFC's , climate change mitigation in polar regions. Causes and control measures, Impact on different ecosystem. Role of mathematical models in predicting climate change and its impact on productivity and soil fertility.

EVS 512 ***Management of Degraded Ecosystems*** **(1+1)**

Theory

Ecological **Theory**, Factors leading to degraded ecosystems – erosion due to wind and water-physical and chemical properties– biological communities. Nature of degraded ecosystems: Wasteland-Arid, water logged, salt affected soils-dynamics of wasteland changes. Desertification and deserts; Mining and environment – degraded forests- nutrient enrichment and eutrophic aquatic ecosystem. Management: Conservation of wetlands, coastal ecosystem, mangrove ecosystem. Restoration ecology- approaches –Reintroduction of species and conservation of biodiversity; Reclamation of land and mine spoils; vegetation – Amelioration; A forestation, Restored forests - succession – community dynamics; 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.

EVS 513 ***Biological Resources – Assessment and Utilization*** **(1+1)**

Theory

Introduction and definition of Biological resources. Global and National biological resource richness. Patterns in diversity of biological resourcdes, Hotspots of biological resources, threats to bioresource. Valuation of bio resources – economic and ecosystem services. Tools to assess bio resource values. Bio resource utilization national wealth. Utilization of bio resources in agriculture, health. Approaches to suitable utilization and conservation of bio resources.

Practical

Techniques for estimating bio resource richness and diversity, mapping of bio resources, techniques for valuating bio resources, approaches to bio prospecting bio resources, threat assessment of bio resource.

EVS 514 / PBT 519 ***Environmental Biotechnology*** **(1+1)**

Theory

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 process; need for water and natural resource management. Microbiology and use of micro-organisms in waste treatment; biodegradation; degradation of Zenobiotic, surfactants; bioremediation of soil and water contaminated with oils, pesticides and toxic chemicals,detergents *etc.*; aerobic processes (activated sludge, oxidation ditches, trickling filter, rotating drums, *etc.*); anaerobic processes; digestion, filtration, *etc.*. 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.*. Treatment schemes of domestic waste and industrial effluents; food, feed and energy from solid waste; 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.

EVS 515 ***Structural and Functional Anatomy of Plant*** **(1+1)**

Theory

Internal orgnisation of plant body, summary of cell types and tissues. Cell and its structure, cell-wall and its chemical

composition. Meristems and differentiation of tissues, detailed study of tissued, vascular cambium, epidermis, parenchyma, collenchyma, sclerenchyma, xylem, phloem, secretory structures and periderm. Anatomy of stem, root, leaf, flower, fruit and seed. Methods of studying internal structure of plant.

Practical

Study of cell, tissue and organs under light microscopy and use of microtechnique in the study of plant anatomy.

EVS 516 ***Plant Taxonomy*** **(1+1)**

Theory

Taxonomy and its significance. General principles of classification. Current systems of classification. Bentham and Hooker, Engler and Prantl and Hutchinson. Plant nomeclature beginning of organized nomenclature, codes of nomenclature, International codes of Botanical nomenclature, concepts of taxon. Evolutionary relationships. Chemical and numerical taxonomy Plant identification, field and herbarium techniques, collection procedures, preparation of specimens general survey of the following families with special reference to their important characters and economic importance: Magnoliaceae, Annonaceae, Malavaceae-Sterculiaceae, Tiliaceae, Cluciaceae Rutaceae, Sapindaceae, Rhamnaceae, Anacaridaceae, Fabaceae, Myrtaceae, Apiaceae, sapotaceae, Asclepiadacae, Oleaceae, Verbenaceae, Lamiaceae, Solanaceae, Rubiaceae, Cucurbitaceae Euphorbiaceae and Asteraceae, Poaceae, Cyperaceae, Arecaceae, Araceae, liliaceae, Cannaceae.

Practical

Study of selected families and representative species. Inventorying the vegetation of a sample area. Preparation of herbarium and submission.

EVS 517 ***Reproductive Biology and Ecology*** **(1+1)**

Theory

Introduction, scope of plant reproductive biology. Structure, development and organization of micro and megasporongia. Microsporogenesis and male gametophyte megasporgenesis and female gametophyte. Fertilization pre and post fertilization changes. Embryo development and classification. Origin of endosperm in dicots and monocots. Polymbryony and Apomixis, its importance in evolution and breeding. Parthenocarpy and parthemoghensis experimental cembryology-role in systamatics and evolution.

Practical

Microtomy its application in preparation of slides for studying some of the embryological aspects covered in **Theory**.

EVS 518 ***Plant Tissue and Organ Culture*** **(1+1)**

Theory

Introduction and scope of biotechnology. Organ, tissue and cell culture. Embryo and ovule culture for hybridization. In-vitro fertilization over coming incompatibility. Intra ovarian pollination. Anther and pollen culture. Production of haploids. Pollen-pistil interaction and control of fertilization. Mechanism and overcoming of intraspecific and inter-specific incompatibility. Meristem culture and production of disease free plants. Somaclonal lines for stress tolerance, somatic embryogenesis, hybridization. Protoplast culture and micro propagation and its role in agriculture. Freeze preservation of germplasm.

Practical

Acquaintance with tissue culture equipments and preparation of nutrient media. Techniques for culture of embryo. Ovule, anther, pollen and other tissues in selected crop plants. Callus induction and in-vitro morphogenesis.

EVS 519 ***Histochemical Techniques*** **(0+2)**

Practical

The study of chromosomes and their behavior during mitosis and meiosis in plant cells. Histological and histochemical studies including steps such as collection, selection, fixation, dehydration and processing of plant material for localization of macromolecules like nucleic acids, total proteins, total insoluble polysaccharides and other compounds in given sections by microtomy. Observation and recording the data using micrometry and Photomicrography.

EVS 520 ***Botany of Bee Flora and Palynology*** **(1+1)**

Theory

Classification of flowering plants, floral anatomy of important bee plants, nectaries - floral and extra floral nectar secretion, composition, yield, abiotic and genetic factors influencing secretion, physiology of secretion including photosynthates mobility and partitioning between plant parts.. Pollen - Classification, sources, yield, factors affecting its production. Melisso-palynology Poisonous nectar and pollen sources

Practical

Identification of bee flora and their taxonomic position. Estimation of nectar and pollen yield; Pollen identification and classification, preparation and submission of slides. Dissection and microtomy of nectar glands. Identification of poisonous bee flora.

EVS 521 ***Floral Biology and Ecology*** **(1+1)**

Theory

Floral biology and its scope in breeding. Inflorescence, Flower morphology and development. Sexuality in plants, anthesis: pollination ecology-crosspollination pre Darwinian, Darwinian, Darwinian and modern studies and pollination ecology. Abiotic pollination biotic pollination structural blossom classes, pollination syndromes. Role of animals in pollination.

Floral development in relation to mode of pollination. Applied pollination ecology. In-vitro flower culture and morphogenetic studies. Retrograde development revertance to abiotic pollination. Autogamy,pomixes and vegetative propagation. Role of pollination in evolution and speciation.

Practical

The study of different types of inflorescence, flower structure, development anthesis. Methods of study of stigma receptivity and pollen fertility. Study of flora biology of a typical example.

EVS 522 ***Environmental Engineering*** **(1+1)**

Theory

Green house gases (CO_2, CO, CH_4, NO_2, CFC, water vapour), major sources of air pollutants, chemistry of secondary pollutants, Air pollution and meteorology, photochemical smog and acid rain, indoor and outdoor air pollution.

Gas exchange (CO_2 & O_2), stomatal function, distribution and stomatal mechanism, carbon assimilation (C3, C4 and CAM), plant pigments.

Biomonitoring of air, water and soil environment, concept of indicator species and their environmental significance.

Sources and measurement of noise pollution, noise exposure levels and standards, noise pollution control and abatement measures.

Principles of water quality monitoring, methods of water sampling, instruments, physico-chemical analysis of water and analysis of water quality.

Sources of soil pollution, heavy metals and sources, effect on biological system, pesticide sources, agricultural inputs and its effect on soil.

Waste land development and its management.

Reclamation and waste lands, afforestation with suitable tree species.

Practical

Techniques for monitoring quality of the Environment, Collection of Soil, Water and Air samples - Analysis of physico-chemical and Bioligical parameters.

Instrumentation - Principles of UV-VIS spectrophotometry, IR spectrometry paper and gas chromatography, HPCL, Microscopy.

Plant analysis - Separation and Quantification of plant pigments CO_2 and O_2 evolution,Stomata, Stomatal distribution, function and mechanism.

Water analysis - Acidity, Alkalinity, hardness, TDS and ES phenols, pH, BOD, COD - Analysis of air sample, CO_2, CH_4, NO_2, particulates.

Methods of Reclamations of Perinial swamps, water logged area, Saline and Rocky outlets with suitable tree species minimize CH_4 evolution.

FOOD SCIENCE AND NUTRITION

Course No.	Title	Credits
FSN 501	Principles of Food Science	1+1
FSN 502	Principles of Nutrition	3+0
FSN 503	Food Analysis	1+2
FSN 504	Principles of Community Nutrition	1+1
FSN 505	Food Processing Technology	2+0
FSN 506	Clinical Nutrition	1+1
FSN 507	Nutrition During Life Cycle	2+0
FSN 508	Nutrition and Physical Fitness	1+1
FSN 509	Principles of Diet Therapy	2+1
FSN 510	Food Toxicology	2+0
FSN 511	Principles of Human Physiology	1+1
FSN 512	Food Service Management	1+1
FSN 513	Food Product Development	1+1
FSN 514	Nutrition and Immunity	1+0
FSN 515	Functional Foods	0+1
FSN 571	Qualifying Examination	2
FSN 581	Seminar	2
FSN 591	Research	16

FSN 501 ***Principles of Food Science*** **(1+1)**

Theory

Colloidal chemistry as related to foods; evaluation of food by subjective and objective methods. Carbohydrates in food sources and characteristics of sugar, starch, cellulose, pectin and gums in foods; effect of cooking and processing techniques. Protein in foods: Plant and animal foods; chemical and physical properties related to foods; effect of cooking and processing techniques. Properties, uses, processing techniques, changes during heating and other processing and storage of fats and oils.

Classification, importance, composition of fruits and vegetables and effect of cooking and other processing on their nutritive value. Classification and importance of beverages; food pigments; browning reaction. Definition, classification, uses and legal aspects of food additives; classification, nature and uses of leavening agents.

Practical

Microscopic structure of different starch granules; evaluation of food by subjective and objective methods; changes in colour, texture and flavor of foods due to processing; effect of cooking on protein, fat and carbohydrates; product preparation using leavening agents; project work related to text.

FSN 502 ***Principles of Nutrition*** **(3+0)**

Theory

Functions, sources, requirements, digestion and absorption of carbohydrates; definition, composition, classification, functions and role of dietary fibre in various physiological disorders. Basis of requirement, functions, sources, digestion and absorption of protein; Methods of assessing protein quality. Basis of requirement, functions, sources, digestion, absorption and deficiency disorders of lipids; essential fatty acids. Requirements, functions, sources, deficiencies and toxicities, of fat and water soluble vitamins. Requirement, functions, sources, deficiency, toxicity and factors affecting absorption and utilization of macro and micro minerals. Water balance; acid and base balance.

FSN 503 ***Food Analysis*** **(1+2)**

Theory

Familiarization to terms and calculations used in preparation of various standard solutions. Sample and sampling techniques. Principles, techniques and applications of colorimetric, spectrophotometer and atomic absorption spectrophotometer. Principles, techniques and applications of fluorimetry, flame photometry and electrophoresis. Principles techniques and

application of chromatography (paper chromatography, TLC,GLC, HPLC). Introduction to animal assay.

Practical

Handling of equipment and instruments; preparation of samples, solutions and buffers; quantitative estimation of proximate principles, minerals and vitamins by use of colorimetry, flame photometry, UV spectrophotometer; chromatography, atomic absorption spectrophotometer and photofluorometry, analysis of antinutritional factors; estimation of protein and starch digestibility; fractionation of protein; food adulteration.

FSN 504 ***Principles of Community Nutrition*** **(1+1)**

Theory

Assessment of the nutritional status at individual, household and institutional level: direct and indirect methods. Ecological, socio-cultural, economic and demographic correlations of malnutrition; 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. National nutritional programmes and policies; nutritional surveillance. National programmes and policies regarding food production and distribution.

Practical

Market survey for food availability and their cost; development of low cost nutritious recipes suitable for various vulnerable groups; visit to the ongoing public health nutrition programme and report writing. Techniques of assessment of nutritional status.

Project Work: 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.

FSN 505 ***Food Processing Technology*** **(2+0)**

Theory

Principles underlying food processing operations including thermal, radiation, refrigeration, freezing and dehydration. Effect of processing on physico chemical characteristics. 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. Technologies underlying in mutual supplementation, enrichment and fortification, fermentation, malting, germination. Food additives commonly used in food industries for color, flavor, and as preservatives. Quality control in food industry: raw material , finished products. Waste management and sanitation in food industries. Packaging of foods. Storage and marketing of processed foods.

FSN 506 ***Clinical Nutrition*** **(1+1)**

Theory

Methods for estimating 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. Interrelationship, etiology and preventive measures of vitamin and mineral deficiencies toxicities. Principles and interpretation of clinical laboratory methods with particular emphasis on their interpretation relative to nutritional status and disease; interaction between nutrients, infections and drugs.

Practical

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;

analysis of urine for specific metabolites under normal and diseased conditions.

FSN 507 ***Nutrition During Life Cycle*** **(2+0)**

Theory

Adulthood: sex, occupation, income. Pregnancy: 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. Lactation: Physiology of lactation, impact of nutrition on efficiency and milk production, food and nutrient requirements during lactation. Infancy: role of nutrition on physical and mental development, rate of growth - weight as an indicator, assessment of growth, nutrient requirement during infancy, feeding of infants – value of breast feeding, breast milk composition, breast feeding Vs artificial feeding, types of milk and their use in infant feeding, 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. Nutritional disorders and common ailments in infancy, feeding the sick child, immunization schedule and growth charts. Preschool age: growth and development – Physical and mental, prevalence of malnutrition in preschool years and food habits, nutritional requirements during preschool year and supplementary foods. School age: growth and development, nutritional requirements of school age children, specific problems in feeding school children. Adolescence: physical and physiological changes, nutritional requirements of adolescents, food preferences and nutritional problems. Elderly: physical and physiological changes, nutritional requirement, problems of old age, nutrients influencing aging process.

FSN 508 ***Nutrition and Physical Fitness*** **(1+1)**

Theory

Overview of nutritional management vis-a-vis physical fitness, body composition and physical fitness. Methods of measuring body composition: direct and indirect. Body composition in different physiological conditions and factors affecting it. Energy metabolism and physical fitness: concept, importance, influencing factors. Techniques to measure energy expenditure and energy intake. Techniques to assess physical fitness. Aging theories, physiology, mechanism and role of nutrients in arresting aging process.

Practical

Project relevant to text: selection of topic, planning of project, development and standardization of tool, collection of data, analysis of data, report writing.

FSN 509 ***Principles of Diet Therapy*** **(2+1)**

Theory

Role of dietician in a health care team in hospital and community. Newer concepts in dietary management of various nutritional disorders and disease conditions: fevers, infections. Dietary management during burns, allergy, gastrointestinal and liver diseases. Dietary management of cardiovascular diseases, renal disorders and obesity. Dietary management of diabetes, cancer and HIV. Nutrition in critical care.

Practical

Formulation of food exchanges. Therapeutic modifications of diet in terms of nutrients, consistency and composition for various disorders and diseases. Preparation of notes on case studies. Visits to hospitals.

FSN 510 ***Food Toxicology*** **(2+0)**

Theory

Introduction and significance of food toxicology. Food poisoning: types, causative factors, preventive symptoms, natural

food toxins, antinutritional factors, other food toxins, harmful effects, methods of removal. Microbial toxins and food intoxications. source of contamination, effect on health, preventive measures, methods of inactivation/destruction. Chemical toxins: Pesticides, insecticides metallic and others, residual effects, preventive measures, methods of removal. Food packaging material: potential contaminants from food packaging material. Food laws and standards: FPO, ISI, AG Mark, Codex Alimentarius, ISO mark for vegetarian and non vegetarian foods, ecofriendly products and others in operation.

FSN 511 ***Principles of Human Physiology*** **(1+1)**

Theory

Reticulo- endothelial system: functions, classification. Lymphatic system: functions, circulation. Circulatory System: blood - composition blood cells - development and function of blood cells, blood clotting, blood grouping and hemoglobin, Heart: anatomy, cardiac cycle, blood pressure and factors affecting blood pressure. Respiratory system: anatomy, physiology and mechanism of respiration, regulation of respiration. Digestive system: anatomy of gastrointestinal tract and accessory organs. Digestion and absorption of food, regulation of appetite. Excretory system: anatomy and functions of kidney, formation, composition and excretion of urine. Endocrine glands, mode of action of hormones. Reproductive system: structure and functions of male and female reproductive organs. Nervous system: anatomy and functions, Musculo skeletal system:anatomy and functions.

Practical

Estimation of hemoglobin. Identification of blood groups. Preparation of blood slide, identification and counting of blood cells. Haematocrit and sedimentation rate. Measurement of blood pressure. Examination of abnormal constituents of urine. Estimation of glucose and cholesterol in blood.

FSN 512 ***Food Service Management*** **(1+1)**

Theory

Types of food services. Organization: Definition, types. Management: tools of management. Personnel management. Books, records and record keeping. Cost control in food services. Menu planning. Meal services management: types of services. Quantity food production: Principles involved in development of recipes in large scale cooking, standardization of recipes, utilization of left over foods. Planning of layout and equipment for foods services. Sanitation and hygiene in handling foods. Personnel hygiene and its importance.

Practical

Standardization of recipes: planning and preparation , modification in basic recipe, preparation of standard recipe. Use of left over foods. Visit to different types of food service institutions and study the following: Organization, physical plan and layout, food service equipment, sanitation and hygiene. Practical experience in organization and management of a college cafeteria/ hotels.

FSN 513 ***Food Product Development*** **(1+1)**

Theory

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- Objective and subjective methods, selection and training of judges, development of score cards and analysis of data. Consumer evaluation-development of schedule and data analysis. Packaging material, types for different products. Food labeling. Food safety issues in product development, food quality regulations and standards, quality control and HACCP. Product formulation and development for general and therapeutic use.

Practical

Sensory evaluation methods, training of judges, score card preparation. Selection and modification of food product to be developed. Formulation and standardization of products. Objective and subjective evaluation of the products. Evaluation of consumer acceptability. Packaging and sale of products. Preparation of video film for media.

FSN 514 ***Nutrition and Immunity*** **(1+0)**

Theory

Immunity: definition, history, classification, immunological responses, cell types involved. Mechanism of phagocytosis and antigen-antibody reactions. Regulation of immunity. Mucosal defence system- effect of nutrients. 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. Role of vitamins in immune functions-effect of deficiency. Role of minerals-effect of deficiency and excess on immune cell functions. Probiotics and antioxidants – their effect on immune function. Immunity against infection – role of immunization.

FSN 515 ***Functional Foods*** **(0+1)**

Practical

Functional properties of food components in food systems with suitable applications. Traditional Foods: Selection of a product and study of preparation variables. 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. Biotechnology in food processing. Microwave technology. 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. 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.

GENETICS AND PLANT BREEDING

Course No.	Title	Credits
GPB 501 / PBT 514	Priciples of Genetics	2+1
GPB 502	Principles of Cytogenetics	2+1
GPB 503	Principles of Plant Breeding	2+1
GPB 504	Principles of Quantitative Genetics	1+1
GPB 505	Mutagenesis and Mutation Breeding	1+0
GPB 506	Breeding for Biotic and Abiotic Stress Resistance	2+0
GPB 507	Heterosis Breeding	2+0
GPB 508	Cell Biology and Molecular Genetics	2+0
GPB 509	Biotechnology for Crop Improvement	1+1
GPB 510	Population Genetics	1+1
GPB 511	Breeding Cereals, Forages and Sugarcane	2+0
GPB 512	Breeding Legumes, Oilseeds and Fibre Crops	2+0
GPB 513	Breeding for Quality Traits	1+0
GPB 514	Maintenance Breeding and Concepts of Variety Release and Seed Production	1+0
GPB 515	Germplasm Collection, Exchange and Quarantine	1+0
GPB 516	Plant Genetic Resources Utilization	1+0
GPB 517	Plant Variety Protection and Biosafety in the Management of Transgencis	1+0
GPB 571	Qualifying Examination	2
GPB 581	Seminar	2
GPB 591	Research	16

GPB 501 / PBT 514 ***Principles of Genetics*** **(2+1)**

Theory

Genetics: Scope and Beginning of Genetics; Early concepts of inheritance, Mendel's laws; Discussion on Mendel's papers; Significance of Mitosis and Meiosis Chromosomal theory of inheritance. Types of dominance, multiple alleles, gene interactions, types and mechanism; one gene- one enzyme hypothesis Probability and Statistics as applied to genetics, Binomial theorem, hypothesis testing and Chi-square test. Sex determination, Dosage compensation, Sex linkage, sex limited and sex influenced traits, Penetrance and expressivity. Linkage and mapping in eukaryotes: Diploid mapping, haploid mapping (tetra analysis), genetics of markers and genetic maps. Non-Mendelian inheritance: maternal effects and cytoplasmic inheritance; Mitochondria, chloroplasts and infective particles; Quantitative inheritance: Basis and significance, Nature and location of poly genes, Genes in populations, Hardy-Weinberg equilibrium: assumptions, proof and testing, extensions of Hardy-Weinberg equilibrium: multiple alleles and multiple loci; Mating systems: Random and nonrandom mating, inbreeding, Processes that change allelic frequencies: Mutation, migration, small population size and random genetic drift, natural selection and selection models, selection-mutation equilibrium. Evolution and speciation: Darwinian evolution, Speciation, Genetic polymorphisms and patterns of variation. Concepts of Eugenics, Epigenetics, Genetic disorders and Behavioural genetics

Practical

Laboratory exercises/problems on Mendelian Genetics, gene interaction, probability and Chi-square; Demonstration of genetic principles using; Linkage and Chromosome mapping using two and three point test cross; Tetrad analysis.

GPB 502 ***Principles of Cytogenetics*** **(2+1)**

Theory

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. Chromosomal theory of inheritance – Cell Cycle and cell division – mitosis and meiosis; Differences, significance and deviations – Synapsis, structure and function of synaptonemal complex and spindle apparatus, anaphase movement of chromosomes and crossing over-mechanisms and theories of crossing over-recombination models, cytological basis, - Variation in chromosome structure: Evolutionary significance - Introduction to techniques for karyotyping; 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 lethals and chromosome complexes. Inter-varietal chromosome substitutions; Polyploidy and role of polyploids in crop breeding; Evolutionary advantages of autopolyploids 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. Reversion of autopolyploids to diploids; Genome mapping in polyploids - Interspecific hybridization and allopolyploids; Synthesis of new crops (wheat, triticale and brassica) – Hybrids between species with same chromosome number, alien translocations - Hybrids between species with different chromosome number; Gene transfer using amphidiploids – Bridge species. Fertilization barriers in crop plants at pre-and postfertilization levels- In vitro techniques to overcome the fertilization barriers in crops; Chromosome manipulations in wide hybridization; case studies – Production and use of haploids, dihaploids and doubled haploids in genetics and breeding.

Practical

Learning the cytogenetics laboratory, 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. Studies on the course of mitosis in onion and other crops - Studies on the course of mitosis in important crops - Studies on the course of meiosis in oilseeds and forage crops - Using micrometers and studying the pollen grain size in various crops -Various methods of staining and preparation of temporary and permanent slides - Pollen germination in vivo and in vitro; Microtomy and steps in microtomy; Agents employed for the induction of various ploidy levels; Solution preparation and application at seed, seedling level - Identification of polyploids in different crops - Induction and identification of haploids; Anther culture and Ovule culture – Morphological observations on synthesized autopolyploids - Observations on C-mitosis, learning on the dynamics of spindle fibre assembly – Morphological observations on alloployploids - Morphological observations on aneuploids - Cytogenetic analysis of interspecific and intergeneric crosses - Maintenance of Cytogenetic stocks and their importance in crop breeding - Various ploidy levels due to somaclonal variation Polyploidy in ornamental crops. -Fluorescent in situ hybridization (FISH) - Genome in situ hybridization GISH.

GPB 503 ***Principles of Plant Breeding*** **(2+1)**

Theory

History of Plant Breeding (Pre and post-Mendelian era); Objectives of plant breeding, characteristics improved by plant breeding; Patterns of Evolution in Crop Plants- Centres of Origin-biodiversity and its significance. Plant introduction and role of plant genetic resources in plant breeding. Genetic basis of mating systems, consequences of Inbreeding, selfing and backcrossing Genetic basis of breeding self- and cross - pollinated crops including and response to selection - nature of variability, Types of gene actions; components of Phenotypic

value and components of variance; and implications in plant breeding; Heritability and Selection response, genotype environment interaction; Combining ability effects and variances. components of variation; Heritability and genetic advance, genotype environment interaction; General and specific combining ability; Pure line theory, pure line selection and mass selection methods; Line breeding, pedigree, bulk, backcross, single seed descent. Population breeding in self-pollinated crops (diallel selective mating approach), Transgressive breeding. Breeding methods in cross pollinated crops; Population breeding-mass selection and ear-to-row methods; S1 and S2 progeny testing, progeny selection schemes, recurrent selection schemes for intra and inter-population improvement and development of synthetics and composites; Hybrid breeding - genetical and physiological basis of heterosis and inbreeding, production of inbreds, breeding approaches for improvement of inbreds, predicting hybrid performance, heterosis breeding. Genetic architecture of clonally propagated crops; Breeding methods in asexually/clonally propagated crops viz., Sugarcane, Potato, Turmeric, other clonally propagated crops of economic importance like grapes, difficulties in breeding clonally propagated crops and methods to improve the specific traits in clonally propagated crops. Self-incompatibility and male sterility in crop plants and their commercial exploitation; Concept of plant ideotype and its role in crop improvement; Special breeding techniques- Mutation breeding; Breeding for abiotic and biotic stresses (To be elaborated as below). Special breeding techniques-Mutation breeding: Types of mutagens and classification; Dosimetry; Handling segregating mutated material and selection for polygenic traits, mutation for specific trait improvement (few examples), hybridization followed by mutation, varieties released by mutation breeding, Breeding for biotic stresses, Gene for gene concept, concept of differentials in resistance breeding, Concept of Vertical and Horizontal resistance, Multilines Breeding for abiotic stresses, wide hybridization. Cultivar development- testing, release and notification, maintenance breeding, Participatory and

anticipatory Plant Breeding, Focus on the Breeding objectives in the light of global climate change.

Practical

Floral biology in self and cross pollinated species, Selfing and crossing techniques in different crop plants. Evaluation of breeding material; Analysis of variance (ANOVA); Estimation of heritability and genetic advance. Maintenance of experimental records. Selection methods in segregating populations; Field Visits and practical exposure for study of segregating generations in field crops viz., Cotton, Wheat, Sorghum, Sunflower, Groundnut, Maize, Sugarcane *etc*.

GPB 504 ***Principles of Quantitative Genetics*** **(1+1)**

Theory

Mendelian traits vs polygenic traits - nature of quantitative traits and its inheritance - Multiple factor hypothesis - analysis of continuous variation; Variations associated with polygenic traits - phenotypic, genotypic and environmental - non-allelic interactions; Nature of gene action - additive, dominance, epistatic and linkage effects. Principles of Analylis of Variance (ANOVA) - Expected variance components, random and fixed models; MANOVA, biplot analysis; Comparison of means and variances for significance. Designs for plant breeding experiments – principles and applications; Genetic diversity analysis – metroglyph, cluster and D^2 analyses - Association analysis - phenotypic and genotypic correlations; Path analysis and Parent - progeny regression analysis; Discriminant function and principal component analyses; Selection indices - selection of parents; Simultaneous selection models- concepts of selection - heritability and genetic advance. Generation mean analysis; Mating designs- Diallel, partial diallel, line x tester analysis, NCDs and TTC; Concepts of combining ability and gene action; Analysis of genotype x environment interaction - adaptability and stability; Models for GxE analysis and stability parameters; AMMI analysis – principles and interpretation.

Practical

Problems on multiple factors inheritance - Partitioning of variance - Estimation of heritability and genetic advance - Covariance analysis - Metroglyph analysis - D^2 analysis - Grouping of clusters and interpretation - Cluster analysis - Construction of cluster diagrams and dendrograms - interpretation - Correlation analysis - Path analysis - Parent-progeny regression analysis - Diallel analysis: Griffing's methods I and II – Diallel analysis: Hayman's graphical approach - Diallel analysis: interpretation of results - NCD and their interpretations - Line x tester analysis and interpretation of results - Estimation of heterosis : standard, mid-parental and better-parental heterosis - Estimation of inbreeding depression - Generation mean analysis: Analytical part and Interpretation – Estimation of different types of gene actions. Partitioning of phenotypic variance and co-variance into components due to genotypes, environment and genotype x environment interactions - ; Phenotype and Marker linkage studies - Working out efficiency of selection methods in different populations and interpretation, Biparental mating, Triallel analysis, Quadriallel analysis and Triple Test Cross (TTC) –analysis and result interpretation, Advanced biometrical models for combining ability analysis, Models in stability analysis Additive Main Effect and Multiplicative Interaction (AMMI) model – Principal Component Analysis model - Additive and multiplicative model – Shifted multiplicative model - Analysis and selection of genotypes - Methods and steps to select the best model - Selection systems - Biplots and mapping genotypes.

GPB 505 ***Mutagenesis and Mutation Breeding*** **(1+0)**

Theory

Mutation and its history - Nature and classification of mutations: spontaneou and induced mutations, micro and macro mutations, pre and post adaptive mutations - Detection of mutations in lower and higher organisms – paramutations. Mutagenic agents: physical — Radiation types and sources: Ionising and non-ionizing radiations viz., X rays, ã rays and â particles, protons, neutrons and UV rays - Radiobiology:

mechanism of action of various radiations (photoelectric absorption, Compton scattering and pair production) and their biological effects –RBE and LET relationships. Effect of mutations on DNA - Repair mechanisms operating at DNA, chromosome, cell and organism level to counteract the mutation effects - Dosimetry - Objects and methods of treatment - Factors influencing mutation: dose rate, acute vs chronic irradiation, recurrent irradiation, enhancement of thermal neutron effects - Radiation sensitivity and modifying factors: External and internal sources- Oxygen, water content, temperature and nuclear volume. 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. Observing mutagen effects in M1 generation: plant injury, lethality, sterility, chimeras *etc*., - Observing mutagen effects in M2 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 M3 generation - Comparative evaluation of physical and chemical mutagens for creation of variability in the same species – Case studies. Achievements of mutation breeding- varieties released across the world- Problems associated with mutation breeding. In vitro mutagenesis – callus and pollen irradiation; Handling of segregating generations and selection procedures Use of mutagens in genomics, allele mining, TILLING.

GPB 506 ***Breeding for Biotic and Abiotic Stress Resistance*** **(2+0)**

Theory

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 - Concepts in 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-defense mechanisms against viruses and bacteria. 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 & 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. Genetics of abiotic stress resistance; Genes and genomics in breeding cultivars suitable to low water regimes and water logging & submergence, high and low/freezing temperatures; Utilizing MAS procedures for identifying resistant types in important crops like rice, sorghum, wheat, cotton and Breeding for resistance to stresses caused by toxicity, deficiency and pollutants/contaminants in soil, water and environment. Exploitation of 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, chitnases and Bt for diseases and insect pest management- Achievements.

GPB 507 ***Heterosis Breeding*** **(2+0)**

Theory

Historical aspect of heterosis - Nomenclature and definitions of heterosis - Heterosis in natural population and inbred population; Evolutionary aspects - Genetic consequences of selfing and crossing in self-and cross-pollinated and asexually propagated crops crops. Pre Mendelian and Post-Mendelian ideas - Genetic theories of heterosis – Physiological, Biochemical and molecular factors underlining heterosis; theories and their estimation; - Evolutionary concepts of heterosis. Prediction of heterosis from various crosses-Inbreeding depression, frequency of inbreeding and residual heterosis in F2 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 inbreds, their improvement for increasing heterosis. Types of male sterility and use in heterosis breeding; Maintenance, transfer and restoration of different types of male sterility; Use of self incompatibility in development of hybrids; Hybrid seed production system: 3-line, 2-line and 1-line system; Development of inbreds 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; Male sterile line creation and diversification in self pollinated, cross pollinated and asexually propagated crops; problems and prospects; Apomixis in fixing heterosis-concept of single line hybrid. Organellar heterosis and complementation - Creation of male sterility through genetic engineering and its exploitation in heterosis. Heterosis breeding in sunflower, wheat, rice, cotton, maize, pearl millet, sorghum and oilseed crops.

GPB 508 ***Cell Biology and Molecular Genetics*** **(2+0)**

Theory

Historical background of molecular genetics; Genetic material in organisms; Structure and properties of nucleic acid, DNA transcription and its regulation – Transcription factors and their role; Genetic code, regulation of protein synthesis in prokaryotes and eukaryotes – ribosomes, t-RNAs and translational factors. Transposable elements; Mechanisms of recombination in prokaryote; DNA organization in eukaryotic chromosomes – DNA content variation, types of DNA sequences – Unique and repetitive sequences; organelle genomes; Gene amplification and its significance; Quantitative estimation of DNA, RNA and protein in an organism; Numericals: problems and assignments.

GPB 509 ***Biotechnology for Crop Improvement*** **(1+1)**

Theory

Biotechnology and its relevance in agriculture; Definitions, terminologies and scope in plant breeding. Tissue culture-History, callus, suspension cultures, cloning; Regeneration; Somatic embryogenesis; Anther culture; somatic hybridization techniques; Meristem, ovary and embryo culture; cryopreservation. Techniques of DNA isolation, quantification; Genotyping; Biochemical and Molecular markers and morphological markers, DNA-based markers (RFLP, RAPD, AFLP, SSR,SNPs, ESTs *etc*.), mapping populations (F2s, back crosses, RILs, NILs and DH). Introduction to Molecular mapping and tagging of agronomically important traits. Statistical tools in marker analysis,; Marker-assisted selection for qualitative and quantitative traits; Introduction to Genomics. Marker-assisted backcross breeding for rapid introgression and gene pyramiding. Recombinant DNA technology, transgenes, method of transformation techniques, selectable markers, vector-mediated gene transfer, and physical gene transfer. Examples of transgenic plants in field crops: cotton, maize, rice, soybean, oilseeds, sugarcane *etc*. Case studies on Commercial releases. MOs and related issues, risk and regulations; GMO; International

regulations, biosafety issues of GMOs; Regulatory procedures in major countries including India, ethical, legal and social issues; Intellectual property rights. Introduction to Bioinformatics, Nanotechnology and its applications in crop improvement programmes.

Practical

Requirements for plant tissue culture laboratory-Techniques in plant tissue culture - Media components and media preparation - Aseptic manipulation of various explants, Inoculation of explants; Callus induction and plant regeneration - Plant regeneration; Standardizing the protocols for regeneration; Hardening of regenerated plants;- Visit to commercial micro propagation unit. Transformation using Agrobacterium strains, GUS assay in transformed cells / tissues. DNA isolation, purity and quantification tests, gel electrophoresis of PCR-based DNA markers, gel scoring and data analysis, interpretation and establishing linkage with traits.

GPB 510 ***Population Genetics*** **(1+1)**

Theory

Population - Properties of population - Mendelian population – Genetic constitution of a population through time, space, age structure *etc*. Mating systems - Random mating population - Frequencies of genes and genotypes-Causes of change: population size, differences in fertility and viability, migration and mutation. Hardy-Weinberg equilibrium - Hardy-Weinberg law - Proof – Applications of the Hardy-Weinberg law - Test of Hardy-Weinberg equilibrium – Mating frequencies - Non-dominance – Codominance – Snyder's ratio, importance and its effect over random mating in succeeding generations. Multiple alleles - More than one locus - Sex linked genes; Use of gene and genotypic frequencies evaluation in field population level; Interpretations - Changes of gene frequency – Migration – Mutation - Recurrent and nonrecurrent - Selection - Balance between selection and mutation – Selection favouring heterozygotes - Overdominance for fitness. Non random mating: selfing –inbreeding coefficient - panmictic index – sibmating -

Assortative mating and disassortative mating – Pedigree populations and close inbreeding - Estimation of selection - Estimation of disequilibrium - Estimation of linkage - Correlation between relatives and estimation of F; Effect of inbreeding and sibbing in cross pollinated crops. Gene substitution and average effects; Breeding value- Genetic drift; Genetic slippage, Co-adapted gene complexes; Homoeostasis-Adapative organization of gene pools, Polymorphism-Balanced and Non-balanced polymorphism, heterozygous advantage-Survival of recessive and deleterious alleles in populations.

Practical

Genetic exercise on probability; Estimation of gene frequencies; Exercises on factors affecting gene frequencies; Estimation of average affect of gene substitution and breeding value; Exercises on inbreeding and linkage disequilibrium-Cavalli's joint scaling test; Exercises of different mating designs; Estimation of different population parameters from experimental data; Measurement of genotype-environment interaction; Genetic divergence.

GPB 511 ***Breeding Cereals, Forages and Sugarcane*** **(2+0)**

Theory

Rice: Evolution and distribution of species and forms - wild relatives and germplasm; Genetics – cytogenetics and genome relationship – Breeding objectives- yield, quality characters, biotic and abiotic stress resistance *etc*. – Hybrid rice breeding-potential and outcome - Aerobic rice, its implications and drought resistance breeding. Wheat: 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, exploitation of heterosis *etc*; Sorghum: 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*; Pearl millet: 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*. Maize: 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* - QPM and Bt maize – strategies and implications - Heterosis breeding attempts taken in Sorghum, Pearl Millet and Maize; Minor millets: Evolution and distribution of species and forms - wild relatives and germplasm; Cytogenetics and genome relationship - Minor millets: breeding objectives yield, quality characters, biotic and abiotic stress resistance *etc*. 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 grasses: 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*., synthetics, composites and apomixes.

Forage legumes: 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.* - Tree fodders: 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*, palatability studies. Distinguishing features of popular released varieties in Rice and Sorghum - Wheat, Pearl millet, Maize and other millets - Sugarcane, forage grasses and legumes and their application to DUS testing - Maintenance of seed purity - Nucleus and Breeder Seed Production.

GPB 512 ***Breeding Legumes, Oilseeds and Fibre Crops*** **(2+0)**

Theory

Pigeonpea: Evolution and distribution of species and forms; Wild relatives and germplasm; Genetics, cytogenetics and

genome relationship; Morphological and molecular descriptors used for differentiating the accessions; Breeding objectives- yield, quality characters, biotic and abiotic stress *etc.* - Hybrid technology; maintenance of male sterile, fertile and restorer lines, progress made at ICRISAT and other Institutes. Chickpea: Evolution and distribution of species and forms - Wild relatives and germplasm - cytogenetics and genome relationship; Breeding objectives- yield, quality characters, biotic and abiotic stress *etc*; Protein quality improvement; Conventional and modern plant breeding approaches, progress made - Breeding for anti nutritional factors. Other pulses: Greengram, blackgram, fieldpea, cowpea, lablab, Evolution, cytogenetics and genome relationship; Learning the descriptors; Breeding objectives- yield, quality characters, biotic and abiotic stress *etc*; Interspecific crosses attempted and its implications, reasons for failure, ways of overcoming them. Groundnut: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; Pod and kernel characters; Breeding objectives- yield, quality characters, biotic and abiotic stress *etc*. Rapeseed and Mustard: Breeding objectives, utilization of wild relatives for yield and quality improvement, biotic and abiotic stress *etc.*; Oil quality – characteristics in different oils; Evolution and distribution of species and forms; Wild relatives and germplasm; Genetics, cytogenetics and genome relationship. Soybean: Breeding objectives, utilization of wild relatives for yield and quality improvement, biotic and abiotic stress *etc*. - Oil quality – characteristics; Evolution and distribution of species and forms; Wild relatives and germplasm; Genetics, cytogenetics and genome relationship. Other oilseed crops: Sunflower, sesame, niger: Sunflower: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship, hybrid sunflower, constraints and achievements. Castor: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship, breeding objectives yield, quality characters, biotic and abiotic stress *etc.* - Hybrid breeding in castor – opportunities, constraints and achievements. Cotton: Evolution of cotton; Breeding

objectives- yield, quality characters, biotic and abiotic stress *etc.*; Development and maintenance of male sterile lines – Hybrid development and seed production – Scenario of Bt cottons, evaluation procedures for BT cotton. Jute: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; breeding objectives- yield, quality characters, biotic and abiotic stress *etc.*; Mesta and minor fibre crops: Evolution and distribution of species and forms; Wild relatives and germplasm; Cytogenetics and genome relationship; breeding objectives- yield, quality characters, biotic and abiotic stress *etc*. Distinguishing features of the released varieties in pulses, oilseeds and cotton; Maintenance of seed purity and seed production.

GPB 513 ***Breeding for Quality Traits*** **(1+0)**

Theory

Developmental biochemistry and genetics of carbohydrates, proteins, fats, vitamins, aminoacids and anti-nutritional factors - Nutritional improvement - A human perspective - 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 - Breeding for quality improvement in barley and oats. Breeding for quality improvement in Sorghum and pearl millet; Quality protein maize – Concept and breeding strategies – Breeding for quality improvement in Ragi and forage crops - Genetic resource management for sustaining nutritive quality in crops. Breeding for quality in pulses - Breeding for quality in groundnut, 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. Genetic engineering protocols for quality improvement – Achievements made - Value addition in crops; Classification and importance – Nutritional genomics and Second generation transgenics.

GPB 514 ***Maintenance Breeding and Concepts of Variety Release and Seed Production*** **(1+0)**

Theory

Variety Development and Maintenance; Definition- variety, cultivar, extant variety, essentially derived variety, independently derived variety, reference variety, farmers' variety, hybrid,and population; Variety testing, release and notification systems in India and abroad. 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-pollination crops- isolation distance; Principles of seed production; Methods of nucleus and breeder seed production. Generation system of seed multiplication -nucleus, breeders, foundation, certified, - Quality seed production technology of self and cross-pollinated crop varieties viz. cereals & 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).; Seed certification procedures; Seed laws and plant variety protection regulations in India and international systems.

GPB 515 ***Germplasm Collection, Exchange and Quarantine*** **(1+0)**

Theory

History and importance of germplasm exploration; Distribution and extent of prevalent genetic diversity; Phyto-geographical regions/ ecological zones and associated diversity; Mapping eco-geographic distribution of diversity, threatened habitats, use of flora. 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. Ethnobotanical aspects of PGR; Crop botany, farming systems, collecting wild 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. 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; Plant quarantine- introduction, history, principles, objectives and relevance; Regulations and plant quarantine set up 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*.). 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. Genetically modified organisms (GMOs) or genetically engineered plants (GEPs), Concepts of biosafety, 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 biosafety.

GPB 516 ***Plant Genetic Resources Utilization*** **(1+0)**

Theory

Historical perspective; Taxonomical classification of cultivated plants; Regions of crop-plant diversity; Gene pool: primary, secondary and tertiary; Centres of origin and diversity; Basic genetic resources, derived genetic resources and transgenes; Principles, strategies and practices of exploration, collection, characterization, evaluation and cataloguing of PGR;

Plant quarantine principles and phytosanitory certification; Germplasm introduction and exchange; Principles of in vitro and cryopreservation; Germplasm conservation – *in situ*, *ex situ* and on-farm ; short, medium, long -term conservation strategies for conservation of orthodox and non-orthodox seed, vegetatively propagated crops; registration of plant genetic resources; PGR database management, description, national and international mechanism for PGR management; Plant genetic resources for food and agriculture (PGRFA), PGR access and benefit sharing; IPR, PBR, UPOV and CBD issues and consequences; Farmers' rights and privilege; Visit to Gene Bank/ National/ Regional Research Centres.

GPB 517 ***Plant Variety Protection and Biosafety in the Management of Transgencis*** **(1+0)**

Theory

Current status of plant variety protection in other countries and the existing scenario in India. Historical perspectives leading to the present status - Plant protection Act (PPA) of 1930 - Diamond vs Chakravarthy case. The Plant variety Protection Act 1970. Revisions of UPOV from time to time. Plant Breeders Rights - Obligations and modalities followed in conferring it. DUS criteria. Essentially derived varieties. Salient features of the PBR system in USA, Australia and Japan. IPR regimes under the GATT agreement. Suigeneris system of protection of crop varieties. Registration of novel genotypes. Farmers right on indigenous knowledge & conservation - benefit sharing. International understanding on the Conservation of Biological Diversity. Role of CGIAR system in the germplasm exchange. Patent filing-opposition-retrieval procedures. Handling of transgenic material by public & private institutes, protocols to be followed and Biosafety considerations. Regulatory issues, Cartagena Protocol.

HORTICULTURE

Course No.	Title	Credits
HRT 501	Major Tropical and Subtropical Fruits	2+1
HRT 502	Commercial Vegetable Crops	2+1
HRT 503	Prodution Technology of Major Commercial Flowers	2+1
HRT 504	Major Spices and Plantation Crops	2+1
HRT 505	Post Harvest Technology of Horticultural Produce	2+1
HRT 506	Protected Cultiveation of Horticulture Crops	1+1
HRT 507	Growth and Development of Horticultural Crops	2+1
HRT 508	Principles and Practices of Dry Land Horticulture	1+1
HRT 509	Organic Horticulture	1+1
HRT 510	Plant Tissue Culture and Its Application in Commercial Production of Horticultural Crops	1+1
HRT 511	Propagation and Nursery Manageent of Fruit Crops	2+1
HRT 512	Minor Tropical and Subtropical Fruits	1+1
HRT 513	Breeding of Fruit Crops	2+1
HRT 514	Canopy Management in Fruit Crops	1+1
HRT 515	Minor Vegetable Crops	1+1
HRT 516	Breeding of Vegetable Crops	2+1
HRT 517	Seed Production Technology of Vegetable Crops	1+1
HRT 518	Production Technology of Medicinal and Aromatic Crops	2+1
HRT 519	Landscaping and Ornamental Gardening	2+1
HRT 520	Production Technology of Minor Commercial Flowers	1+1
HRT 521	Breeding of Flower Crops and Ornamental Plants	2+1
HRT 522	Fundamentals of Processing of Fruits and Vegetables	1+1
HRT 571	Qualifying Examination	2
HRT 581	Seminar	2
HRT 591	Research	16

HRT 501 ***Major Tropical and Subtropical Fruits*** **(2+1)**

Theory

Importance, history, origin, area, distribution, production and culture of major tropical and sub-tropical fruit crops – Botany, taxonomy, varieties and their classification. Climatic influences, soil requirements, propagation and root stocks and problem of multiplication. Establishment of commercial orchards; propagation, planting and after care.

Nutrition – disorders; training and pruning. Irrigation and intercropping. Pests, diseases and their management.

Vegetative and reproductive phases of fruits and fruiting. Techniques for high productivity. Post-harvest handling.

Crops

UNIT I : Mango and Banana

UNIT II : Citrus and Papaya

UNIT III : Grape, Guava, Sapota

UNIT IV : Pineapple, and Jackfruit

UNIT V : Special problems – Mango-irregular bearing and malformation, Citrus decline and developments done.

Practicals

Study of varieties and species. Propagation methods. Planting and after care. Study of flowering and fruit set. Identification of pests and diseases and their management. Hybridization techniques. Visit to progressive orchards and research centers may be arranged.

HRT 502 ***Commercial Vegetable Crops*** **(2+1)**

Theory

Importance, history, origin, area, distribution, production and culture of commercial vegetable crops. Taxonomy and improved varieties / hybrids. 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.

Harvesting and post-harvest technology, seed production, specific problems associated with different crops and prospects of improvement through breeding.

UNIT I -Tomato, potato, eggplant, hot and sweet peppers

UNIT II- Beans, cowpea

UNIT III-Carrot, radish, beetroot and sweet potato UNIT IV-Cabbage, cauliflower, knol-khol UNIT V-Onion, Garlic

UNIT VI -Okra, Sweet potato

UNIT VII-Leafy vegetables, Amaranthus & palak

UNIT VIII-Major Cucurbitaceous vegetables, cucumber, Gherkin, water melon, muskmelon, Bitter gourd, ash gourd and pumpkin

Practicals

Cropping systems, Study of varieties, study of nursery techniques, seed treatment, role of growth substances in vegetable production. Rhizobium inoculation; hardening of seedlings, *etc*. 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 may be arranged.

HRT 503 ***Production Technology of Major Commercial Flowers*** **(2+1)**

Theory

Importance, history, origin, area, distribution and culture of major commercial flower crops. Botany, taxonomy, varieties, classification and crop improvement. Climatic and soil requirements. Propagation, rootstocks and problems of

multiplication. Planting and after care. Nutrition, training, pruning, pinching, disbudding, irrigation, intercropping and use of growth regulators. Pests/diseases and their management and physiological disorders.

UNIT I - Jasmine, Chrysanthemum

UNIT II - Rose, Marigold, Gladiolus

UNIT III - Crossandra, Tuberose, Anthuriums

UNIT IV - China aster, Alstroemeria, Orchids, Gerbera, Lilums

UNIT V - Harvesting, grading, storing, packing, marketing, and economics. Vase life of cut flowers.

Practicals

Identification, classification and description of commercial species and varieties of major commercial flower crops. Propagation, pruning, pinching, disbudding of commercial flower. Layout of experiments to prolong the vase life of cut flowers. Harvesting, grading, storing and packing of flowers. Use of growth regulators. Survey of different cut flower markets.

Visit to commercial flower gardens and research centers may be arranged.

HRT 504 ***Major Spices and Plantation Crops*** **(2+1)**

Theory

Role of spices and plantation crops in national economy, export potential, IPR issues, classification and varietal wealth. 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, high density planting, 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. Cost benefit analysis, organic farming, management of drought, precision farming. Organic certification and quality analysis.

Crops

UNIT I: Coffee, cocoa and tea

UNIT II: Cashew, rubber and oil palm

UNIT III: Coconut and arecanut

UNIT IV: Black pepper, cardamom, turmeric and ginger

UNIT V: Clove, cinnamon, nutmeg and seed spices

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.

HRT 505 ***Post-harvest Technology of Horticultural Produce*** **(2+1)**

Theory

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.

Unit III - Pre and Post-harvest treatments for extending storage life – use of protective coats, fungicides and chemicals. Control of ripening and senescence by growth regulators control of dormancy, sprouting and discoloration in vegetables.

Unit IV - 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.

Cold storage, controlled atmosphere storage and hypobaric storage – equipments used. Preservation by freezing and irradiation.

Unit V - 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.

HRT 506 ***Protected Cultivation of Horticultural Crops*** **(1+1)**

Theory

UNIT I - Introduction, history, present status, importance, problems and prospects of protected cultivation. Types and designs of protected structures and their management. Environment control in protected structures. Growing media and sterilization. Soilless cultivation, hydroponics and aero ponics. Irrigation, Fertigation and water management of green house crops.

UNIT II - Physiology of green house crops. Vegetable seedlings production under protection.

UNIT III - Protected cultivation of crops (media, bed preparation, varieties, planting, irrigation and fertigation, harvesting, specific operation for different crops and economics): rose, carnation, gerbera, orchids, anthurium. lilium, chrysanthemum, new ornamentals, growing filler materials like limonium (statice), ligianthus, gypsophila, fern, asparagus, *etc*.

UNIT IV - Protected cultivation of crops (media, bed preparation, varieties, planting, irrigation and fertigation, harvesting, specific operation for different crops and economics) capsicum, tomatoes, cucumber and other exotic vegetables

UNIT V- Post harvest management of flowers and vegetable (sorting, grading, packing, storage, transportation and marketing). Integrated insect pest and disease management

Practicals

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

HRT 507 ***Growth and Development of Horticultural Crops*** **(2+1)**

Theory

UNIT I - Growth and development- 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.

UNIT IV - 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 V - 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.

Practical

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.

HRT 508 ***Principles and Practices of Dry-land Horticulture*** **(1+1)**

Theory

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*.

UNIT II - 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.

UNIT III - 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 IV - Selection of plants/crops having drought resistance/ tolerance characteristics.

UNIT V - Special techniques of planting and after care - use of seedling races, root stocks, in situ grafting, deep pitting/planting, canopy reduction etc.

Practicals

Study of rainfall patterns. Contour bunding/trenching, micro catchments, 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 crops.

HRT 509 ***Organic Horticulture*** **(1+1)**

Theory

UNIT I - Organic horticulture – definition, synonyms and misnomers, principles, methods, merits and demerits.

UNIT II - Organic farming systems, components of organic horticultural systems, different organic inputs, their role in organic horticulture, role of biofertilizers, biodynamics and the recent developments.

UNIT III - 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.

UNIT IV - 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 V - 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.

Practical

Features of organic orchards, working out conversion plan, Input analysis manures, nutrient status assessment of manures, bio-composting, bio-fertilizers and their application, panchagavya preparation 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, 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.

HRT 510 ***Plant Tissue Culture and its Application in Commercial Production of Horticultural Crops*** **(1+1)**

Theory

Plant Tissue Culture: principles, practices and its application in Micro propagation , Methods in Micro propagation, aspects of commercial propagation, including problems and prospectus in reference to high value Horticultural crops.

UNIT I - Principles of tissue morphogenesis under in vitro conditions

UNIT II - Factors influencing *in vitro* cultures

Callus culture - principles and practices of its regeneration in to organs

UNIT III - Micro propagation, methods in micro propagation and its relevant in varied horticultural plants.

UNIT IV - Principles and practices of hardening .

UNIT V - Commercial propagation methods in relation to various commercial important horticultural crops

Practical's

Layout of Plant Tissue Culture laboratory. Designing laboratory for commercial production, laboratory practices, methods in Micro propagation, advantages and disadvantages, aspects of commercial propagation, starting from selection of mother plant, initiation of ex-plant, to secondary hardening. Maintenance and upkeeping of laboratory, planning large scale production, book keeping, sales and marketing.

HRT 511 ***Propagation and Nursery Management of Fruit Crops*** **(2+1)**

Theory

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.

Layering – principles and methods.

UNIT III - 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 IV- 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.

UNIT V- 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.

HRT 512 ***Minor Tropical and Sub Tropical Fruits*** **(1+1)**

Theory

Importance, history, origin, area, distribution, production and culture of minor tropical and sub-tropical fruit crops.

Botany and taxonomy. Climatic and soil requirements. Propagation, root stocks and problem of large scale multiplication. Planting and after care. Training, pruning and nutrition.

Pests - diseases and their management.

Vegetative and reproductive phases, fruit set and fruiting. Developments in crop improvement.

UNIT I: Pomegranate, fig, ber, annonanceous fruits.

UNIT II: Jamun, rose apple, jack fruit, bread fruit, passion fruit.

UNIT III: West Indian cherry, karonda, wood-apple, bael fruit.

UNIT IV: Avocado, litchi, loquat, strawberry, carambola, rambutan.

UNIT V: Durian, mangosteen, langsat, bilimbi, tamarind, *etc*.

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.

HRT 513 ***Breeding of Fruit Crops*** **(2+1)**

Theory

Origin and distribution, taxonomical status - species and cultivars, cytogenetics, genetic resources, blossom biology, breeding systems, breeding objectives, ideotypes, approaches 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.

Crops

UNIT I: Mango, banana and pineapple.

UNIT II: Citrus, grapes, guava and sapota.

UNIT III: Jackfruit, papaya, custard apple, aonla, avocado and ber.

UNIT IV: Mangosteen, litchi, jamun, phalsa, raspberry and nuts.

UNIT V: Apple, pear, plums, peach, apricot, cherries and strawberry.

Practical

Characterization of germplasm, blossom biology, study of 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.

HRT 514 ***Canopy Management in Fruit Crops*** **(1+1)**

Theory

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.

Practical

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.

HRT 515 ***Minor Vegetable Crops*** **(1+1)**

Theory

Importance, history, origin, area, distribution, production and culture of minor vegetable crops. Taxonomy and improved varieties. Climatic and soil requirements, sowing/planting. After care, water and, nutrient requirements, interculture, plant protection, intercropping and use of growth regulators. Harvesting and post harvest technology. Seed production.

Specific problems and management of each crops and prospects of improvements through breeding.

UNIT I- Cluster Bean, Winged Bean, Dolichos, Cowpea.

UNIT II- Leafy vegetables (Lettuce, Methi, Coriander *etc.*),

UNIT III- Cassava, Colocasia, Amorphophallus, Dioscoria.

UNIT IV- Tinda, Chow-chow, Little gourd, Snake gourd, ridge gourd, sponge ground and oriental pickling melon.

UNIT V- Broccoli, Brussel sprout.

UNIT VI-Perennial Vegetables (Drum Stick, Chow Chow, Coccinia, Curry Leaf, *etc.*).

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.

HRT 516 ***Breeding of Vegetable Crops*** **(2+1)**

Theory

Origin, botany, taxonomy, cytogenetics, male sterility and self-compatibility in plants-causes and implication in breeding, Genetics basis of plant breeding, Vegetables breeding objectives & breeding methods, Heterosis and hybrid breeding, resistance breeding for biotic and abiotic stress, concept of bio-technology

and its application in vegetable breeding, issue of patenting, PPVFR act.

UNIT I- Potato and Tomato, Eggplant, Hot Pepper, Sweet Pepper.

UNIT II- Peas, Beans.

UNIT III- Amaranth and Lettuce.

UNIT IV- Cucumber, Melons, Gourds, Pumpkins and Squashes.

UNIT V- Cabbage, Cauliflower.

UNIT VI- Carrot, Beetroot, Radish, Sweet Potato and okra.

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 in vegetable crops; hybrid seed production of vegetable crops in bulk. Screening techniques for insectpests, disease and environmental stress resistance in above mentioned 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.

HRT 517 ***Seed Production Technology of Vegetable Crops*** **(1+1)**

Theory

UNIT I- Definition of seed and its quality, new seed policies; DUS test, scope of vegetable seed industry in India.

UNIT II- 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 behaviour, seed development and maturation; methods of hybrid seed production.

UNIT III- 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 IV- 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.

UNIT V- Techniques for seed production in annual vegetables *viz*., solanaceous vegetables, cucurbits, leguminous vegetables, okra, leafy vegetables, techniques of seed production biennial vegetables viz., cole crops, bulb crops, root vegetables, and vegetative 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 and spice 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.

HRT 518 ***Production Technology of Medicinal and Aromatic Crops*** **(2+1)**

Theory

UNIT I- Herbal industry, WTO scenario, Export and import status, Indian system of medicine, Indigenous Traditional Knowledge, IPR issues, Classification of medicinal crops, Systems of cultivation, Organic production, Role of institutions and NGO's in production, GAP in medicinal crop production.

UNIT II – Production technology for Senna, Periwinkle, Coleus, Aswagandha, Glory lily, Sarpagandha, Aloe vera, *Andrographis paniculata*.

UNIT III- Production technology for Isabgol, Poppy, *Stevia rebaudiana, Ocimum* sp.

UNIT IV- Post harvest handling – Drying, Processing, Grading, Packing and Storage, processing and value addition; GMP and Quality standards in herbal products.

UNIT V- Influence of biotic and abiotic factors on the production of secondary metabolites, Regulations for herbal raw materials, Phytochemical extraction techniques.

UNIT VI- Aromatic industry, WTO scenario, Export and import status, Indian perfumery industry, History, Advancements in perfume industry.

UNIT VII- Production technology for palmarosa, lemongrass, citronella, vettiver, geranium, davana,mentha, ocimum, eucalyptus, rosemary, patchouli.

UNIT VIII- 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.

UNIT IX- Institutional support and international promotion of essential oil and perfumery products.

Practical

Botanical description, Propagation techniques, Maturity standards, Digital documentation, 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.

HRT 519 ***Landscaping and Ornamental Gardening*** **(2+1)**

Theory

UNIT I- Landscape designs & principles of gardening, types and styles of gardens, English, Mughal, Japanese, Persian, Italian.

UNIT II- Urban landscaping, Landscaping for specific situations, institutions, industries, residents, hospitals, roadsides, traffic islands, dam, sites, IT parks,corporates.

UNIT III- 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.

UNIT IV- Lawns, Establishment and maintenance. Special types of gardens; vertical garden, roof garden, bog garden, sunken garden, rock garden.

UNIT V- Bio-aesthetic planning, eco-tourism, theme parks, indoor gardening, therapeutic gardening, non-plant components, water scaping, xeriscaping, hardscaping.

Practical

Selection of ornamental plants, practices in preparing designs for home gardens, industrial gardens, institutional gardens, corporates, avenue planting, practices in planning and planting of special types of gardens, lawn making, planting herbaceous and shrubbery borders, project preparation on landscaping for different situations, visit to parks and botanical gardens, case study on commercial landscape gardens.

HRT 520 ***Production Technology of Minor Commercial Flowers*** **(1+1)**

Theory

Importance, history, origin; area, distribution, production and culture of minor commercial flowers. Botany, taxonomy, varieties and their classification and crop improvement.

Climatic and soil requirements. Propagation, planting and aftercare. Nutrition, irrigation, interculture, weed control and use of growth regulators. Pests/diseases and their managements.

UNIT I: Lotus, Amaryllis and Hippeastrum,

UINIT II: Bird of paradise, Gaillardia, Gomphrena

UNIT III: Zinnia, Gypsophylla, Statice, Salvia, Dahlia

UNIT IV: Zantedeschia, Solidago, Berlaria, Heliconia

UNIT V: Harvesting, grading, storing, packing, marketing and economics. Vase life of cutflowers.

Practicals

Identification, classification and description of commercial species and varieties. Studies on propagation. Layout of experiments to prolong the vase life of cut flowers. Harvesting, grading, storing and packing of flowers. Use of growth regulators. Survey of cut flower markets. .

Visit to commercial flower gardens and research centres may be arranged.

HRT 521 ***Breeding of Flower Crops and Ornamental Plants*** **(2+1)**

Theory

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.

UNIT III- Breeding methods suitable for sexually and asexually propagated flower crops and ornamental plants— introduction, selection, domestication, polyploid and mutation breeding for varietal development, Role of heterosis, Production of hybrids, Male sterility, incompatibility problems, seed production of flower crops.

UNIT IV- Breeding constraints and achievements made in commercial flowers - rose, jasmine, chrysanthemum, marigold, tuberose, crossandra, carnation, dahlia, gerbera, gladioli, orchids, anthurium, China aster, heliconia, liliums,

UNIT V- Breeding constraints and achievements made in ornamental plants –petunia, hibiscus, bougainvillea, Flowering annuals (zinnia, cosmos, dianthus, snap dragon, pansy) and ornamental foliages– Introduction and selection of plants for water scaping and xeriscaping.

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 and environmental pollution, in vitro breeding in flower crops and ornamental plants.

HRT 522 ***Fundamentals of Processing of Fruits and Vegetables*** **(1+1)**

Theory

UNIT I- Importance of processing of fruits and vegetables. Indian and global scenario on production and processing of fruits and vegetable. History of food preservation, Present status and future prospects of fruit and vegetable preservation industry in India.

UNIT II- 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.

UNIT III- 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.

UNIT IV- 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 V- Investment analysis. Principles and methods of sensory evaluation of fresh and processed fruits and vegetables.

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.

PLANT BIOCHEMISTRY

Course No.	Title	Credits
BCM 501 / PBT 515	Basic Biochemistry	2+1
BCM 502	Intermediary Metabolism	2+0
BCM 503	Enzymology	2+0
BCM 504	Molecular Biology	3+0
BCM 505	Biochemical Techniques	1+2
BCM 506	Immunochemistry	2+1
BCM 507	Plant Biochemistry	2+0
BCM 508	Food and Nutritional Biochemistry	1+1
BCM 509	Carbon and Nitrogen Metabolism	2+1
BCM 571	Qualifying Examination	2
BCM 581	Seminar	2
BCM 591	Research	16

BCM 501 / PBT 515 ***Basic Biochemistry*** **(2+1)**

Theory

Scope and importance of biochemistry in agriculture; Fundamental principles governing life; structure of water; acid-base concept and buffers; pH; hydrogen bonding; hydrophobic, electrostatic and Van der Waals forces; General introduction to physical techniques for determination of structure of biopolymers. Classification, structure and function of carbohydrates, lipids and biomembranes, amino acids, proteins, and nucleic acids. Structure and biological functions of vitamins; Enzymes: classification and mechanism of action, regulation, factors affecting enzyme action. Hormones: animals, plants and insects Fundamentals of thermo-dynamic principles applicable to biological processes, Bioenergetics. Metabolism of carbohydrates, photosynthesis and respiration, oxidative

phosphorylation, lipids, proteins and nucleic acids. DNA replication, transcription and translation; recombinant DNA technology. Nutritional aspects of carbohydrates, lipids, proteins and minerals.

Practical

Preparation of standard and buffer solutions, Extraction and estimation of sugars, Amino acids, Estimation of Proteins by Lowry's method, Estimation of DNA and RNA by diphenylamine and orcinol methods. Estimation of Ascorbic acid. Separation of biomolecules by TLC and Paper chromatography.

BCM 502 ***Intermediary Metabolism*** **(2+0)**

Theory

The living cell: a unique chemical system, Introduction to metabolism, methods of studying metabolism, transport mechanism, bioenergetics, biological oxidation, signal transduction. Catabolic and anabolic pathways of carbohydrates and lipids, regulation and their metabolic disorders. Energy transduction and oxidative phosphorylation. General reactions of amino acid metabolism, Degradative and biosynthetic pathways of amino acids and their metabolic disorders. Sulphur metabolism, Metabolic engineering concepts. Compartmentation of metabolic pathways, metabolic profiles of major organs and regulation of metabolic pathways.

BCM 503 ***Enzymology*** **(2+0)**

Theory

Introduction and historical perspective, Enzyme nomenclature and classification, enzyme compartmentalization in cell organelles, isolation and purification of enzymes, measurement of enzyme activity. Ribozymes, isozymes, abzymes. Enzyme structure, enzyme specificity, active site, active site mapping, mechanism of enzyme catalysis. Cofactors and coenzymes-their structure and role. Enzyme kinetics, enzyme inhibition and activation, multienzyme complexes,

allosteric enzymes and their kinetics, regulation of enzyme activity. Isolation and purification of enzymes, Applications of enzymes in chemical and food industry, enzyme immobilization, biosensors and clinical applications of enzymes.

Enzyme assay by taking any model enzyme like alpha-amylase or acid phosphatase, isolation and purification of any model enzyme like alpha- amylase or acid phosphatase, study of the effect of enzyme and substrate concentrations and determination of K_m and V_{max}, determination of pH, temperature optima and effect of various inhibitors, determination of the pH and temperature stability of enzyme.

BCM 504 ***Molecular Biology*** **(3+0)**

Theory

Historical development of molecular biology, nucleic acids as genetic material, chemistry and structure of DNA and RNA, Genome organization in prokaryotes and eukaryotes, chromatin structure and function. DNA replication, DNA polymerases, topoisomerases, DNA ligase, reverse transcriptase, repetitive and non-repetitive DNA, satellite DNA; transcription process, RNA editing, RNA processing. Ribosomes structure and function, organization of ribosomal proteins and RNA genes, genetic code, aminoacyl tRNA synthases' inhibitors of replication, transcription, translation and Post translational modification; nucleases and restriction enzymes, regulation of gene expression in prokaryotes and eukaryotes, molecular mechanism of mutation. DNA sequencing, recombinant DNA technology, vectors, isolation of genes, recombinant vector, selection of recombinants, PCR; general features of replication, transcription, site directed mutagenesis and translation in eukaryotes.

BCM 505 ***Biochemical Techniques*** **(1+2)**

Theory

Chromatographic and electrophoretic methods of separation, Principles and applications of Paper, Thin layer & HPTLC, Gas, Gas-liquid and Liquid chromatography, HPLC and FPLC; Paper and gel electrophoresis, Different variants of polyacrylamide gel

electrophoresis (PAGE) like native and SDS-PAGE, 2D-PAGE, capillary electrophoresis. Spectrophotometry: Principles and applications; UV-Visible, Fluorescence, IR and FTIR, Raman, NMR and FTNMR, ESR and X-Ray spectroscopy. Hydrodyanmic methods of separation of biomolecules such as viscosity and sedimentation- their principles, variants and applications. 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, principles and applications of phosphor imager.

Practical

Determination of absorption maxima of some important chemicals from their absorption spectra, estimation of biomolecules using spectrophotometer, Separation of carbohydrates and amino acids by paper chromatography, Separation of lipids by thin layer and column chromatography, Separation of proteins by ion exchange and gel filtration chromatography, Electrophoretic techniques to separate proteins and nucleic acids, Centrifugation- Cell fractionation; Application of GLC, HPLC and FPLC in separation of biomolecules, Use of radioisotopes in metabolic studies.

BCM 506 ***Immunochemistry*** **(2+1)**

Theory

History and scope of immunology, antigens, adjuvants, immune system, organs, tissues and cells, immunoglobulins, molecular organization of Immunoglobulin. Classes of antibodies, Antibody diversity, theories of generation of antibody diversity, Vaccine, Monoclonal antibodies, polyclonal antibodies, Hybridoma, Recombinant antibodies, complement system- classical and alternate. Cellular interactions in the immune response, major histocompatibility complex, cell mediated immune response, cytokines. Immunoregulation, immunological tolerance, hypersensitivity, mechanisms of

immunity, innate resistance and specific immunity. Current immunological techniques - ELISA, RIA.

Practical

Handling, inoculation and bleeding of laboratory animals, Preparation of antigens and antisera, natural antibodies, Carbon clearance test, lymphoid organs of the mouse, Morphology of the blood leucocytes, separation of lymphocytes from blood, viable lymphocyte count, Antigen-antibody interaction, precipitation, agglutination, direct and indirect haemagglutination, Immunoelectrophoresis, Complement fixation, Quantitation of immunoglobulins by zinc sulphate turbidity and single radial immunodiffusion.

BCM 507 ***Plant Biochemistry*** **(2+0)**

Theory

Scope and importance of biochemistry in Agriculture, Plant cell organelles and their separation, structure and function of cell organelles. Photosynthetic pigments in relation to their functions, photosynthesis, C_3, C_4 and CAM pathways, photorespiration. Sucrose-starch interconversion, biosynthesis of structural carbohydrates, storage proteins and lipids. Biochemistry of nitrogen fixation and nitrate assimilation, sulphate reduction and incorporation of sulphur into amino acids. Biochemistry of seed germination and development, Biochemistry of fruit ripening, phytohormones and their mode of action, signal transduction. Biochemistry and significance of secondary metabolites-cyanogenic glycosides, glucosinolates, phenolic compounds, terpenoids, alkaloids, plant defense system.

BCM 508 ***Food and Nutritional Biochemistry*** **(1+1)**

Theory

Fundamentals of human nutrition, concept of balanced diet, biochemical composition, energy and food value of various food grains (including cereals, pulses, oilseeds), fruits and vegetables. Physico-chemical, functional and nutritional characteristics of

carbohydrates, proteins and fats and their interactions (emulsions, gelation, browning *etc*.). Biochemical and nutritional aspects of vitamins, minerals Nutraceuticals, antinutritional factors, biochemistry of post harvest storage. Effect of cooking, processing and preservation of different food products on nutrients, biochemical aspects of food spoilage, role of lipase and lipoxygenase, oxidative rancidity and antioxidants. Enzymes in food industry, food additives (coloring agents, preservatives, *etc*.), biogenesis of food flavours and aroma, nutritional quality of plant, dairy, poultry and marine products.

Practical

Estimation of starch, lipid/oil, phenols in plant tissue/sample, Estimation of carotenoids, Estimation of Trypsin and chymotrypsin inhibitor activities in seeds, Estimation of Vitamin C in fruits, Reducing & non reducing sugar in fruits, Estimation of protein contents, Estimation of dietary fibre, Determination of limiting amino acids, Estimation of Phytate/Oxalate.

BCM 509 ***Carbon and Nitrogen Metabolism*** **(2+1)**

Theory

Carbon metabolism: Synthesis of sucrose, Regulation of sucrose-phosphate synthesis, Transport of sucrose, phloem loading and unloading, synthesis of starch in leaves and seeds, concept of transitory starch. Synthesis of fructose, galactomannans, raffinose series oligosaccharides and trehalose. Nitrogen cycle- Biochemistry of nitrate assimilation and its regulation, GS/GOGAT and GDH pathway, ureides and amides as nitrogen transport compounds, chemoautotrophy in denitrifying bacteria. Biological nitrogen fixation; structure, function and regulation of nitrogenase; nif genes and their regulation; biochemical basis of legume- rhizobium symbiosis, genes involved in synthesis.

Practical

Estimation of nitrite content, Estimation of protein by Lowry's method, Estimation of starch, Estimation of nitrate content by hydrazine sulphate reduction method, *in vivo* assay of nitrate reductase activity, *in vitro* assay of nitrate reductase activity, *in vitro* assay of nitrite reductase activity, *in vitro* assay of glutamine synthetase activity, *in vitro* assay of glutamate synthase and glutamate dehydrogenase activity, Estimation of ureides and amides, Assay of nitrogenase activity by acetylene reduction method, Estimation of hydrogen evolution by legume nodules.

PLANT BIOTECHNOLOGY

Course No.	Title	Credits
PBT 501 / BIM 501	Principles of Biotechnology	1+1
PBT 502	Funcamentals of Molecular Biology	3+0
PBT 503	Molecular Cell Biology	2+0
PBT 504	Plant Tissue Culture and Genetic Transformation	2+1
PBT 505	Techniques in Molecular Biology – I	0+2
PBT 506	Microbial / Industrial Biotechnology	2+1
PBT 507	Molecular Breeding	2+0
PBT 508	Genomics and Proteomics	2+0
PBT 509	Techniques in Molecular Biology – II	0+2
PBT 510	Biosafety, IPR and Bioethics	2+0
PBT 511	Animal Biotechnology	2+0
PBT 512	Immunology and Molecular Diagnostics	1+1
PBT 513	Nano-Biotechnology	2+0
PBT 514 / GPB 501	Principles of Genetics	2+1
PBT 515 / BCM 501	Basic Biochemistry	2+1
PBT 516	Biostatistics and Computers	2+1
PBT 517 / AMB 501	Principles of Microbiology	2+1
PBT 518	Introduction to Bioinformatics	1+1
PBT 519 / EVS 514	Environmental Biotechnology	2+0
PBT 571	Qualifying Examination	2
PBT 581	Seminar	2
PBT 591	Research	16

PBT 501 / BIM 501 ***Principles of Biotechnology*** **(1+1)**

Theory

History, scope and importance; DNA structure, function and metabolism. DNA modifying enzymes and vectors; Methods of recombinant DNA technology; Nucleic acid hybridization; Gene libraries; PCR amplification; Plant and animal cell and tissue culture techniques and their applications. Molecular markers and their applications; DNA sequencing; Applications of gene cloning in basic and applied research; Genetic engineering and transgenics; Genomics, transcriptomics and proteomics. General application of biotechnology in Agriculture, Medicine, Animal husbandry; Environmental remediation, Energy production, Forensics; Public perception of biotechnology; Bio-safety and bioethics issues; Intellectual property rights in biotechnology.

Practical

Isolation of genomic and plasmid DNA, Gel electrophoresis techniques, Restriction enzyme digestion, ligation, transformation and screening of transformants, PCR and molecular marker analysis; Plant tissue culture: media preparation, cell and explant culture, regeneration and transformation.

PBT 502 ***Fundamentals of Molecular Biology*** **(3+0)**

Theory

Historical developments of molecular biology; Nucleic acids as genetic material; Chemistry, structure and properties of DNA and RNA. Genome organization in prokaryotes and eukaryotes; Chromatin structure and function; DNA replication; DNA polymerases, topoisomerases, DNA ligase *etc.*; Molecular basis of mutations; DNA repair mechanisms. Transcription process; RNA processing; Reverse transcriptase; RNA editing; Ribosome structure and function; Organization of ribosomal proteins and RNA genes; Genetic code; Aminoacyl tRNA synthases. Translation and post-translational modifications; Operon

concept; Attenuation of trp operon; important features of gene regulation in eukaryotes.

PBT 503 ***Molecular Cell Biology*** **(2+0)**

Theory

General structure and constituents of cell; Similarities and distinction between plant and animal cells; Cell wall, cell membrane, structure and composition of biomembranes, cell surface related functions. Structure and function of major organelles: Nucleus, Chloroplasts, Mitochondria, Ribosomes, Lysosomes, Peroxisomes, Endoplasmic reticulum, Microbodies, Golgi apparatus, Vacuoles, *etc*. Organellar genomes and their manipulation; Ribosomes in relation to cell growth and division; Cyto-skeletal elements. Cell division and regulation of cell cycle; Membrane transport; Transport of water, ion and biomolecules; Signal transduction mechanisms; Protein targeting.

PBT 504 ***Plant Tissue Culture and Genetic Transformation*** **(2+1)**

Theory

History of plant cell and tissue culture; Culture media; Various types of cultures; callus, suspension, nurse, root, meristem, *etc*.; *In vitro* differentiation: organogenesis and somatic embryogenesis; Plant growth regulators: mode of action, effects on in vitro culture and regeneration; Molecular basis of plant organ differentiation. Micropropagation; Anther and microspore culture; Somaclonal variation; *In vitro* mutagenesis; *In vitro* fertilization; *In vitro* germplasm conservation; Production of secondary metabolites; Synthetic seeds. Embryo rescue and wide hybridization; Protoplast culture and regeneration; Somatic hybridization: protoplast fusion, cybrids, asymmetric hybrids *etc*. Methods of plant transformation; Vectors for plant transformation; Genetic and molecular analyses of transgenics; Target traits and transgenic crops; Biosafety issues, testing of transgenics, regulatory procedures for commercial approval.

Practical

Laboratory set-up. Preparation of nutrient media; handling and sterilization of plant material; inoculation, subculturing and plant regeneration. Anther and pollen culture. Embryo rescue. Suspension cultures and production of secondary metabolites. Protoplast isolation, culture and fusion. Gene cloning and vector construction. Gene transfer using different methods, reporter gene expression, selection of transformed tissues/plants, molecular analysis.

PBT 505 ***Techniques in Molecular Biology – I*** **(0+2)**

Theory

Good lab practices; Biochemical techniques: Preparation of buffers and reagents, Principle of centrifugation; Chromatographic techniques (TLC, Gel Filtration Chromatography, Ion exchange Chromatography, Affinity Chromatography). Gel electrophoresis- agarose and PAGE (nucleic acids and proteins); Growth of bacterial culture and preparation of growth curve; Isolation of plasmid DNA from bacteria; Growth of lambda phage and isolation of phage DNA; Restriction digestion of plasmid and phage DNA; Isolation of high molecular weight DNA and analysis. Gene cloning – Recombinant DNA construction, transformation and selection of transformants; PCR and optimization of factors affecting PCR. Dot blot analysis; Southern hybridization; Northern hybridization; Western blotting and ELISA; Radiation safety and non-radio isotopic procedure.

PBT 506 ***Microbial / Industrial Biotechnology*** **(2+1)**

Theory

Introduction, scope and historical developments; Isolation, screening and genetic improvement (involving classical approaches) of industrially important organisms. Primary metabolism products, production of industrial ethanol as a case study; Secondary metabolites, bacterial antibiotics and non ribosomal peptide antibiotics; Recombinant DNA technologies for microbial processes; Strategies for development of industrial

microbial strains with scale up production capacities; Metabolic pathway engineering of microbes for production of novel product for industry. Microbial enzymes, role in various industrial processes, production of fine chemicals for pharmaceutical industries; Bio-transformations, 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. Industrial biotechnology for pollution control, treatment of industrial and other wastes, biomass production involving single cell protein; Bio- remediation 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. Production of industrial compounds such as alcohol, beer, citric acid, lactic acid and their recovery. Study of bio-reactors and their operations. Production of biofertilizers. Experiments on microbial fermentation process, harvesting purification and recovery of end products. Immobilization of cells and enzymes, studies on its kinetic behavior, growth analysis and biomass estimation. Determination mass transfer co-efficients.

PBT 507 ***Molecular Breeding*** **(2+0)**

Theory

Principles of plant breeding; Breeding methods for self and cross pollinated crops; Heterosis breeding; Limitations of conventional breeding; Aspects of molecular breeding. Development of sequence based molecular markers-SSRs and SNPs; Advanced methods of genotyping; Mapping genes for qualitative and quantitative traits. QTL mapping using structured populations;AB-QTL analysis; Association mapping of QTL; Fine mapping of genes/QTL; Map based gene/QTL isolation and development of gene based markers; Allele mining by TILLING and Eco-TILLING; Use of markers in plant breeding. Marker assisted selection (MAS) in backcross and heterosis breeding;

Transgenic breeding; Foreground and background selection; MAS for gene introgression and pyramiding: MAS for specific traits with examples.

PBT 508 ***Genomics and Proteomics*** **(2+0)**

Theory

Structural genomics: Classical ways of genome analysis, large fragment genomic libraries; Physical mapping of genomes; Genome sequencing, sequence assembly and annotation; Comparative genomics, *etc*. Functional genomics: DNA chips and their use in transcriptome analysis; Mutants and RNAi in functional genomics; Metabolomics and ionomics for elucidating metabolic pathways *etc*. Proteomics - Protein structure, function and purification; Introduction to basic proteomics technology; Bio-informatics in proteomics; Proteome analysis *etc*. Applications of genomics and proteomics in agriculture, human health and industry.

PBT 509 ***Techniques in Molecular Biology – II*** **(0+2)**

Practical

Construction of gene libraries; Synthesis and cloning of cDNA and RT- PCR analysis; Real time PCR and interpretation of data. Molecular markers (RAPD, SSR, AFLP *etc.*) and their analysis; Case study of SSR markers (linkage map, QTL analysis *etc.*); SNP identification and analysis; Microarray studies and use of relevant software. Proteomics (2D gels, mass spectrometry *etc*.); RNAi (right from designing of construct to the phenotyping of the plant); Yeast 1 and 2-hybrid interaction. Generation and screening of mutants; Transposon mediated mutagenesis.

PBT 510 ***Biosafety, IPR and Bioethics*** **(2+0)**

Theory

Biosafety and risk assessment issues; Regulatory framework; National biosafety policies and law, The Cartagena protocol on biosafety, WTO and other international agreements related to biosafety, Cross border movement of germplasm; Risk management issues - containment. General principles for the

laboratory and environmental biosafety; Health aspects; toxicology, allergenicity, antibiotic resistance *etc.*; Impact on environment: gene flow in natural and artificial ecologies; Sources of gene escape, tolerance of target organisms, creation of superweeds/superviruses, *etc*. Ecological aspects of GMOs and impact on biodiversity; Monitoring strategies and methods for detecting transgenics; Radiation safety and non- radio isotopic procedure; Benefits of transgenics to human health, society and the environment. The WTO and other international agreements; Intellectual properties, copyrights, trademarks, trade secrets, patents, geographical indications *etc.*; Protection of plant variety and farmer's right act; Indian patent act and amendments, patent filing; Convention on biological diversity; Implications of intellectual property rights on the commercialization of biotechnology products.

PBT 511 ***Animal Biotechnology*** **(2+0)**

Theory

Structure of animal cell; History of animal cell culture; Cell culture media and reagents, culture of mammalian cells, tissues and organs, primary culture, secondary culture, continuous cell lines, suspension cultures, somatic cell cloning and hybridization, transfection and transformation of cells, commercial scale production of animal cells, application of animal cell culture for in vitro testing of drugs, testing of toxicity of environmental pollutants in cell culture, application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins. Introduction to immune system, cellular and hormonal immune response, history of development of vaccines, introduction to the concept of vaccines, conventional methods of animal vaccine production, recombinant approaches to vaccine production, hybridoma technology, phage display technology for production of antibodies, antigen-antibody based diagnostic assays including radioimmunoassay and enzyme immunoassays, immunoblotting, nucleic acid based diagnostic methods, commercial scale production of diagnostic antigens and antisera, animal disease diagnostic kits, probiotics. Structure of sperms and ovum, cryopreservation of sperms and ova of

livestock, artificial insemination, super ovulation, in vitro fertilization, culture of embryos, cryopreservation of embryos, embryo transfer, embryo-spliting, embryo sexing, transgenic manipulation of animal embryos, different applications of transgenic animal technology, animal viral vectors, animal cloning: basic concept, cloning from - embryonic cells and adult cells, cloning of different animals, cloning for conservation of endangered species, ethical, social and moral issues related to cloning, in situ and ex situ preservation of germplasm, in utero testing of foetus for genetic defects, pregnancy diagnostic kits, anti-fertility animal vaccines, gene knock-out technology and animal models for human genetic disorders. Introduction to different breeds of cattle, buffalo, sheep, goats, pigs, camels, horses, canines and poultry, genetic characterization of livestock breeds, marker assisted breeding of livestock, introduction to animal genomics, different methods for characterization of animal genomes, SNP, STR, QTL, RFLP, RAPD, genetic basis for disease resistance, Transgenic animal production and application in expression of therapeutic proteins. Immunological and nucleic acid based methods for identification of animal species, detection of meat adulteration using DNA based methods, detection of food/feed adulteration with animal protein, identification of wild animal species using DNA based methods using different parts including bones, hair, blood, skin and other parts confiscated by anti-poaching agencies.

PBT 512 ***Immunology and Molecular Diagnostics*** **(1+1)**

Theory

History and scope of immunology; Components of immune system: organs, tissues and cells, Immunoglobulin: chemistry, structure and functions; Molecular organization of immunoglobulins and classes of antibodies. Antibody diversity; antigens, haptens, antigen-antibody interactions; immuno-regulation and tolerance; Allergies and hypersensitive response; Immunodeficiency; Vaccines; Immunological techniques. Immunological application in plant science, monoclonal antibodies and their uses, molecular diagnostics. Introduction to the basic principles of molecular technology and techniques used

in pathogen detection, Principles of ELISA and its applications in viral detection. Basics and procedures of PCR, Real time PCR, PCR based and hybridization based methods of detection, microarrays based detection, multiplexing *etc.*, detection of soil borne and seed born infections, transgene detection in seed, planting material and processed food, molecular detection of varietal impurities and seed admixtures in commercial consignments.

Practical

Preparation of buffers and reagents. Immunoblotting, immunoelectrophoresis and fluorescent antibody test. Enzyme immunoassays including ELISA, western blotting. Extraction and identification of DNA/RNA of pathogenic organisms. Restriction hybridoma technique and production of monoclonal antibodies. Immunogenic proteins, expression and immunogenicity studies, purification of immunogenic protein and immunization of laboratory animals.

PBT 513 ***Nano-Biotechnology*** **(2+0)**

Theory

Introduction to Biomacromolecules: The modern concepts to describe the conformation and dynamics of biological macromolecules: scattering techniques, micromanipulation techniques, drug delivery applications *etc*. Cellular engineering: signal transduction in biological systems, feedback control signaling pathways, cell-cell interactions *etc*. Effects of physical, chemical and electrical stimuli on cell function and gene regulation. Chemical, physical and biological properties of biomaterials and bioresponse: biomineralization, biosynthesis, and properties of natural materials (proteins, DNA, and polysaccharides); structure-property relationships in polymeric materials (synthetic polymers and structural proteins); Erosol properties, application and dynamics; Statistical Mechanics in Biological Systems, Preparation and characterization of nanoparticles; Nanoparticular carrier systems; Micro- and Nano-

fluidics; Drug and gene delivery system; Microfabrication, Biosensors, Chip technologies, Nano- imaging, Metabolic engineering and Gene therapy.

PBT 514 / GPB 501 ***Principles of Genetics*** **(2+1)**

Theory

Genetics: Scope and Beginning of Genetics; Early concepts of inheritance, Mendel's laws; Discussion on Mendel's papers; Significance of Mitosis and Meiosis and life cycles; Chromosomal theory of inheritance. Types of dominance, multiple alleles, genotypic interactions, types and mechanism; inborn errors of metabolism, one gene- one enzyme hypothesis Probability and Statistics as applied to genetics, Binomial theorem, hypothesis testing and Chi-square test. Sex determination, Dosage compensation, Sex linkage, sex limited and sex influenced traits, pedigree analysis, Penetrance and expressivity. Linkage and mapping in eukaryotes: Diploid mapping, haploid mapping (tetra analysis), genetics of markers and genetic maps. Non-Mendelian inheritance: maternal effects and cytoplasmic inheritance. Mitochondria, chloroplasts and infective particles; Imprinting. Quantitative inheritance: Basis and significance, Nature and location of poly genes, Selection experiments and heritability. Genes in populations, Hardy-Weinberg equilibrium: assumptions, proof and testing, extensions of Hardy-Weinberg equilibrium: multiple alleles and multiple loci; Mating systems: Random and nonrandom mating, inbreeding, pedigree analysis and population analysis. Processes that change allelic frequencies: Mutation, migration, small population size and random genetic drift, natural selection and selection models, selection-mutation equilibrium. Evolution and speciation: Darwinian evolution, Speciation, Genetic polymorphisms and patterns of variation. Concepts of Eugenics, Epigenetics, Genetic disorders and Behavioural genetics

Practical

Laboratory exercises on Mendelian problems, gene interaction, linkages, probability and Chi-square; Demonstration of genetic principles using; Chromosome mapping using three point test cross; Tetrad analysis; Induction and detection of mutations through genetic tests.

PBT 515 / BCM 501 ***Basic Biochemistry*** **(2+1)**

Theory

Scope and importance of biochemistry in agriculture; Fundamental principles governing life; structure of water; acid-base concept and buffers; pH; hydrogen bonding; hydrophobic, electrostatic and Van der Waals forces; General introduction to physical techniques for determination of structure of biopolymers. Classification, structure and function of carbohydrates, lipids and biomembranes, amino acids, proteins, and nucleic acids. Structure and biological functions of vitamins; enzymes: classification and mechanism of action; regulation, factors affecting enzyme action. Hormones : animals, plants and insects Fundamentals of thermodynamic principles applicable to biological processes, Bioenergetics. Metabolism of carbohydrates, photosynthesis and respiration, oxidative phosphorylation, lipids, proteins and nucleic acids. DNA replication, transcription and translation; recombinant DNA technology, Nutritional aspects of carbohydrates, lipids, proteins and minerals.

Practical

Preparation of standard and buffer solutions. Extraction and estimation of sugars, Amino acids. Estimation of proteins by Lowry's method. Estimation of DNA and RNA by diphenylamine and orcinol methods. Estimation of Ascorbic acid. Separation of biomolecules by TLC and paper chromatography.

PBT 516 ***Biostatistics and Computers*** **(2+1)**

Theory

Aims, scope and idea of elementary statistics; Measures of central tendency and dispersion, skewness and kurtosis. Concept of probability and probability laws, mathematical expectation, moments, moments generating function; Standard probability distributions- Binomial, Poisson and Normal distributions. Tests of significance based on Z, x^2, t and F statistics; Correlation and regression, curve fitting by least squares methods. Basic principles, organization and operational aspects of computers, operating systems. Introduction to MS-Office, MS-Word, MS-Excel. Statistical data analysis based on above topics through MS-Excel.

Practical

Data analysis using probability, test of significance. Correlation and regression analysis. Usage of MS-Windows. Exercises on test processing, spreadsheet and DBMS. SPSS

PBT 517 / AMB 501 ***Principle of Microbiology*** **(2+1)**

Theory

Development of Microbiology in the 18th and 19th century. Morphology, structure and function of prokaryotic and eukaryotic cell. Archea. Classification of prokaryotes – Basic principles and techniques used in bacterial classification. Evolutionary relationship among prokaryotes. Phylogenetic and numerical taxonomy. Use of DNA and r-RNA sequencing in classifications. Study of major groups of bacteria belonging to Gracilicutes, Firmicutes, Tanericutes and Mendosicutes. Viruses – morphology, classification and replication of plant, animal and bacterial viruses. Cultivation methods of viruses. Immune response – specific and non-specific resistance. Normal microflora of human body; some common bacterial and viral diseases of humans and animals.

Practical

Methods of isolation, purification and maintenance of microorganisms from different environments (air, water, soil, milk and food). Enrichment culture technique – isolation of asymbiotic; symbiotic nitrogen fixing bacteria. Isolation of photosynthetic bacteria. Use of selective media, antibiotic resistance and isolation of antibiotic producing microorganisms. Morphological, physiological and biochemical characterization of bacteria.

PBT 518 / BIM 502 ***Introduction to Bioinformatics*** **(1+1)**

Theory

Introduction, biological databases – primary, secondary and structural; Protein and Gene Information Resources – PIR, SWISSPROT, PDB, genebank, DDBJ. Specialized genomic resources. DNA sequence analysis, cDNA libraries and EST, EST analysis, pairwise alignment techniques, database searching, multiple sequence alignment. Secondary database searching, building search protocol, computer aided drug design – basic principles, docking, QSAR. Analysis packages – commercial databases and packages, GPL software for bioinformatics, web-based analysis tools.

Practical

Usage of NCBI resources, Retrival of sequence/structure from databases, Visualization of structures, Docking of ligand receptors, BLAST exercises.

PBT 519 / EVS 514 ***Environmental Biotechnology*** **(2+0)**

Theory

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. Microbiology and use of micro-organisms in waste treatment; biodegradation; degradation of Xenobiotic, surfactants; bioremediation of soil & water contaminated with oils, pesticides & toxic chemicals, detergents *etc.*; aerobic processes (activated sludge, oxidation ditches, trickling filter, rotating drums, *etc*.); anaerobic processes: digestion, filtration, *etc*. 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*. Treatment schemes of domestic waste and industrial effluents; food, feed and energy from solid waste; 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.

PLANT PATHOLOGY

Course No.	Title	Credits
PAT 501	Mycology	2+1
PAT 502	Plant Virology	2+1
PAT 503	Plant Bacteriology	2+1
PAT 504	Plant Nematology	1+1
PAT 505	Principles of Plant Pathology	1+1
PAT 506	Chemicals in Plant Disease Management	1+1
PAT 507	Epidemiology and Forecasting of Plant Diseases	2+1
PAT 508	Detection and Diagnosis of Plant Diseases	0+2
PAT 509	Principles of Plant Disease Management	1+1
PAT 510	Diseases of Field and Medicinal Crops	2+1
PAT 511	Diseases of Fruits, Plantation and Ornamental Crops	2+1
PAT 512	Diseases of Vegetable and Spices Crops	2+1
PAT 513	Seed Health Technology	1+1
PAT 514	Ecology of Soil-Borne Plant Pathogens	1+1
PAT 515	Disease Resistance in Plants	1+1
PAT 516	Insect Vectors of Plant Viruses and Other Pathogens	1+1
PAT 517	Biological Control of Plant Diseases	1+1
PAT 518	Integrated Disease Management	2+1
PAT 519	Post Harvest Diseases	1+1
PAT 520	Plant Quarantine	2+0
PAT 521	Nematode Ecology and Management	1+1
PAT 571	Qualifying Examination	2
PAT 581	Seminar	2
PAT 591	Research	16

PAT 501 ***Mycology*** **(2+1)**

Theory

Introduction, definition of different terms, basic concepts. Importance of mycology in agriculture, relation of fungi to human affairs, history of mycology. Modern concept of nomenclature and classification, importance of culture collection and herbarium fungi, somatic characters and reproduction in fungi. The taxonomic classification of kingdom fungi, Stramenopila and Protists. The general characteristics of protists and life cycle in the Phyla Plasmodiophoromycota, Dictyosteliomycota, Acrasiomycota and Myxomycota. Kingdom Stramenopila: characters, and life cycles of representative genera under Hyphochytriomycota, Oomycota and Labyrinthulomycota. Kingdom fungi: General characters, ultrastructure, and life cycle patterns in representative genera under Chytridiomycota, Zygomycota, Ascomycota; Archiascomycetes, Ascomycetous yeasts, Pyrenomycetes, Plectomycetes, Discomycetes, Loculoascomycetes, Erysiphales and anamorphs of ascomycetous fungi. Basidiomycota; general characters, mode of reproduction, types of basidiocarps and economic importance of Hymenomycetes, Uredinales and Ustilaginales, variability, host specificity and lifecycle pattern in rusts and smuts. Deuteromycotina; status of asexual fungi, their teliomorph relationships, Saccardoan classification and classification based on conidiogenesis.

Practical

Detailed comparative study of different groups of fungi; Collection of cultures and live specimens. 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, Rhizpus, General characters of VAM fungi, Ascomycetes; thallus and fruiting structures of Erysiphales, and Eurotiales; general identification characters of pyrenomycetes, discomycetes, loculoascomycetes and laboulbeniomycetes,

Basidiomycetes; characters, ultrastructures and life cycle patterns in Ustilaginomycetes and Teliomycetes, Deuteromycetes; characters of Hyphomycetes and Coelomycetes and their teliomorphic and anamorphic status, Collection, preservation, culturing and identification of plant parasitic fungi.

PAT 502 ***Plant Virology*** **(2+1)**

Theory

History of plant viruses, composition and structure of viruses. Symptomatology of important plant viral diseases, transmission, chemical and physical properties, host virus interaction, virus vector relationship. Virus nomenclature and classification, genome organization, replication and movement of viruses. Isolation and purification, electron microscopy, protein and nucleic acid based diagnostics. Myco-viruses, phytoplasma, satellite viruses, satellite RNAs, viroids, prions. Principles of the working of electron microscope and ultra microtome. Ecology, epidemiology and management of plant viruses. mechanisms of resistance and genetic engineering.

Practical

Study of symptoms caused by viruses, transmission, assay of viruses, physical properties, purification, methods of rising antisera, serological tests, electron microscopy and ultratomy, PCR.

PAT 503 ***Plant Bacteriology*** **(2+1)**

Theory

History and introduction to phytopathogenic viz., bacteria and other fastidious procarya. Importance of phytopathogenic bacteria. Evolution, classification and nomenclature of phytopathogenic procarya and important diseases caused by them. Growth, nutrition requirements, reproduction, preservation of bacterial cultures and variability among phytopathogenic procarya. General biology of bacteriophages, L form bacteria, plasmids and bdellovibrios. Procaryotic inhibitors and their mode of action against phytopathogenic bacteria. Survival and dissemination of phytopathogenic bacteria.

Practical

Isolation, purification, identification and host inoculation of phytopathogenic bacteria, staining methods, biochemical and serological characterization, isolation of plasmid and use of antibacterial chemicals/antibiotics.

PAT 504 ***Plant Nematology*** **(1+1)**

Theory

History and growth of Nematology; nematode habitats and diversity- plant, animal and human parasites; useful nematodes; economic importance of nematode diseases to agriculture, horticulture and forestry. Gross morphology of plant parasitic nematodes; broad classification, nematode biology, physiology and ecology. Types of parasitism; nature of damage nematode diseases of crop plants and general symptomatology; interaction of plant parasitic nematodes with other organisms. Plant nematode relationships, cellular responses to infection by important phytonematodes; physiological specialization among phytonematodes. Principles and practices of nematode management; integrated nematode management.

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.

PAT 505 ***Principles of Plant Pathology*** **(1+1)**

Theory

Importance, definitions and concepts of plant diseases, history and growth of plant pathology, biotic and abiotic causes of plant diseases. Growth, reproduction, survival and dispersal of important plant pathogens, Pathogen variability, role of environment and host nutrition on disease development. Host parasite interaction, recognition concept and infection, Syndrome wise symptomatology, disease development- role of enzymes,

toxins, growth regulators; defense strategies- oxidative burst; Phenolics, Phytoalexins, PR proteins, Elicitors. Altered plant metabolism as affected by plant pathogens. Genetics of resistance; 'R' genes; mechanism of genetic variation in pathogens; molecular basis for resistance; marker-assisted selection; genetic engineering for disease resistance. Disease management strategies.

Practical

Study of growth in fungi and bacteria, inoculatin techniques and proving Koch's postulates. Purification of enzymes, toxins and their bioassay. Estimation of growth regulators, phenolics, Phytoalexins in resistant and susceptible plants. Molecular techniques to study variability in different plant pathogens. Molecular markers related to resistance. Plant transformation techniques.

PAT 506 *Chemicals in Plant Disease Management* (1+1)

Theory

History and development of chemicals; definition of pesticides and related terms; advantages and disadvantages of chemicals. Classification of chemicals used in plant disease control and their characteristics. Chemicals in plant disease control, *viz*., fungicides, bactericides, nematicides, antiviral chemicals and botanicals. Formulations, mode of action and application of different fungicides; chemotherapy and phytotoxicity of fungicides, Registration and Regulation of Pesticides. Handling, storage and precautions to be taken while using fungicides; compatibility with other agrochemicals, persistence, cost-benefit ratio, factor affecting fungicides. 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 based on active ingredients against pathogens; persistence, compatibility with other agro-chemicals; detection of naturally occurring fungicide resistant mutants of pathogen; methods of application of chemicals, Analysis of Pesticide residue.

PAT 507 ***Epidemiology and Forecasting of Plant Diseases*** **(2+1)**

Theory

Epidemic concept and historical development, pathometry and crop growth stages, epidemic growth and analysis, Disease progress models/curves. Common and natural logrithms, function fitting area under disease progress curve and correction factors, inoculum dynamics, population biology of pathogens, temporal spatial variability in plant pathogens. Survey, surveillance and vigilance, Remote sensing technique and image analysis, crop loss assessment and models. Principles and pre-requisites of forecasting, systems and factors affecting various components of forecasting, some early forecasting, and procedures based on weather and inoculum potential, modeling disease growth and disease prediction.

Practical

Measuring diseases, spore dispersal and trapping, weather recording, survey, multiplication of inoculum, computerized data analysis, function fitting, model preparation and validation.

PAT 508 ***Detection and Diagnosis of Plant Diseases*** **(0+2)**

Theory

Methods to prove Koch's postulates with biotroph and necrotroph pathogens, pure culture techniques, use of selective media to isolate pathogens. Preservation of plant pathogens and disease specimens, use of haemocytometer, micrometer, centrifuge, pH meter, camera lucida. Microscopic techniques and staining methods, phase contrast system, chromatography, use of electron microscope, spectrophotometer, ultracentrifuge and

electrophoretic apparatus, disease diagnostics, serological and molecular techniques for detection of plant pathogens. Evaluation of fungicides, bactericides *etc*.; field experiments, data collection and preparation of references.

PAT 509 ***Principles of Plant Disease Management*** **(1+1)**

Theory

Principles of plant disease management by cultural, physical, biological, chemical, organic amendments and botanicals, Methods of plant disease control, biological methods: antagonists, mode of avtion, mass multiplication and delivery systems. Integrated control measures of plant diseases. Disease resistance and molecular approach for disease management. Foliage, seed and soil application of chemicals, role of stickers, spreaders and other adjuvants, health vis-a-vis environmental hazards, residual effects and safety measures. History of fungicides, bactericides, antibiotics, concepts of pathogen, immobilization, chemical protection and chemotherapy, nature, properties and mode of action of antifungal, antibacterial and antiviral chemicals. Biotechnological methods: Tissue Culture, Resistant genes, Genetic engineering methods and Transgenics

Practical

In vitro and in vivo evaluation of chemicals against plant pathogens; ED and MIC values, study of structural details of sprayers and dusters.

PAT 510 ***Diseases of Field and Medicinal Crops*** **(2+1)**

Theory

Diseases of Cereal crops- wheat, barley, rice, pearl millet, sorghum and maize. Diseases of Pulse crops- gram, urdbean, mungbean, lentil, pigeonpea, soybean. Diseases of Oilseed crops- rapeseed and mustard, sesame, linseed, sunflower, niger, cowpea, sunflower, groundnut, castor. Diseases of Cash crops- cotton, sugarcane. Diseases of Fodder legume crops- berseem, oats, guar, lucerne, cowpea. Medicinal crops- plantago, liquorice, mulathi, rosagrass, sacred basil, mentha, ashwagandha, 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.

PAT 511 ***Dieseases of Fruits, Plantation and Ornamental Crops*** **(2+1)**

Theory

Introduction, symptoms and etiology of different fruit diseases. Factors affecting disease development in fruits like apple, pear, peach, plum, apricot, cherry, walnut, almond, strawberry, citrus, mango, grapes, guava, ber, banana, pineapple, papaya, fig, pomegranate, date palm and their management. Symptoms, mode of perpetuation of diseases of plantation crops such as tea, coffee, rubber and coconut and their management. Symptoms and life cycle of pathogens. Factors affecting disease development of ornamental plants such as roses, gladiolus, tulip, carnation, orchids, marigold, chrysanthemum and their management.

Practical

Detailed study of symptoms and host parasite relationship of representative diseases of plantation crops. Collection and dry preservation of diseased specimens of important crops.

PAT 512 ***Diseases of Vegetable and Spices Crops*** **(2+1)**

Theory

Nature, prevalence, factors affecting disease development of bulb, leafy vegetable, crucifers, cucurbits and solanaceaous vegetables. Diseases of protected cultivation. Symptoms and management of diseases of different root, bulb, leafy vegetables, crucifers, cucurbits and solanaceaous vegetable crops. Symptoms, epidemiology and management of diseases of different spice crops such as black pepper, saffron, cumin, coriander, turmeric, cardamom, fennel, fenugreek and ginger.

Practical

Detailed study of symptoms and host pathogen interaction of important diseases of vegetable and spice crops.

PAT 513 ***Seed Health Technology*** **(1+1)**

Theory

History and economic importance of seed pathology in seed industry, plant quarantine and SPS under WTO. Morphology and anatomy of typical monocotyledonous and dicotyledonous infected seeds. Recent advances in the establishment and subsequent cause of disease development in seed and seedling. Localization and mechanism of seed transmission in relation to seed infection, seed to plant transmission of pathogens. Seed certification and tolerance limits, types of losses caused by seed-borne diseases in true and vegetatively propagated seeds, evolutionary adaptations of crop plants to defend seed invasion by seed-borne pathogens. Epidemiological factors influencing the transmission of seed-borne diseases, forecasting of epidemics through seed-borne infection. Production of toxic metabolites affecting seed quality and its impact on human, animal and plant health, management of seed-borne pathogen/diseases and procedure for healthy seed production, seed health testing, methods for detecting microorganism(seed mycoflora).

Practical

Conventional and advanced techniques in the detection and identification of seed-borne fungi, bacteria and viruses. Relationship between seed-borne infection and expression of the disease in the field.

PAT 514 ***Ecology of Soil-borne Plant Pathogens*** **(1+1)**

Theory

Soil as an environment for plant pathogens, nature and importance of rhizosphere and rhizoplane, host exudates, soil and root inhabiting fungi. Types of biocontrol agents. Inoculum potential and density in relation to host and soil variables, competition, predation, antibiosis and fungistasis. Suppressive soils, biological control- concepts and potentialities for managing soil borne pathogens.

Practical

Quantification of rhizosphere and rhizoplane microflora 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 biocontrol agents.

PAT 515 ***Disease Resistance in Plants*** **(1+1)**

Theory

Introduction and historical development, dynamics of pathogenicity, process of infection, variability in plant pathogens, gene centres as sources of resistance, disease resistance terminologies. Disease escapes, disease tolerance, disease resistance, types of resistance, identification of physiological races of pathogens, disease progression in relation to resistance, stabilizing selection pressure in plant pathogens. Host defence system, morphological and anatomical resistance, preformed chemicals in host defence, post infectional chemicals in host defence, phytoalexins, hypersensitivity and its mechanisms. Genetic basis of relationships between pathogen and host, Gene-for-gene concept, protein-for-protein and immunization basis, management of resistance genes. Strategies for gene deployment, Biotechnological approaches in developing disease resistant transgenics.

Practical

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.

PAT 516 ***Insect Vectors of Plant Viruses and other Pathogens*** **(1+1)**

Theory

History of developments in the area of insects as vectors of plant pathogens. Important insect vectors and their characeristics; mouth parts and feeding processes of important insect vectors. Efficiency of transmission. Transmission of plant viruses and fungal pathogens. Relation between viruses and their vectors. Transmission of plant viruses by leaf hoppers, aphids, whiteflies, mealy bugs and thrips. Transmission of mycoplasma and bacteria by leaf hoppers and plant hoppers. Transmission of plant viruses by psyllids, beetles and mites. Epidemiology and management of insect transmitted diseases through vector management. Molecular basis of virus vector relationship, management of vectors for controlling virus diseases

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. Determination of virus vector relationship using any one specific virus-vector.

PAT 517 ***Biological Control of Plant Diseases*** **(1+1)**

Theory

Concept of biological control, definitions, importance, principles of plant disease management with bioagents, history of biological control, suppressive soils, merits and demerits of biological control. Types of biological interactions, competition, mycoparasitism, exploitation for hypovirulence, rhizosphere colonization, competitive saprophytic ability, antibiosis, induced resistance, mycorrhizal associations, operational mechanisms and its relevance in biological control. Factors governing biological control, role of physical environment, agroecosystem, operational mechanisms and cultural practices in biological control of pathogens, pathogens and antagonists and their relationship, biocontrol agents, comparative approaches to

biological control of plant pathogens by resident and introduced antagonists, control of soil-borne and foliar diseases. Compatibility of different bioagents. Commercial production of antagonists, their delivery systems, application and monitoring, biological control in IDM, IPM and organic farming system, biopesticides available in market. Quality control system of biocontrol 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. Study of cfu/g.

PAT 518 ***Integrated Disease Management*** **(2+1)**

Theory

Introduction, definition, concept and tools of disease management, components of integrated disease management-their limitations and implicarions. Development of IDM-basic principles, biological, chemical and cultural disease management. IDM in important crops-rice, wheat, cotton, sugarcane, chickpea, rapeseed, mustard, pearl millet, kharif pulses, vegetable crops and fruit crops.

Practical

Application of biological, cultural, chemical and biocontrol agents, their compatibility and integration in IDM; demonstration of IDM in certain crops as project work.

PAT 519 ***Post Harvest Diseases*** **(1+1)**

Theory

Concept of post harvest diseases, definitions, importance with reference to environment and health, principles of plant disease management as pre-harvest and post-harvest, merits and demerits of biological/phytoextracts in controlling post-harvest diseases. Types of post harvest problems both by biotic and abiotic causes, rhizosphere colonization, competitive, saprophytic ability, antibiosis, induced resistance, microbial associations, concept, operational mechanisms and its relevance

in control. Factors governing post harvest problems both as biotic and abiotic, role of physical environment, agro-ecocystem leading to quiescent infection, operational mechanisms and cultural practices in perpetuation of pathogens, pathogens and antagonist and their relationship, role of biocontrol agents and chemicals in controlling post-harvest diseases, comparative approaches to control of plant pathogens by resident and introduced antagonists. Isolation, characterization and maintenance of pathogens, role of different storage conditions. Integrated approach in controlling diseases and improving the shelf life of produce, control of aflatoxigenic and mycotoxigenic fungi, application and monitoring for any health hazard, knowledge of Codex Alimentarious for each product and commodity.

Practical

Isolation, characterization and maintenance of post harvest pathogens, role of different storage conditions on disease development, application of antagonists against pathogens in vivo and in vitro conditions. Comparative efficacy of different chemicals, fungicides, phytoextracts and bioagents.

PAT 520 ***Plant Quarantine*** **(2+0)**

Theory

Definition of pest, pesticides and transgenics as per Govt. notification; relative importance; Quarantine – domestic and international. Quarantine restrictions inthemovement of agricultural produce, seeds and planting material; case histories of exotic pests/ diseases and their status. Plant protection organization in India. Acts related to registration of pesticides and transgenics. History of quarantine legislations, PQOrder 2003. Environmental Acts, Industrial registration; APEDA, Import and Export of bio-control agents. Identification of pest/disease free areas; contamination of food with toxigens, 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. WTO regulations; non-tariff barriers; Pest risk analysis,

good laboratory practices for pesticide laboratories; pesticide industry; Sanitary and Phytosanitary measures. Inspection procedures for import/export of plant material for research purposes at the point of enrty/export stations, detection techniques for various plant pathogens. Treatment procedures and chemicals. Hints for researchers to import/export of plant genetic material.

PAT 521 ***Nematode Ecology and Management*** **(1+1)**

Theory

Concepts and history of nematode management; crop loss estimation,ecological and socio-economic aspects, cost-benefit ratios and pest risk analysis. Chemical methods- nematicides, their types, classification, mode of action, applicators and application methods, antidotes, and economizing nematicidal use. Cultural practices- crop rotations and cropping sequences, fallowing, flooding, soil solarisation, time of sowing, organic amendments of soil, biofumigation, antagonistic and trap crops, sanitation *etc*. Physical methods- use of heat, hot water treatment and other methods of disinfestations of planting material. Biological methods- concepts and terminology, use of predators and parasites as biological control agents, their mass multiplication and field use; phytotherapeutic methods – use of antagonistic plants and antinemic plant products. Definition and scope; components of environment; evolution of nematodes; ecological classification, prevalence, distribution and dispersal of nematodes. Genetic methods- plant resistance; legal methods-quarantine regulations; integrated nematode management-concepts and applications.

Practical

In vitro screening of synthetic chemicals and plant products for nematicidal activity, and their application methods; methods for screening of crop germplasm for resistance against nematodes, laboratory exercises on biocontrol potential of fungal, bacterial parasites, and predacious fungi and nematodes.

SEED SCIENCE AND TECHNOLOGY

Course No.	Title	Credits
SST 501	Floral Biology, Seed Development and Maturation	1+1
SST 502	Principles of Seed Production	2+0
SST 503	Seed Production in Field Crops	1+1
SST 504	Seed Production in Vegetables	1+1
SST 505	Seed Production in Flowers, Medicinal Fruits and Plantation Crops	1+1
SST 506	Seed Legislation and Certification	1+1
SST 507	Seed Processing and Storage	2+1
SST 508	Seed Quality Testing	2+1
SST 509	Seed Physiology	2+1
SST 510	Seed Pathology	1+1
SST 511	Seed Entomology	1+1
SST 512	Seed Production in Forage, Pasture and Green Manure Crops	1+1
SST 513	Emerging Trends in Seed Quality Enhancement	1+1
SST 514	Data Base Management, Evaluation and Utilization of PGR	1+1
SST 515	Germplasm Collection, Exchange and Quarantine	1+1
SST 571	Qualifying Examination	2
SST 581	Seminar	2
SST 591	Research	16

SST 501 ***Floral Biology, Seed Development and Maturation*** **(1+1)**

Theory

Floral types, structure and biology in relation to pollination mechanisms; sporogenesis: microsporogenesis and megasporogenesis; gametogenesis - development of male and female gametes and their structures; effect of environmental factors on floral biology. Fertilization – embryo sac structure, process, barriers to fertilization, incompatibility and male sterility, factors affecting fertilization. Embryogenesis - development of typical monocot and dicot embryos; endosperm development, modification of food storage structures with reference to crop plants; different types of embryos, endosperm and cotyledons; development and their structure in representative crop plants with reference to food storage; external and internal features of monocot and dicot seed; seed coat structure and development in representative crop plants. Apomixis – identification, classification, significance and its utilization in different crops for hybrid seed production; Polyembryony - types and significance; haplontic and diplontic sterility, causes of embryo abortion, embryo rescue and synthetic seeds.

Practical

Study of floral biology of monocots and dicots; microsporogenesis and megasporogenesis; study of pollen grains - pollen morphology, pollen germination and pollen sterility; types monocot and dicot embryos; external and internal structures of monocot and dicot seeds; seed coat structure, preparation of seed albums and identification.

SST 502 ***Principles of Seed Production*** **(2+0)**

Theory

Introduction - Seed as basic input in agriculture; seed development in cultivated plants; seed quality concept and importance of genetic purity in seed production; types of cultivars, their maintenance and factors responsible for deterioration; seed production in self and cross pollinated crops. Mode of pollination and reproduction in crop plants and their

modification in relation to hybrid seed production. Principles of hybrid seed production, isolation distance, synchronization of flowering, roguing *etc*., male sterility and incompatibility system in hybrid seed production, role of pollinators and their management. Seed multiplication ratios, seed replacement rate, demand and supply; suitable areas of seed production and storage, agronomy of seed production – agro climatic requirements and their influence on quality seed production; generation system of seed multiplication; maintenance of Nucleus seed, production of Breeder, Foundation and Certified seed– criteria involved; life span of a variety and causes for its deterioration; certification standards for self and cross pollinated and vegetatively propagated crops. Hybrid Seed - Methods of development of hybrids; use of male sterility and self-incompatibility and CHA in hybrid seed production; one, two and three line system; maintenance of parental lines of hybrids; planning and management of hybrid seed production technology of major field crops and vegetables. Planning of seed production for different classes of seeds for self and cross pollinated crops, Seed quality control system and organization, seed village concept; Seed production agencies, seed industry and custom seed production in India.

SST 503 ***Seed Production in Field Crops*** **(1+1)**

Theory

Basic principles in seed production and importance of quality seed. Floral structure, breeding and pollination mechanism in self-pollinated cereals and millets viz, wheat, paddy, ragi *etc*. Floral structure, breeding and pollination mechanism in cross-pollinated cereals and millets viz., maize, sorghum, bajra, *etc.* ; methods and techniques of quality seed production in cross-pollinated cereals and millets. Floral structure, breeding and pollination mechanism; methods and techniques of seed production in pulses (pigeon pea, field beans, peas *etc*.). Floral structure, breeding and pollination mechanism; methods and techniques of seed production in major oil seeds (groundnut, castor, sunflower, safflower *etc.*). Floral structure, breeding and pollination mechanism; methods and techniques of

seed production in commercial fibers (cotton, jute *etc*.) and vegetatively propagated crops like sugar cane, potato *etc.*

Practical

Planning of Seed Production, requirements for different classes of seeds in field crops - unit area and rate; Seed production in cross pollinated crops with special reference to land, isolation, planting ratio of male and female lines, synchronization of parental lines and methods to achieve synchrony; supplementary pollination, pollen storage, hand emasculation and pollination in Cotton, detasseling in Corn, identification of rogues and pollen shedders; Pollen collection, storage, viability and stigma receptivity; gametocide application and visits to seed production plots *etc*.

SST 504 ***Seed Production in Vegetables*** **(1+1)**

Theory

Introduction; share of vegetable seeds in seed industry; importance and present status of vegetable industry; intellectual property rights and its implications, impact of PVP on growth of seed industry, modes of propagation in vegetables. Seed morphology and development in vegetable seeds. Floral biology of these plant species; classification of vegetable crops based on pollination and reproduction behavior; steps in quality seed production; identification of suitable areas/locations for seed production of these crops. Classification based on growth cycle and pollination behavior; methods of seed production; comparison between different methods e.g. seed-to-seed vs. root-to-seed method in radish; seed multiplication ratios in vegetables; pollination mechanisms; sex types, ratios and expression and sex regulation in cucurbits; nursery raising and transplanting stage. Seed production technology of vegetables *viz.* solanaceous, cucurbitaceous, leguminous, malvaceous, cole crops, leafy vegetables, root, tuber and bulb crops and spices; harvesting/picking stage and seed extraction in fruit vegetables; clonal propagation and multiplication in tuber crops e.g. Potato, sweet potato, colocasia, tapioca; seed-plot technique in potato tuber seed production; hybrid seed production technology of

vegetable crops, TPS (true potato seed) and its production technique; hybrids in vegetables; maintenance of parental lines; use of male sterility and self incompatibility in hybrid seed production, environmental factors related to flowering/bolting in vegetable crops.

Practical

Selection of suitable areas/locations for high quality seed/ planting material production; study of floral biology of vegetables, determination of planting ratios for hybrid seed production vegetables; use and maintenance of monoecious line in hybrid seed production of cucumber; growth regulator, preparation (cone) and application methods, exercises on emasculation and pollination; seed extraction methods and their effect on quality of vegetables; seed production technology of varieties and hybrids in vegetables.

SST 505 ***Seed Production in Flowers, Medicinal Fruits and Plantation Crops*** **(1+1)**

Theory

Introduction: modes of propagation in fruits, flower and plantation crops. Floral biology of these plant species; classification of medicinal and plantation crops based on pollination and reproduction behavior; steps in quality seed production; identification of suitable areas/locations for seed production of these crops. Flowers and Medicinal Plants; classification based on growth cycle, reproduction and pollination behavior; nursery requirement, planning and management; technology for quality seed production in important flower crops i.e. marigolds, petunias, dahlia, roses, gladiolus, tulips, chrysanthemum, *etc.*; development of hybrids and their seed production technology flower plants. Seed production technology of annual medicinal plants viz., isabgol, ashawagandha etc. Fruit and Plantation Crops: role of seed in perennial plant species; classification based on reproduction and pollination behavior; polyembryony and its significance; nursery requirement, planning and management; clonal propagation and multiplication in tropical, sub-tropical and temperate fruits and

plantation crops; seed orchards; seed collection, extraction and processing. IPR issues with special reference to floral and plantation crops.

Practical

Selection of suitable areas/locations for high quality seed/ planting material production; study of floral biology of flowers, fruits, medicinal and plantation crops; determination of planting ratios for hybrid seed production in flowers; exercises on emasculation and pollination; seed extraction methods and their effect on quality of fruit; seed production technology of varieties and hybrids; seed collection and extraction in fruit and plantation crops.

SST 506 ***Seed Legislation and Certification*** **(1+1)**

Theory

Historical development of Seed Industry in India; Seed quality: concept and factors affecting seed quality during different stages of production, processing and handling; seed quality control- concept and objectives; Central Seed Certification Board (CSCB). Regulatory mechanisms of seed quality control- organizations involved in seed quality control programmes; seed legislation and seed law enforcement as a mechanism of seed quality control; the Seed Act (1966), Seed Rules (1968), Seed (Control) Order 1983; Essential Commodities Act (1955); Plants, Fruits and Seeds Order (1989); National Seed Development Policy (1988) and EXIM Policy regarding seeds, plant materials; New Seed Bill-2004, *etc*. Introduction, objectives and relevance of plant quarantine, regulations and plant quarantine set up in India. Seed Certification- history, concept and objectives of seed certification; seed certification agency/organization and staff requirement; legal status and phases of seed certification; formulation, revision and publication of seed certification standards; Indian Minimum Seed Certification Standards (I.M.S.C.S.) - general and specific crop standards including GM varieties, field and seed standards; planning and management of seed certification programmes- eligibility of a variety for certification, area assessment, cropping

history of the seed field, multiplication system based on limited generation concept, isolation and land requirements etc. Field Inspection- principles, phases and procedures; reporting and evaluation of observations; pre and post-harvest control tests for genetic purity evaluation (grow-out tests); post harvest inspection and evaluation; seed sampling, testing, labeling, sealing and grant of certificate; types and specifications for tags and labels; maintenance and issuance of certification records and reports; certification fee and other service charges; training and liaison with seed growers. OECD seed certification schemes. Introduction to WTO and IPRs; Plant Variety Protection and its significance; UPOV and its role; DUS testing- principles and applications; essential features of PPV & FR Act, 2001 and related Acts.

Practical

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 at harvesting/threshing, processing and after processing for seed law enforcement; testing physical purity, germination and moisture; specifications for tags and labels to be used for certification purpose; grow-out tests for pre and post-harvest quality control; visits to regulatory seed testing laboratory, including plant quarantine lab and seed certification agency.

SST 507 ***Seed Processing and Storage*** **(2+1)**

Theory

Introduction-principles of seed processing; seed drying – principles and methods including dehumidification and its impact on seed quality. Relative humidity and equilibrium moisture content of seed; Thumb rules of seed storage; loss of viability in important agricultural and horticultural crops, viability equations and application of nomograph. Seed cleaning equipment and their functions: Preparing seed for processing; functions of scalper debearder, scarifier, huller, seed cleaner and grader. Screen cleaners, specific gravity separator, indented cylinder,

velvet-spiral-disc separators, colour sorter, delinting machines; seed blending. Assembly line of processing and storage, receiving, elevating and conveying equipments, plant design and layout, requirements and economic feasibility of seed processing plant. Seed treatments-methods of seed treatment, seed treating formulations and equipments, seed disinfestations, identification of treated seeds; Packaging: principles, practices and materials; bagging and labeling. Seed storage: Seed drying and storage; drying methods-importance and factors affecting it, changes during storage, concepts and significance of moisture equilibrium, methods of maintaining safe seed moisture content. Methods to minimize the loss of seed vigour and viability; factors influencing storage losses. Storage methods and godown sanitation. Storage structures. Storage problems of recalcitrant seeds and their conservation.

Practical

Operation and handling of mechanical drying equipments; effect of drying temperature and duration on seed germination and storability with particular reference to oil seeds; seed extraction methods; seed processing equipments; seed treating equipments; visit to seed processing plant and commercial controlled and uncontrolled Seed Stores;. seed quality up-gradation; measurement of processing efficiency; seed blending, bag closures; study of orthodox, intermediary and recalcitrant seeds; evaluating seed viability at different RH and temperature levels and packaging materials; prediction of storability by accelerated ageing, controlled deterioration tests, visits to seed processing and seed storage units etc.

SST 508 ***Seed Quality Testing*** **(2+1)**

Theory

Introduction: Structure of monocot and dicot seeds; seed quality: objectives, concept and components and their role in seed quality control; instruments, devices and tools used in seed testing. ISTA and its role in seed testing. Seed Sampling: definition, objectives, seed-lot and its size; types of samples; sampling devices; procedure of seed sampling; sampling

intensity; methods of preparing composite and submitted samples; sub-sampling techniques, dispatch, receipt and registration of submitted sample in the laboratory, sampling in the seed testing laboratory. Physical Purity: definition, objective and procedure, weight of working samples for physical purity analysis; components of purity analysis and their definitions and criteria; pure seed definitions applicable to specific genera and families; multiple seed units; general procedure of purity analysis; calculation and reporting of results, prescribed seed purity standards; determination of huskless seeds; determination of weed seed and other seed by number per kilogram; determination of other distinguishable varieties (ODV); determination of test weight and application of heterogeneity test. Seed moisture content: importance of moisture content; equilibrium moisture content; principles and methods of moisture estimation - types, instruments and devices used; pre-drying and grinding requirements, procedural steps in moisture estimation; calculation and reporting of results. Germination: importance; definitions; requirements for germination, instrument and substrata required; principle and methods of seed germination testing; working sample and choice of method; general procedure for each type of method; duration of test; seedling evaluation; calculation and reporting of results; dormancy: definition, importance, causal mechanisms, types and methods for breaking dormancy. Viability and Vigour Testing: definition and importance of viability tests; different viability tests; quick viability test (TZ- test) - advantages, principle, preparation of seeds and solutions, procedure, evaluation and calculation of test results. Genetic purity testing : objective and criteria for genetic purity testing; types of test; laboratory, Growth Chamber and field testing based on seed , seedling and mature plant morphology; principles and procedures of chemical, biochemical and molecular tests. Seed health Testing: field and seed standards ; designated diseases, objectionable weeds - significance of seed borne disease vis-a-vis seed quality - seed health testing and detection methods for seed borne fungi, bacteria, viruses and nematodes. Storage of guard samples; application and use of seed standards and tolerances.

Practical

Structure of monocot and dicot seeds of important plant species; identification and handling of instruments used in seed testing laboratory; identification of seeds of weeds and crops; physical purity analysis of samples of different crops; estimation of seed moisture content (oven method); seed dormancy breaking methods requirements for conducting germination test, specifications and proper use of different substrata for germination; seed germination testing in different agri-horticultural crops; seedling evaluation; viability testing by tetrazolium test in different crops; seed and seedling vigour tests applicable in various crops; species & cultivar identification; genetic purity testing by chemical, biochemical and molecular methods; seed health testing for designated diseases, blotter methods, agar method and embryo count methods; testing coated/pelleted seeds, visits to the seed testing labs.

SST 509 ***Seed Physiology*** **(2+1)**

Theory

Physiology of seed development and maturation; chemical composition, synthesis and accumulation of seed reserves, induction of desiccation tolerance, hormonal regulation of seed development. Seed germination- factors affecting germination; role of embryonic axis; growth hormones and enzyme activities, effect of age, size and position of seed on germination; Physiological processes during seed germination; seed respiration, breakdown of stored reserves in seeds, mobilization and inter conversion pathways. Seed dormancy- types, significance, mechanism, endogenous and exogenous, factors regulating dormancy, role of phytochrome and PGRs, genetic control of dormancy etc. Seed viability and longevity, pre and post-harvest factors affecting seed viability; seed ageing; physiology of seed deterioration ; lipid peroxidation and other viability theories; means to prolong seed viability; mechanism of desiccation sensitivity and recalcitrance with respect to seed longevity. Seed vigour and its concept, vigour test methods, factors affecting seed vigour, physiological basis of seed vigour

in relation to crop performance and yield. Seed invigoration and physiological and molecular control of seed invigouration.

Practical

Proximate analysis of chemical composition of seed; methods of testing viability; kinetics of seed imbibition and solute leakage; seed germination and dormancy breaking methods; seed invigoration and priming treatments; accelerated ageing and controlled deterioration tests; enzymatic activities and respiration during germination and effect of accelerated ageing; vigour testing methods, *etc*.

SST 510 ***Seed Pathology*** **(1+1)**

Theory

History and economic importance of seed pathology in seed industry and plant quarantine; terminology, important seed transmitted pathogens; seed microbes and their mode of action, detection techniques and identification of common seed borne pathogens. Morphology and anatomy of typical monocotyledonous and dicotyledonous seeds; mode and mechanism of transmission of seed borne pathogens and microorganisms. Rate of transmission of major plant pathogens, microorganisms in relation to seed certification and tolerance limit; type of losses caused by seed- borne diseases. Role of microorganisms in seed quality deterioration; management of seedborne plant pathogens/diseases and procedure for healthy seed production; different seed health testing methods for detecting microorganisms; treatments to control seed borne diseases. Pest Risk Analysis (PRA) and disease free seed production, Sanitary & Phytosaintory (SPS) requirements in seed trade, International regulation (ISHI) in respect of seed health standards.

Practical

Different methods of examination of seeds to assess seed-borne microorganisms and to quantify infection percentage, detection of seedborne fungi, bacteria and viruses, identification

of storage fungi, control of seed borne diseases, seed treatment methods to combat seed borne pathogens, visit to seed pathology lab, *etc*.

SST 511 ***Seed Entomology*** **(1+1)**

Theory

Principles of seed entomology; pollinator insects, insect pests and their classification based on mode of infestation, *etc*. Principles of insect pollination, role of pollinators in seed production. Augmenting quality seed production through honeybee pollination in crucifers and forage legumes. Plant protection measures in bee pollinated crops. Management of pollinators for hybrid seed production, *etc*. Seed yield loss due to insect pest and their control measures in important seed crops. Classes of pesticides, their handling and safe use on seed crops. Storage insect pests infecting seeds and their classification based on primary and secondry pests their development and economic importance. Storage losses due to pests, control of storage pests, Management of storage insects pests, mites and rodents, seed sampling and loss estimation. Principles of fumigation and their use, effect of different fumigants; preservatives and seed protectants on seed quality; Type of storage structures – domestic and commercial.

Practical

Collection and identification of insect-pollinators, collection and identification of important pests of stored seeds. Detection and estimation of pest infestation vis- a- vis loss of seed quality. Safe handing and use of fumigants and insecticides; safety measures in fumigating and disinfecting, exposure period, aeration, *etc*. the storage structures. Plant protection equipments, their operation and maintenance; Pesticides, its dose determination, preparation of solution and its application, visit to the seed godowns / warehouses.

SST 512 ***Seed Production in Forage, Pasture and Green Manure Crops*** **(1+1)**

Theory

Forage seed production prospective and strategies in India, Important forage crops in India; classification of forage, pastures and green manure crops; pollination behavior. Factors influencing seed production; maintenance of varietal purity, generation systems of seed multiplication self pollinated crops; Technologies for forage seed production in important grasses, pastures legumes and green manure crops; Agronomical aspects of seed crop management in forage crops. Selection of seed production areas, influence of season, seed rate and spacing, sowing methods, direct seed sowing, transplanting, pelleting, fertilizer and manure requirement, isolation distance, weed control, pollination and seed setting, seed shattering, seed maturity and stage of harvest, seed collection, economics of seed production of important fodder crops and problems and prospective of marketing forage seeds.Seed processing, seed treatment, seed storage of these crops.

Practical

Study of flower structure, seed collection and identification, characteristics of forage, pastures and green manure crops; maturity indices for harvest, seed testing- sampling, purity, moisture, germination and dormancy, seed treatments. Visit to fodder seed production centres.

SST 513 ***Emerging Trends in Seed Quality Enhancements*** **(1+1)**

Theory

Concept and significance of seed quality enhancement; physical, chemical and pesticidal seed treatments, history, principles and methods of seed treatment, methodology and factors affecting seed enhancement treatments. Seed priming: physiological and biochemical basis, types of priming technology, biochemical and molecular changes associated, pre-germination, film coating and pelleting, seed tapes, seed mats, seed colouring, bio-priming. Synthetic seeds – Aim and scope for

synthetic seeds, historical development, somatic embryogenesis, somaclonal variation and their control, embryo encapsulation systems, hardening of artificial seeds, cryopreservation, storage of artificial seeds, desiccation tolerance, use of botanicals in improving seed quality *etc*.

Practical

Seed treatments – methods and techniques, equipments required for seed treatment, film coating; seed invigoration/priming – hydration and dehydration, PEG priming, solid matrix priming, bio priming, effects of priming; methods for hydrogel encapsulation of artificial endosperm, hydrophobic coating *etc*.; protocols for production of synthetic seeds, Visit to leading Seed Companies to study the seed enhancement processes.

SST 514 ***Data Base Management, Evalution and Utilization of PGR*** **(1+1)**

Theory

Statistical techniques in management of germplasm; Core identification, estimation of sample size during plant explorations, impact of sampling on population structure, sequential sampling for viability estimation; Introduction of binomial, normal and negative cumulative normal, use of Probit scales, viability equations and nomograms; Estimation of sample size for storage and viability testing. Germplasm documentation; Basics of computer and operating systems; Database management system, use of statistical software, pictorial and graphical representation of data; introduction to communication network. Germplasm management system- global scenario; Genetic variation in crop plants and management of germplasm collection, limitations in use of germplasm collections; necessity of germplasm evaluation; Predictive methods for identification of useful germplasm; Characterization of germplasm and evaluation procedures including specific traits; Gene markers and their use in PGR management. Management and utilization of germplasm collections; Concept of core collection, molecular markers and their use in characterization; Evaluation and utilization of genetic

resources; Pre-breeding/ genetic enhancement, utilizing wild species for crop improvement; Harmonizing agrobiodiversity and agricultural development crop diversification, participatory plant breeding.

Practical

Basics of computer and operating systems; Identification of useful germplasm, evaluation of crop germplasm; Statistical techniques in management of germplasm- estimation of sample size for storage and viability testing; Evaluation procedure and experimental protocols (designs and their analysis), Assessment of genetic diversity; Techniques of characterization of germplasm; Molecular markers and their use in characterization, visit to the plant germplasm centers.

SST 515 ***Germplasm Collection, Exchange and Quarantine*** **(1+1)**

Theory

History and importance of germplasm exploration; Distribution and extent of prevalent genetic diversity; Phyto-geographical regions/ ecological zones and associated diversity; Mapping eco-geographic distribution of diversity, threatened habitats, use of flora. 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. Ethnobotanical aspects of PGR; Crop botany, farming systems, collecting wild 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.

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; Plant quarantine- introduction, history, principles, objectives and relevance; Regulations and plant quarantine set up 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. 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.

Practical

Plant exploration and collection; Techniques of coarse and fine grid surveys; Identification 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.

SERICULTURE

Course No.	Title	Credits
SER 501	Mulberry Production and Protection	1+1
SER 502	Breeding of Food Plants of Silkworms	1+1
SER 503	Silkworm Seed and Cocoon Production	2+1
SER 504	Silkworm Protection	1+1
SER 505	Genetics and Breeding of Silkworms	1+1
SER 506	Non-Mulberry Sericulture	1+1
SER 507	Silk Technology	1+1
SER 508	Silkworm Biochemistry and Nutrition	1+1
SER 509	Entrepreneurship and Value Addition in Sericulture	0+1
SER 510	Biotechnoloy in Mulberry and Silkworm	2+0
SER 511	Systematics and Morphology of Sericigenous Insects	1+1
SER 512	Anatomy and Physiology of Sericigenous Insects	1+1
SER 513	Nutrition of Host Plants of Silkworms	1+1
SER 571	Qualifying Examination	2
SER 581	Seminar	2
SER 591	Research	16

SER 501 *Mulberry Production and Protection* (1+1)

Theory

Scope of mulberry sericulture, global distribution, factors influencing mulberry leaf yield and quality. Criteria for selection of site for gardens, propagation techniques, *etc*. soil and climatic requirements. Agronomic practices for garden of chawki and late age silkworm rearing. Use of growth hormones and growth regulators on leaf yield and quality. Method and time of harvest of leaf, leaf preservation techniques and their influence on

quality. Farm records, role of non-monetary inputs in mulberry production. Economics of mulberry production, cultivation practices for high bush and small tree in hilly regions. Pests and diseases of mulberry – causative agents, seasonal occurrence, symptoms, extent and nature of damage, life-cycles and management measures.

Practical

Analysis of area, production and productivity of mulberry and sericulture in Karnataka, in India and world. Practice of different planting systems and study of rooting and sprouting behavior. Pot culture studies of raising of mulberry through sexual and asexual methods with special emphasis of raising saplings through soft, semi soft and apical tender shoots. Nursery preparation Selection of fruits and preparation of mulberry seeds for rising mulberry saplings. Study on Agronomic features of different mulberry varieties. Estimation of leaf area by non-destructive and destructive method. Effect of different pruning systems on mulberry yield. Study on different leaf preservation techniques, different methods of leaf harvest with special reference to chawki and grown up silkworm larvae. Study of different schedules of operation in mulberry garden and fertilizer application, irrigation schedules in both irrigated and rainfed mulberry cultivation. Study of weed flora in mulberry garden. Study on Farm records, cost of cultivation and economics of mulberry cultivation. Study of pests and diseases of mulberry and IPM practices.

SER 502 ***Breeding of Food Plants of Silkworms*** **(1+1)**

Theory

Centre of origin and diversity studies of mulberry. Mulberry species and their distribution in India and other countries. Taxonomy of the genus Morus. Cytology of mulberry. Karyomorphological studies. Microsporogenesis and Megasporogenesis in mulberry. Embryological studies of mulberry. Collection, conservation, evaluation and maintenance of mulberry germplasm. Role of mulberry germplasm in crop

improvement. Study of floral structure and biology, objectives and pre-requisites of mulberry breeding. Genetics of important traits. Conventional methods of breeding-introduction, clonal selection, backcross method. Intervarietal and distant hybridization. Heterosis breeding. Population improvement. Development of polycross hybrids. Non-conventional methods of breeding - polyploidy, mutation, breeding for leaf quality, diseases, pest drought, alkalinity and salinity tolerance. Evolution of mulberry genotypes for different growth and yield parameters. Centres involved in mulberry improvement. Different breeding methods employed for improvement of host plants of non-mulberry silkworms. Statistical approaches for yield test, In vitro techniques-achievements and prospects. Improved varieties evaluation and distribution, maintenance. Challenges for future.

Practical

Floral biology, hybridization techniques, selection methods, techniques of treatment with colchicines, techniques of induction of mutation, testing for resistant to biotic and abiotic factors, application of in-vitro techniques. Evaluation of germplasm. Categorization of collections available using standard key provided by CSB. Visit to CSGRC, Hosur. Operation of growth and yield parameters in mulberry for varietal differences.

SER 503 ***Silkworm Seed and Cocoon Production*** **(2+1)**

Theory

Organization of egg production. Breeder stock, foundation stock and commercial egg production (egg card and loose egg). Grainage, plan of grainage, grainage equipments. Transportation and marketing of seed cocoons, selection of seed cocoons, storage, handling and processing of seed cocoons, sex separation, moth emergence, pairing, moth examination, disinfection and washing of eggs. Artificial methods of hatching, preservation, storage and transportation of seed, hibernation schedules, incubation, production of hybrid seeds (multivoltine, bivoltine).Economics of egg production and special

determinants. 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, disinfection of rearing room and equipment. Planning for silkworm rearing, harvesting, transportation and preservation of mulberry leaves. Different methods of incubation of silk moth eggs, hatching and brushing. Early instar silkworm (Chawki) rearing, different methods, environmental conditions, quality of leaf, feeding, bed cleaning, spacing. Chawki rearing centres. Different methods of late age silkworm rearing, environmental conditions, feeding and bed spacing. Management of silkworm during moulting. Mounting of ripe worms, different kinds of mountages. Rearing house and equipment for shoot method of rearing. Comparing shoot feeding and shelf method of rearing.

Practical

Study of structure of egg of mulberry, silkworm. Ground plan of model grainage building. Grainage equipments. Handling and processing of seed cocoons. Sex separation at pupal and adult stages. Hibernation schedules. Incubation. Silkworm breeds and their classification. Seed legislative act, 1959. Management of commercial grainages. Economics of silkworm egg production. Ground plan for model rearing house for shelf method of rearing. Chemical and physical agents used in silkworm rearing and disinfection. Disinfectants. Rearing equipments for shelf method of rearing. Incubation of silk moth eggs, hatching and brushing. Early instar silkworm rearing. Late age silkworm rearing. Environmental conditions for silkworm rearing. Harvesting and preservation of leaf. Management of silkworm during moulting. Mounting of ripe worms. 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.

SER 504 ***Silkworm Protection*** **(1+1)**

Theory

Classification of disease causing organisms of mulberry and non-mulberry silkworms including viral, fungal, bacterial, protozoan and mixed infections. Occurrence, causative agent, symptoms and infection, source of infection, predisposing factors, transmission and management. Symptoms seasonal incidence of diseases associate with mulberry and non-mulberry silkworms. Diagnosis of different pathogens based on symptoms (external and internal). Comparative etiology of silkworm pathogens. Management, prevention and control of diseases of mulberry and non-mulberry silkworms, regulation of environmental factor contributing to diseases. Pests of mulberry and non-mulberry silkworms, uzi fly occurrence, nature and extent of damage, life-cycle and management. Other pests and predators effecting silkworm crop and their management.

Practical

Study of symptoms of different diseases of mulberry and non-mulberry silkworms. Study of life-cycle of different diseases. Study of life-cycle of silkworm uzi fly, tasar uzi fly, dermested beetles and predators of non-mulberry silkworms. Study of management techniques of different diseases and pests. Visits to farmers' field to study management measures adopted/recommended.

SER 505 ***Genetics and Breeding of Silkworms*** **(1+1)**

Theory

Cytological aspects of silk production and achievements in deciphering molecular biology of silk gene. Phenomena of spermatogenesis and oogenesis with relevance to crossing over, cell division types in silkworms, synaptonemal complex, fertilization, chromosomes in silkworms. Hereditary traits of importance in egg, larva, pupa-cocoon and adult. E- Group as a tool in genetics & significance. Linkage groups in silkworms. Ancestor and cytological basis of origin of silkworms. Sex determination, sex linked inheritance, parthenogenesis,

polyploidy, Hormonal control mechanisms, mosaics. Translocation of characters in metamorphic stages. Genetics of cocoon colours. Bombyx mori genome and latest genome sequence, methods of silkworm breeding and its importance with relevance to Indian scenario. Characters of importance in silkworm breeding. Multivoltine & bivoltine races and hybrids, authorization and release of races. Indian sex linked and sex limited races, their importance and need of the hour. Silkworm germplasm and resource potential, Breeding for thermotolerance, disease resistance, special characters required for the nation and also for export.

Practical

Study of mitosis, meiosis, oogenesis, spermatogenesis and fertilization in silkworms. Study of important hereditary traits in egg, larva, pupa-cocoon and adult. Marker genes and linkage groups in silkworm. Study of heterosis - work out heterosis, heterobeltiosis and standard deviation for economic characters. Study of biometrical methods used in silkworms breeding, modern methods of silkworm breeding, induction of parthenogenesis and polyploidy, breeding plans of newly evolved breeds.

SER 506 ***Non-mulberry Sericulture*** **(1+1)**

Theory

Scope of non-mulberry sericulture in India. Global distribution of non-mulberry silkworm species and their breeds. Non-insect silk fauna and their use. Grainage operations and rearing methods including improved rearing techniques for tropical tasar, temperate tasar, muga and eri silkworms. Anaphe culture. Natural enemies and their management of non-mulberry silkworms and economics of tasar and eri cultures. Exploitation of cultivated castor / tapioca for sericulture. Lesser known silkworm species, their distribution, host plants and their economic importance.

Practical

Study of life history of eri, tasar and muga silkworms. Host plants of eri, tasar and muga silkworms. Pests of host plants of eri, muga and tasar silkworms. Eri silkworm rearing equipments and disinfection. Grainage operations in eri DFLs preparation. Effect of mating duration on fecundity and hatchability. Effect of different strata on egg laying. Eri egg incubation and brushing. Rearing of eri silkworms on different host plants. Instar wise leaf requirements for eri silkworm. Diseases and pests of eri silkworm. Spinning, harvesting and grading of cocoons. Cocoon characters of eri, tasar and muga silkworms. Economics of ericulture.

SER 507 ***Silk Technology*** **(1+1)**

Theory

Introduction; Importance and use of silk – cocoon quality – Importance of quality. Physical and commercial characteristics. Defective cocoons – technological aspects. Selection of raw material for silk reeling – scientific method of testing and classification. Cocoon marketing, price fixing, different methods of stifling of cocoons – sun drying, steam stifling, hot drying and other methods. Brushing of cocoons, different methods of brushing. Different methods of reeling, reeling machineries – charaka, cottage basin, multiend and automatic reeling machine – Importance of reeling, water and amelioration of water. Re-reeling, silk examination and lacing, book and bale making. Silk testing and grading, procedure followed and equipments used for testing of silks, throwing, by-products of reeling, reeling waste as raw material for spun silk industry. Factors influencing quantity of silk. Marketing of raw silk. Economics of silk reeling.

Practical

Classification of cocoons of silkworm breeds. Physical characters of cocoons. Commercial characteristics of cocoons. Cocoon transportation and marketing. Cocoon sorting and estimation of defective cocoons, Cocoon stifling methods, Cocoon cooking, Cocoon brushing and estimation of waste percentage. Charaka and improved charaka. Cottage basin,

domestic basin and multiend reeling machine. Automatic reeling machine. Determination of waste percentage in cocoons of different breeds. Re-reeling, examination, skein making and book making. Reeling water and its quality. Purification of reeling water. Properties of mulberry raw silk. Microscopic examination of silk bave. Quality tests of raw silk. Byproducts in silk reeling.

SER 508 ***Silkworm Biochemistry and Nutrition*** **(1+1)**

Theory

Carbohydrate, protein and fat metabolism, chemical nature of vitamins and hormones. Nutritional requirements and metabolism of amino acids, lipids, vitamins, minerals. Physiology of moulting, egg and pupal diapause in silkworms, biochemical pathways of silk synthesis. Leaf composition as affecting silkworm growth, qualitative and quantitative requirements of nutrients, feed efficiency, supplementation of nutrients.

Practical

Qualitative tests and quantitative estimations of carbohydrates in silkworm tissues; Ascorbic acid levels in the mulberry leaves; Solubility and extraction of lipids; quantitative and qualitative estimations of phospholipids and cholesterol in silkworm tissues; qualitative tests and quantitative estimations of proteins and study of digestive enzymes in silkworms.

SER 509 ***Entrepreneurship and Value Addition in Sericulture*** **(0+1)**

Practical

Concept, need, scope, prospects and problems of entrepreneurship in sericulture. Sericultural entrepreneurial development in India, China, Japan and other sericultural countries. Entrepreneurship development in mulberry cultivation-kissan nursery, vermicomposting, leaf production. Entrepreneural development in silkworm-egg production, Chawki rearing centres, cocoon production. Entrepreneurship development in silk reeling-establishment of reeling units, twisting and dying

units, weaving units. Entrepreneurship development in manufacture/production, marketing/hiring of sericultural material/equipments and seri-inputs. Value addition during host plant cultivation-mulberry as fuel, green manure, fodder, line fencing material, wind breakers. Mulberry fruits and uses in pickle, jam, jelly, beverage/wine preparation. Mulberry as medicine, mulberry in agriculture and sports industry, mulberry in biogas production, mulberry as shade tree, avenue tree. Processing of mulberry leaf for the tea preparation. Value addition during silkworm rearing –silkworm litter as cattle, sheep, goat feed; as a organic manure, raw material for biogas production, mushroom raising, poulty feed, fish feed, silkworm excreta in cosmetic industry. Value addition during silk reeling-pupal oil extraction and its uses, pupal powder as animal feed, manure. Silkworms in human consumptions-commercialized products and locally prepared dishes. Preparation of handicrafts, toys, wall plates, garlands, greeting cards, *etc*. Sericin for medicine, ceramics, artificial membranes and plastic industry and other uses of silk.

SER 510 ***Biotechnology in Mulberry and Silkworm*** **(2+0)**

Theory

Biotechnology and its scope in Sericulture. In vitro propagation in mulberry-production of haploids, polyploids. Somaclonal variations, gametoclonal variations - their scope and applications. Cryopreservation. Mulberry and Silkworm germplasm characterization by using molecular markers, Application of biotechnological tools in screening for biotic and abiotic stress resistance. Molecular markers: Development of maps, QTL mapping, MAS for economically important traits in mulberry and silkworm. Molecular aspects of silk synthesis. Recombinant DNA technology, genes transfer systems-vector mediated gene transfer, microinjection, electroporation, direct DNA uptake, gene gun technique, selectable markers and reporter system; transgenic silkworm-prospects, achievements in silkworm. Silkworm as a bioreactor for foreign gene expression. Biosafety and regulatory issues, Intellectual Property Rights.

Mapping populations (F_2S and back crosses RILs, NILs, DHs), Molecular mapping, and tagging of economically important traits, Seri bioinformatics. Genomics-structural, functional and applications.

SER 511 ***Systematics and Morphology of Sericigenous Insects*** **(1+1)**

Theory

External morphology of sericigenous insects. Integument, structure, segmentation and outgrowths. Body regions, appendages and other structures, their modifications. Principles and types of classification, zoological nomenclature. Use of keys, species concept. Study of the Orders and important families of insects producing silk.

Practical

Critical examination of head, thorax and abdominal regions and structures borne on them. Diagrammatic representations of structures and modifications seen in sericigenous insects. Exposure to use of keys and practical preparation of keys to key out specimens.

SER 512 ***Anatomy and Physiology of Sericigenous Insects*** **(1+1)**

Theory

Structure of the various systems – digestive, circulatory, respiratory, excretory, muscular, reproductive and nervous (including central, visceral and peripheral) and sense organs of larvae, pupae and adults. Physiology of various systems – digestion, circulation, respiration, excretion, reproduction and nervous systems. Glandular system – exocrine, endocrine glands, hormones and hormonal mechanism. Nutritional role of vitamins and other growth factors, properties of haemolymph, nerve impulses and sense organs. Classification of diets for silkworm, vitamins, enzymes, role of microbes in nutrition. Structure and histology of silk glands, chemical composition and biosynthesis of silk proteins, endocrinological aspects of silk production.

Practical

Study of digestive, circulatory, respiratory, excretory and nervous systems of larva and adult stages of mulberry, eri, tasar and muga silkworms. Male and female reproductive systems in mulberry, eri, tasar and muga silk moths. Silkglands of mulberry, eri, tasar and muga silkworms. Endocrine system of Bombyx mori L. Synthetic diets/Artificial diets.

SER 513 ***Nutrition of Host Plants of Silkworms*** **(1+1)**

Theory

Role of mineral nutrition in growth and development of mulberry and other host plants of silkworms. Influence of physical and chemical properties of soil and other factors in relation to nutrient availability, uptake and growth. Principles of manure and fertilizer applications, methods of green manuring and composting, deficiency and toxicity of nutrients in host plants and their effect on nutritional status of leaf. Nutrient deficiencies, role of bio-fertilizers, fertilizer recommendation based on soil tests and quality of leaf required.

Practical

Study on effect of fertilizer use pattern on physico-chemical and microbiological environment of soils under mulberry cultivation. Study on recent methods of vermi composting techniques using sericulture wastes. Study on different methods of green manuring. Pot culture studies on the effect of nutrient solution and bacterial inoculants on the growth of mulberry cuttings. Study on collection of soil sample in mulberry garden and interpretation of soil test results and drawing fertilizer recommendation to mulberry cultivation. Development of nutrient deficiency symptoms using sand culture techniques. Study of Seri Suvarna method of mulberry cultivation using organic manures and green leaf manure and by adopting soil moisture conservation techniques

SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

Course No.	Title	Credits
SAC 501	Analytical Techniques in Soil and Plant Analysis	1+1
SAC 502	Soil Mineralogy, Genesis, Survey and Classification	2+1
SAC 503	Soil Physics	2+1
SAC 504	Soil Chemistry	2+1
SAC 505 / AMB 504	Soil Microbiology and Biochemistry	1+1
SAC 506	Soil Fertility and Nutrient Management	2+1
SAC 507	Management of Problematic Soils and Waters	1+1
SAC 508	Soil, Water and Air Pollution	1+1
SAC 509	Soil Testing and Fertilizer Recommendation	1+1
SAC 510	Manures and Fertilisers	1+1
SAC 511	Agricultural Chemicals	1+1
SAC 512	Soil Erosion and Conservation	1+1
SAC 571	Qualifying Examination (External)	2
SAC 581	Seminar	2
SAC 591	Research	16

SAC 501 ***Analytical Techniques in Soil and Plant Analysis*** **(1+1)**

Theory

Preparation of solutions for standard curves, analytical reagents, qualitative reagents, indicators and standard solutions for acid-base, oxidation-reduction and complexometric titration; electrochemical titration of clays. Nutrient potentials and potential buffering capacities and fixation capacity of soils for phosphorus, ammonium and potassium; estimation of organic carbon, available N,P,K, Ca, Mg, S, Fe, Mn,Zn, Cu and Boron.

Principles of spectrophotometery (visible, ultraviolet and infrared), atomic absorption spectroscopy, flame-photometry, inductively coupled plasma spectrometry, Potentiometr,; chromatographic techniques, mass spectrometry. Analysis of soil and plant samples for N, P, K, Ca, Mg, S, Zn, Cu, Fe, Mn, B and Mo; methods of plant samples digestion, good labouratory practices, preparation of analytical reagents

Practical

Principles of analytical chemistry, Sampling of soils, water, effluents and plant, Estimation of electrochemical properties of soils, Estimation of cation and anion exchange capacity of soils, Chemical analyses of soils and interpretation and recommendation, Chemical analyses of plant and interpretation and recommendation.

SAC 502 ***Soil Mineralogy, Genesis, Survey and Classification*** **(2+1)**

Theory

Space lattice, coordination theory, isomorphism and polymorphism. 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. Factors of soil formation, soil formation models; soil forming processes; weathering of rocks and minerals; soil profile; weathering sequences of minerals with special reference to Indian soils. Concept of soil individual; soil classification systems – modern systems of soil classification with special emphasis on soil taxonomy; soil maps – usefulness. Soil survey and its types; soil survey techniques - conventional and modern; soil series – characterization and procedure for establishing soil series; soil survey interpretations; soil mapping, thematic soil maps, techniques for generation of soil maps. Landform – soil relationship; major soil groups of India with special reference to Karnataka; 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.

Practical

Identification and quantification of minerals in soil fractions by X-ray and different methods. Morphological properties of soil profile in different landforms, Classification of soils using soil taxonomy, Calculation of weathering indices and its application in soil formation, Grouping soils using available data base in terms of soil quality, 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 construction of maps in different scales, Land use planning exercises using conventional and RS tools

SAC 503 ***Soil Physics*** **(2+1)**

Theory

Scope of soil physics and its relation with other branches of soil science; soil as a three phase system. Soil texture, textural classes, mechanical analysis, specific surface. Soil consistence; dispersion and workability of soils; soil compaction and consolidation; soil strength; swelling and shrinkage - basic concepts. Soil structure – genesis, types, characterization and management of 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. Soil water: content and potential, soil water retention, soil-water constants, energy state of soil water, soil water potential, soil-moisture curve; hysteresis, water flow in saturated and unsaturated soils, Poiseuille's law, Darcy's law; hydraulic conductivity, permeability and fluidity, hydraulic diffusivity. Infiltration; internal drainage and redistribution; evaporation; hydrologic cycle, field water balance; soil-plant-atmosphere continuum. Composition of soil air; renewal of soil air - convective flow and diffusion; measurement of soil aeration;

aeration requirement for plant growth; soil air management. 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

Mechanical analysis by international pipette and Hydrometer methods, 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.

SAC 504 ***Soil Chemistry*** **(2+1)**

Theory

Chemical (elemental) composition of the earth's crust and soils. Elements of equilibrium thermodynamics, chemical equilibria, electrochemistry and chemical kinetics. 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; electrometric properties of soil colloids; sorption properties of soil colloids; soil organic matter - fractionation of soil organic matter and different fractions, clay-organic interactions. 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, thermodynamics, statistical mechanics; anion and ligand exchange – innersphere and outer-sphere surface complex formation, fixation of oxyanions, hysteresis in sorption-desorption of oxy-anions and anions, shift of PZC on ligand exchange, AEC, CEC; experimental methods to study ion exchange phenomena and practical implications in plant nutrition. Potassium, phosphate and ammonium fixation in soils covering specific and non-specific sorption; precipitation-dissolution equilibria; step and constant-rate K; management aspects. Chemistry of acid soils; active and potential acidity; lime potential, chemistry of acid soils; sub-soil acidity. Chemistry of salt-affected soils and amendments; soil pH, ECe, ESP, SAR and important relations; soil management and amendments. Chemistry and electrochemistry of submerged soils.

Practical

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 serial potentiometric titration method, Potentiometric and conductometric titration of soil humic and fulvic acids, (E4/E6) ratio of soil humic and fulvic acids by visible spectrophotometric studies and the Ä (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 lime requirement of an acid soil by buffer method, Determination of gypsum requirement of an alkali soil.

SAC 505 / AMB 504 ***Soil Microbiology and Biochemistry*** **(1+1)**

Theory

Soil biota, soil microbial ecology, types of organisms in different soils; soil microbial biomass; microbial interactions; un-culturable soil biota. Microbiology and biochemistry of root-soil interface; phyllosphere; soil enzymes, origin, activities and importance; soil characteristics influencing growth and activity of microflora. Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil; biochemical composition and biodegradation of soil organic matter and crop residues, humus formation; cycles of important organic nutrients. Biodegradation of pesticides, organic wastes and their use for production of biogas and manures; biotic factors in soil development; microbial toxins in the soil. Preparation and preservation of farmyard manure, animal manures, rural and urban composts and vermicompost. Biofertilizers – definition, classification, specifications, method of production and role in crop production.

Practical

Determination of soil microbial population, Soil microbial biomass, 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 micro nutrients Study of rhizosphere effect

SAC 506 ***Soil Fertility and Nutrient Management*** **(2+1)**

Theory

Soil fertility and soil productivity; nutrient sources – fertilizers and manures; essential plant nutrients - functions and deficiency symptoms. 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. 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, equilibrium in soils and its agricultural significance; mechanism of potassium fixation; management of potassium fertilizers under field conditions. Sulphur - source, forms, fertilizers and their behavior in soils; calcium and magnesium– factors affecting their availability in soils; management of sulphur, calcium and magnesium fertilizers. Micronutrients – critical limits in soils and plants; factors affecting their availability and correction of their deficiencies in plants; role of chelates in nutrient availability. Common soil test methods for fertilizer recommendations; quantity– intensity relationships; soil test crop response correlations and response functions. Fertilizer use efficiency; blanket fertilizer recommendations – usefulness and limitations; site-specific nutrient management; plant need based nutrient management; integrated nutrient management. Soil fertility evaluation - biological methods, soil, plant and tissue tests; soil quality in relation to sustainable agriculture.

Practical

Principles of colorimetry, Flame-photometry and atomic absorption spectroscopy, Chemical analysis of soil for total and available nutrients, Analysis of plants for essential elements

SAC 507 ***Management of Problematic Soils and Waters*** **(1+1)**

Theory

Area and distribution of problem soils – acidic, saline, sodic and physically degraded soils; origin and basic concept of problematic soils, and factors responsible. Morphological features of saline, sodic and saline-sodic soils; characterization of salt-affected soils - soluble salts, ESP, pH; physical, chemical and microbiological properties. Management of salt-affected soils; salt tolerance of crops - mechanism and ratings; monitoring

of soil salinity in the field; management principles for sandy, clayey, red lateritic and dry land soils. 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. 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. 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^{2+} and Mg^{2+}) in ground water and soil samples, Determination of anions (Cl^-, SO_4^{2-}, CO_3^{2-}, and HCO_3^-) in ground waters and soil samples, Lime and gypsum requirements of acid and sodic soils

SAC 508 ***Soil, Water and Air Pollution*** **(1+1)**

Theory

Soil, water and air pollution problems associated with agriculture, nature and extent. 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. Sewage and industrial effluents – their composition and effect on soil properties/ health, and plant growth and human beings; soil as sink for waste disposal. Pesticides – their classification, behavior in soil and effect on soil microorganisms. Toxic elements – their sources, behavior in soils, effect on nutrients availability, effect on plant and human health. Pollution of water resources due to leaching of nutrients and pesticides from soil; emission of greenhouse gases – carbon dioxide, methane and nitrous oxide. 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, Estimation of dissolved and suspended solids, chemical oxygen demand (COD), biological demand (BOD), nitrate and ammoniacal nitrogen and phosphorus, heavy metal content in effluents, Heavy metals in contaminated soils and plants, Air sampling and determination of particulate matter and oxides of sulphur, Visit to various industrial sites to study the impact of pollutants on soil and plants

SAC 509 ***Soil Testing and Fertiliser Recommendation*** **(1+1)**

Theory

Principles of soil testing; Factors affecting the availability of nutrients; Field sampling for soil testing. Testing soils for pH, plant nutrients, Lime and gypsum requirement; Interpretation of soil test results for fertilizer recommendation. Experimental methods for correlation and calibrating soil tests; The changing philosophy of soil test interpretation, Principles and practices in plant analysis; Leaf analysis as an aid in fertilizer recommendation; Operation and management of commercial soil testing and plant analysis laboratories; Concepts of soil testing and response studies in soil fertility evaluation; Visual and hidden hunger symptoms in plants and their diagnostic techniques; Crop logging techniques, biological methods in determining nutrients in soils; Mitscherlich pot culture methods for Neubauer techniques.

Practical:

Collection of soil samples from varying fertility levels, analysis, fertility ratings and computations of nutrient indices, Preparation of soil fertility maps, Fertilizer recommendation to crops based on soil test data: Use of soil test crop response concept in computing target yield of crops; Determination of available nutrients using pot culture method and Neubauer techniques.

SAC 510 ***Manures and Fertilisers*** **(1+1)**

Theory

Fertilizers – production, consumption and future projections with regard to nutrient use in the country and respective states. Manures- classification, chemistry, nutrient contents of bulky and concentrated organic manure. Manufacturing processes for different fertilizers (nitrogenous, phosphatic and potassic fertilizers) using various raw materials, characteristics and nutrient contents. Recent developments in secondary and micronutrient fertilizers and their quality control as per fertilizer control order. New and emerging issues in fertilizer technology – production and use of slow and controlled release fertilizers, supergranules fertilizers and fertilizers for specific crops/situations. Environmental pollution due to fertilizer use. Biofertilizers – important biofertlisers like Rhizobium, Azotobacter, Azospirilum, Mycorrhiza; quality control and legal aspects- fertilizer control order.

Practical

Determination of moisture content in fertilizers, Qualitative tests of inorganic fertilizers, Determination of total nitrogen in fertilizers, Determination of water soluble P_2O_5 in fertilizer, Determination of water soluble K_2O in K fertilizers, Analysis of manures for different nutrients, Determination of lime and gypsum contents in amendments, Visit to fertilizer quality control laboratories.

SAC 511 ***Agricultural Chemicals*** **(1+1)**

Theory

Definition, IUPAC approved terminology, statistics of production and consumption. Plant protection chemicals: Pesticides – classification of pesticides by different methods. Botanical insecticides, structure, properties, mode of action and uses of conventional insecticides such as nicotine, pyrethrins and rotenones. Structure, properties, mode of action and uses of Insecticides-chlorinated hydrocarbons, organophosphates, carbamates, synthetic pyrethroids. Fungicides - inorganic, organic- heterocyclic, formamide, alkane, alkane carboxylic acid

and miscellaneous groups. Herbicides- classification and important groups- phenoxy compounds, substituted ureas, amides, thiocarbamates, triazines, pyridines, imidazolines and sulphonyl ureas. Nematicides - aliphatic halogen compounds, methyl isocyanate liberators, organophosphates and carbamates. Formulation of pesticides - definition, classification. Pesticide adjuvants: synergists. Pesticide residue: Concept definition, significance and analysis as per BIS specifications; Insecticide Act, Directorate of Plant Protection, Quarantine and Storage.

Practical

pH, Acidity/ Alkalinity, Bulk density, Wettability, Specific gravity, Suspensibility of pesticides, Titrimetric procedure for active ingredient analysis of Pesticide formulation, Extraction procedures for pesticide residues from soil and plant samples, Cleanup procedures for pesticide residues from soil and plant samples, Ultra-Violet (UV) Spectrophotometric methods in Pesticide, Infrared (IR) Spectroscopy, Thin Layer Chromatograph (TLC), Gas Chromatograph (GC) in Pesticide formulation/ residue analysis, High Performance Liquid Chromatograph (HPLC) in Pesticide formulation/ residue analysis, Studies on Bioassay techniques for Persistence of herbicides, Calculations, Reporting and Interpretation of the Pesticide Residue Data, Safety measures in handling pesticides, BIS standards for commonly used pesticides

SAC 512 ***Soil Erosion and Conservation*** **(1+1)**

Theory

History, distribution, identification and description of soil erosion problems in India. 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; empherical and quantitative estimation of water erosion; methods of measurement and prediction of runoff; soil losses in relation to soil properties and precipitation. Wind erosion- types, mechanism and factors affecting wind erosion;

extent of problem in the country. Principles of erosion control; erosion control measures – agronomical and engineering; erosion control structures - their design and layout. Soil conservation planning; land capability classification; soil conservation in special problem areas such as hilly, arid and semi-arid regions, waterlogged and wet lands. Watershed management – concept, objectives and approach; water harvesting and recycling; flood control in watershed management; socioeconomic aspects of watershed management; case studies in respect to monitoring and evaluation of watersheds; use of remote sensing in assessment and planning of watersheds.

Practical

Determination of different soil erodibility indices - suspension percentage, dispersion ratio, erosion ratio, clay ratio, clay/moisture equivalent ratio, percolation ratio, raindrop erodibility index, Computation of kinetic energy of falling rain drops, Computation of rainfall erosivity index (EI30) using rain gauge data, Visits to watersheds.

PROCESSING AND FOOD ENGINEERING

Course No.	Title	Credits
PFE 501	Transport Phenomena in Food Processing	2+1
PFE 502	Engineering Properties of Food Materials	2+1
PFE 503	Advanced Food Process Engineering	2+1
PFE 504	Unit Operations in Food Process Engineering	1+1
PFE 505	Processing of Cereals, Pulses and Oilseeds	1+1
PFE 506	Food Processing Equipment and Plant Design	1+1
PFE 507	Fruits and Vegetables Process Engineering	1+1
PFE 508	Storage Engineering, Food Packaging and Handling of Agricultural Products	2+1
PFE 509	Industry / Institute Training	NC
PFE 510	Neural Network and its Applications	1+1
PFE 511	Applied Instrumentation	2+1
PFE 512	Mechanism Analysis nd Synthesis	3+0
PFE 513	Application of Solar Energy in Agriculture	2+0
PFE 571	Qualifying Examination	2
PFE 581	Seminar	2
PFE 591	Research	16

PFE 501 ***Transport Phenomena in Food Processing*** **(2+1)**

Theory

Introduction to heat and mass transfer and their analogous behaviour, steady and unsteady state heat conduction, analytical and numerical solution of unsteady state heat conduction equations, use of Gurnie-Lurie and Heisler Charts in solving heat conduction problems. Applications in food processing including freezing and thawing of foods. 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, jacketed vessels. Radiation heat transfer and its governing laws, its applications in food processing. 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.

Practical

Solving problems on steady and unsteady state conduction with or without generation; numerical analysis; problems in natural and forced convection; radiation; design of heat exchangers; performing experiments on heat conduction, convection and radiation heat transfer.

PFE 502 ***Engineering Properties of Food Materials*** **(2+1)**

Theory

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. 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. Thermal properties: Specific heat, thermal conductivity, thermal diffusivity, methods of determination, steady state and transient heat flow. Electrical properties; Dielectric loss factor, loss tangent, A.C. conductivity and dielectric constant, method of

determination, energy absorption from highfrequency electric field. Application of engineering properties in design and operation of agricultural equipment and structures

Practical

Experiments for the determination of physical properties like, length, breadth, thickness, surface area, bulk density, porosity, true density, coefficient of friction, angle of repose and colour for various food grains, fruits, vegetables, spices and processed foods, aerodynamic properties like terminal velocity, lift and drag force for food grains, thermal properties like thermal conductivity, thermal diffusivity and specific heat, firmness and hardness of grain, fruits and stalk, electrical properties like dielectric constant, dielectric loss factor, loss tangent and A.C. conductivity of various food materials.

PFE 503 ***Advanced Food Process Engineering*** **(2+1)**

Theory

Thermal processing: Death rate kinetics, thermal process calculations, methods of sterilization and equipments involved, latest trends in thermal processing. Evaporation: Properties of liquids, heat and mass balance in single effect and multiple effect evaporator, aroma recovery, equipments and applications. Drying: Rates, equipments for solid, liquid and semi-solid material and their applications, theories of drying, novel dehydration techniques. Non-thermal processing: Microwave, irradiation, ohmic heating, pulsed electric field preservation, hydrostatic pressure technique *etc*. Freezing: Freezing curves, thermodynamics, freezing time calculations, equipments, freeze drying, principle, equipments. Separation: Mechanical filtration, membrane separation, centrifugation, principles, equipments and applications, latest developments in separation and novel separation techniques. Extrusion: theory, equipments, applications. Distillation and leaching: Phase equilibria, multistage calculations, equipments, solvent extraction.

Practical

Solving problems on single and multiple effect evaporator, distillation, crystallisation, extraction, leaching, membrane separation and mixing, experiments on rotary flash evaporator, humidifiers, reverse osmosis and ultra filtration - design of plate and packed tower, visit to related food industry.

PFE 504 ***Unit Operations in Food Process Engineering*** **(1+1)**

Theory

Review of basic engineering mathematics; Units and dimensions; Mass and energy balance. Principles of fluid flow, methods of heat transfer, heat exchangers and their designs. Psychrometry, dehydration, EMC, Thermal processing operations; Evaporation, dehydration/drying, types of dryers, blanching, pasteurization, distillation, steam requirements in food processing. Refrigeration principles and Food freezing. Mechanical separation techniques, size separation equipments; Filtration, sieving, centrifugation, sedimentation. Material handling equipment, conveyors and elevators; Size reduction processes; Grinding and milling. Homogenization; Mixing-mixers, kneaders and blenders. Extrusion. Membrane technology. Non-thermal processing techniques. Food plant design; Food plant hygiene- cleaning, sterilizing, waste disposal methods, engineering aspects of radiation processing. Food packaging: Functions materials, technique, machinery and equipment.

Practical

Fluid flow properties, study of heat exchangers problems, application of psychrometric chart, determination of EMC, study of driers, elevating and conveying equipments, size reduction equipments, cleaning and sorting equipments, mixing equipments, sieve analysis, kinetics of fruits and vegetables dehydration, calculation of refrigeration load, food plant design, gas and water transmission rate, solving of numerical problems.

PFE 505 ***Processing of Cereals, Pulses and Oilseeds*** **(1+1)**

Theory

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. 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 equipments. 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. Packaging of processed products, design characteristics of milling equipments; selection, installation and their performance, BIS standards for various processed products.

Practical

Physical properties of cereals and pulses, raw and milled products quality evaluations; parboiling and drying; terminal velocities of grains and their fractions; study of paddy, wheat, pulses and oilseeds milling equipments; planning and layout of various milling plants, visit to related agroprocessing industry.

PFE 506 ***Food Processing Equipment and Plant Design*** **(1+1)**

Theory

Design considerations of processing agricultural and food products. Design of machinery for drying, milling, separation, grinding, mixing, evaporation, condensation, membrane separation. 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 theory models, computer aided selection of the location. Feasibility analysis and preparation of feasibility report: plant size, factors affecting plant

size and their interactions, estimation of break-even and 36 economic plant size; Product and process design, process selection, process flow charts, computer aided development of flow charts. Hygenic 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 profitabilities, management techniques in plant design including applications of network analysis, preparation of project report and its appraisal.

Practical

Detailed design and drawing of mechanical dryers, milling equipment, separators, evaporators, mixers and separators. Each individual student will be asked to select a food processing plant system and develop a plant design report which shall include product identification and selection, site selection, estimation of plant size, process and equipment selection, process flow-sheeting, plant layout, and its evaluation and profitability analysis.

PFE 507 ***Fruits and Vegetables Process Engineering*** **(1+1)**

Theory

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. Harvesting and washing, pre-cooling, preservation of fruits and vegetables, blanching, commercial canning of fruits and vegetables, minimal processing of fruits and vegetables. Cold storage of fruits and vegetables, controlled atmosphere packaging of fruits and vegetables, gas composition, quality of storage. Dehydration of fruits and vegetables, methods, osmotic dehydration, foam mat drying, freeze drying, microwave heating, applications, radiation preservation of fruits and vegetables, irradiation sources. 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.

Practical

Determination of size, shape, density, area-volume-mass relationship of fruits and vegetables, sugar-acid ratio of fruits, evaluation of washer, grader and packaging methods, experiments on drying of fruits and vegetables, controlled atmosphere storage and quality evaluation.

PFE 508 ***Storage Engineering, Food Packaging and Handling of Agricultural Products*** **(2+1)**

Theory

Storage of grains, biochemical changes during storage, production, distribution and storage capacity estimate models, storage capacity models, ecology, storage factors affecting losses, storage requirements. Introduction of packaging: Package, functions and design. Principle in the development of protective packaging. Deteriorative changes in foodstuff and packaging methods of prevention. Food containers: Rigid containers, glass, wooden boxes, crates, plywood and wire bound boxes, corrugated and fibre board boxes, textile and paper sacks, corrosion of containers (tin plate); Flexible packaging materials and their properties; Aluminium as packaging material; Evaluation of packaging material and package performance. Bag and bulk storage, godowns, bins and silos, rat proof godowns and rodent control, method of stacking, preventive method, 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. Methods to extend shelf life; Packaging of perishables and processed foods; Special problems in packaging of food stuff. 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.

Practical

Quality evaluation of stored products, design of storage structures, cold storage, load estimation, construction, maintenance, static pressure drop, experiment on controlled and modified atmosphere storage system, estimation of storage loss, and quality of stored products. Packaging of fruits/vegetables; Estimation of shelf-life of packaged food stuff; Familiarization of types of packaging material.

PFE 509 ***Industry / Institute Training*** **NC**

Theory

In-plant training in the relevant food industry during processing operation of the plant to study the actual working of the equipment and various unit operations. The evaluation will be based on the written report of the student and the comments of the factory managers. The duration of training shall be three weeks. The student shall be required to do training in the institute other than the institute in which he/she is enrolled.

PFE 510 ***Neural Network and its Applications*** **(1+1)**

Theory

Introduction to neural network and its comparison with biological system. Perceptron and linear separable functions, multi-layers perceptrons. Back propagation, one basic learning algorithm for feed-forward neural network, variation and improvement for back-propagation algorithm, Generalisation of learning algorithm. Recurrent Networks: Hopefield networks and Boltzmann Machine. Unsupervised learning and self organized features maps. Application of neural network in function approximation, time series predictions, pattern recognition, control systems and optimization in engineering problems.

Practical

Development of neural network by back-propagation learning algorithm using MATLAB for function approximation, time series predictions, pattern recognition, control systems and optimization in engineering problems.

PFE 511 ***Applied Instrumentaion*** **(2+1)**

Theory

Basic instrumentation systems and transducer principles. Displacement Transducers: Potentiometer, LVDT, Piezoelectric and capacitive transducers. Digital Transducers. Velocity transducers – Analog and Digital. 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 techniques. Temperature measurement using Bi-metals, PTRs, Thermistors, Thermocouples, Electronic IC sensors and Pyrometers. Heat flux measurement. Humidity measurement – Dry and Wet bulb, Hair hygrometer and Humister. Soil and Grain moisture transducers, pressure measurement – Manometers, Bourdon Tube, Diaphragm type transducer. High pressure and vacuum sensing techniques. Flow transducers, Positive displacement, venturimeter, Rotameter, Drag force, Ultrasonic, Electromagnetic, Hot wire anemometers. Time and frequency measurement. Level measurement, OD and pH measurement, PCO2 and grain quality measurement. Biomedical measurement – BP, ECG *etc*., Ultrasonic flaw detection, Spectroscopy.

Practical

Study of the characteristics of various transducers : Potentiometer, LVDT, Proximity sensors and Photo pickups, Load cell, Thermistor and Thermocouple, LM 335/AD 590se of various Analog interfacing blocks: Attenuators, Amplifiers, A/D converters, Filters, digital interfaces using Wave shapers and level shifters. Practice of using interfaces and developing suitable software for data acquisition through PC/Microcomputer: Use of Microcomputer kit, Study of the use of 8255 I/O IC, Study the use of printer port in a PC. Data acquisition through PC/Kit.

PFE 512 ***Mechanism Analysis and Synthesis*** **(3+0)**

Theory

Introduction to kinematics of mechanisms, kinematic analysis and synthesis, mobility and degree of freedom of a

mechanism, systematics of mechanisms deriving other mechanisms from linkages. Relative motion, instantaneous center method, Kennedy's theorem. Graphical and analytical methods of displacement, velocity and acceleration analysis, Computer – Aided analysis of mechanisms. Dimensional synthesis of linkages for path generation, function generation and rigid-body guidance problems. Graphical techniques. Relative pole method and method of inversion *etc*. Analytical kinematics synthesis of linkages, Freudenstein's method, Loop closure equations based on complex variable approach. Kinematics of gears-Analysis of epicyclic gear trains. Synthesis of gear trainscompound and epicyclic. Cam – follower system; standard follower motions and combinations, importance of follower acceleration in cam system dynamics, terms related to cam design-their importance. Cam synthesis – graphical cam profile layout for a desired follower motion. Analytical determination of cam profile co-ordinates for disc cam operating common types of follower.

PFE 513 ***Application of Solar Energy in Agriculture*** **(2+0)**

Theory

Solar radiation:

Introduction- the physics of sun layering of biosphere- solar energy production. Solar spectrum- spectral distribution of solar radiation- terrestrial solar radiation- solar radiation measuring instruments.

Collectors solar: Introduction-types of solar collectors- thermal flat plate collectors- the physics of conversion of solar radiation into heat-operation of flat plate thermal collectors- solar thermal flat plate air heating collectors. Solar energy concentrating collectors. Factors influencing the thermal efficiency of the collector and durability of collectors.

Solar thermal storage: Methods of storage- liquid sensible heat storage material- solid sensible heat storage material- latent heat storage –eutectic mixture of inorganic salts-phase change

materials for high temperature operations non convecting solar pond.

Solar cells: Principles of semi conductors, p-n junction functional properties- solar cell efficiency- factors affecting cell efficiency-some typical solar cells.

Applications of solar energy:

Harnessing of solar energy for domestic, agriculture and industrial applications – water heating – solar drying – solar water pumping – solar furnace – solar refrigeration – conversion of solar energy into electricity.

SOIL AND WATER ENGINEERING

Course No.	Title	Credits
SWE 501	Watershed Hydrology	2+1
SWE 502	Design of Farm Irrigation Systems	2+1
SWE 503	Agricultural Drainage Systems	2+1
SWE 504	Ground Water Engineering	2+1
SWE 505	Soil and Water Conservation Engineering	1+1
SWE 506	GIS and Remote Sensing for Land and Water Resource Management	1+1
SWE 507	Watershed Management and Modelling	1+1
SWE 508	Land Development and Earth Moving Machinery	1+1
SWE 509	Industry / Institure Training	NC
SWE 510	Water Quality and Pollution Control	1+1
SWE 511	Similitude in Engineering	2+1
SWE 512	Control of Pollution from Solid Wastes	2+0
SWE 513	Design of Bins and Soils	2+1
SWE 571	Qualifying Examination	2
SWE 581	Seminar	2
SWE 591	Research	16

SWE 501 ***Watershed Hydrology*** **(2+1)**

Theory

Hydrologic processes and systems; Hydrologic problems of small watersheds; Hydrologic characteristics of watersheds. Measurement and analysis of hydrologic parameters, rainfall-runoff models, stream flow measurement and analysis of data. Hydrograph analysis; Unit hydrograph theory; Synthetic and dimension less hydrograph, convolution of unit hydrograph. Concept of hydraulic flood routing, flood routing (reservoir and

channel routing). Definition and concept of different types of hydrologic models for simulation of hydrologic problems.

Practical

Rainfall analysis, runoff computation, construction of hydrographs, Delineation of watershed, hydrograph analysis, reservoir and channel routing, hydrologic models, visit to dam sites.

SWE 502 ***Design of Farm Irrigation Systems*** **(2+1)**

Theory

Concepts of Irrigation; Irrigation principles, losses, conveyance, distribution; Application, scheduling parameters, water budgeting. Surface irrigation, hydraulics of water advance and recession, hydraulic resistance to flow, gravity irrigation. Design of Border irrigation, furrow irrigation, check basin irrigation; Sub Irrigation methods and concepts. Preliminary design criteria of sprinkler and micro irrigation systems, hydraulics of sprinkler and micro irrigation systems. Design of lateral, submain and main line of sprinkler and micro irrigation. Fertigation aspects. Underground water conveyance system; Evaluation of irrigation systems and practices.

Practical

Design and evaluation of border, furrow, check basin, sprinkler and micro irrigation, computation of frictional losses, Design of underground water conveyance systems, economics of irrigation methods, visit to irrigated farms.

SWE 503 ***Agricultural Drainage Systems*** **(2+1)**

Theory

Theories and applications of surface and sub-surface drainage, steady state, unsteady state drainage equations for layered and non-layered soils, horizontal sub-surface drainage. Principle and applications of Ernst, Glover Dumm, Kraijenhoff-van-deleur equations. Salt balance, leaching requirement and management practices under drained conditions. Design of

different components of sub-surface drainage systems, theories of vertical drainage and multiple well point system. Disposal of drainage effluents, Management of drainage projects of waterlogged and saline soils, case studies.

Practical

Measurement of *in-situ* hydraulic conductivity, estimation of drainage coefficient and leaching requirements, Delineation of waterlogged areas through isobar, isobath and topographic maps. Design of surface and subsurface drainage systems, design of filter and envelop materials.

SWE 504 ***Ground Water Engineering*** **(2+1)**

Theory

Properties affecting groundwater storage and movement, groundwater balance studies. Well hydraulics, two dimensional flow, steady and unsteady state flow in confined, unconfined and semi-confined aquifers, steady flow in sloping aquifers, partial penetrating wells. Analysis of multi-aquifers. Flow analysis in interfering wells. Pumping tests and determination of aquifer parameters. Groundwater modeling for water resources planning. Techniques for groundwater recharge.

Practical

Water table contour maps and determination of groundwater flow, estimation of aquifer characteristics, problems on non leaky and leaky aquifers, analysis of pumping test data; Computation of interference of wells; groundwater computer simulation models.

SWE 505 ***Soil and Water Conservation Engineering*** **(1+1)**

Theory

Probability and continuous frequency distribution; Fitting empirical distributions. Layout and planning of soil and water conservation measures; Design principles of soil and water structures including contour bunds and terraces; Gully control measures. Hydraulic jump and energy dissipaters for soil

conservation structures; Hydrologic, hydraulic and structural design of drop structures. Sediment deposition process. Estimation of sediment load, earthen dams, seepage through dams and stability analysis. Rainwater harvesting, Flood control and stream bank protection measures.

Practical

Design of Drop spillway, chute spillway, drop inlet spillway, hydraulic jump calculation, design of bench terrace, contour bunds and contour trenches, design and problems on earthen dam, silt detention tanks and check dams, visit to soil conservation structures sites.

SWE 506 ***GIS and Remote Sensing for Land and Water Resource Management*** **(1+1)**

Theory

Basic principles of remote sensing and sensors. Elements of photogrametry. Electromagnetic spectrum. Energy interaction with surface features, Aerial photo and satellite imagery. Photo and image interpretation. Principles of Geographical Information System tools, their types and capabilities, Advantages of GIS over conventional methods. Importance of ground truth establishment, GIS and remote sensing for land and water resources data collection, analysis and interpretation, Application of GIS in water and land resource development and management.

Practical

Familiarization with remote sensing and GIS hardware, software and their principle of working, Methods of establishing ground truth, Comparison between ground truth and remotely sensed data, Application of GIS packages.

SWE 507 ***Watershed Management and Modelling*** **(1+1)**

Theory

Problems of desertification and degradation. Models of sediment yield. Survey, monitoring, reclamation and conservation of agricultural and forest lands, hill slopes and

ravines. Concept of operational watershed. National land use policy, legal and social aspects. Watershed management research instrumentation and measurement, problem identification, simulation and synthesis. Modelling of flood and drought phenomenon, drought management and dry farming

Practical

Preparation of watershed development proposal, preparation of watershed evaluation report. Application of Models of flood and drought phenomenon. Application of watershed models.

SWE 508 ***Land Development and Earth Moving Machinery*** **(1+1)**

Theory

Objectives, methods and equipment for land clearing and development. Machinery selection, mechanics of operation and vegetation types. Earth moving machinery and earthmoving mechanics. Grading of sloppy lands. Principles of mechanisms used in crawler mounted tractors.

Earth diggers and ditchers. Bull dozers and scrapers. Elevating and self powered graders. Automation of earth moving and grading machines. Laser guided leveler with global positioning system. Boring machines. Different methods of boring.

SWE 509 ***Industry / Institute Training*** **NC**

Theory

In-plant training in the relevant irrigation, pumps and drainage industry to study the actual working of the equipment and various unit operations. The evaluation will be based on the written report of the student and the comments of the factory managers. The duration of training shall be three weeks. The student shall be required to do training in the institute other than the institute in which he/she is enrolled.

SWE 510 ***Water Quality and Pollution Control*** **(1+1)**

Theory

Impurities in water. Water analysis (Physical, Chemical and Bacteriological). Indices of water quality for domestic and industrial uses. Monitoring of water quality from various sources of water pollution. Purification of water supplies. Waste water characteristics and disposal methods. Waste water treatment. Mathematical modeling on pollution control. Environmental legislation on water pollution in India and abroad.

Practical

Determination of pH, dissolved and suspended solids, Chlorides, Sulphates, turbidity, dissolved oxygen hardness, BOD, COD, Nitrogen (Ammonical, nitrate, nitrite), MPN, Total count of bacteria in water/sewage samples.

SWE 511 ***Similitude in Engineering*** **(2+1)**

Theory

Dimensions and units. Dimensional and similarity analysis. Theory of models. True, distorted and dissimilar models. Application to different systems with special reference to Structural and fluid flow systems, Analogues.

Practical

Equations for the period of simple pendulum. Uniform rectangular cantilever beam. Spring mass level system. Investigation of extrapolation. Deflection of a cantilever beam. Prediction of the deflection of a beam using a model. Analogue model experiments.

SWE 512 ***Control of Pollution from Soild Wastes*** **(2+0)**

Theory

Definition. Sources. Quality, Classification and characteristics of solid waste collection, Transport and reduction at source. Handling, Collection , Storage, transport of Solid wastes. Disposal methods and their merits and demerits.

Processing of solid wastes. Fertilizers, fuel and food values. Recycling and reuse materials and energy recovery operations.

SWE 513 ***Design of Bins and Soils*** **(2+1)**

Theory

Computer aided design manuals. Rankine's and Coloumb's theories of active and passive pressures. Janssen's and Airy's theories grain pressure theories for design of deep and shallow silos. Reimbert's theory of silo design. Comparison of Australian (AS) and Indian (BIS) design criteria for bins and silos. Computer aided design of grain silos by developing flowcharts and programs for underground and over ground silos.

Practical

Analysis and design of silos of various capacities using available software. Use of different standard codes and theories in the development of flowcharts and design program for various capacity soils.

RESTRUCTURING OF PG COURSES ACROSS THE ALLIED DEPARTMENTS

Group – I

PLANT PROTECTION
AGRICULTURAL ENTOMOLOGY, PLANT PATHOLOGY

Course No.	Title	Credits
PET 501	Integrated Pest & Disease Management	2+1
PET 502	Plant Quarantine	2+0
PET 503	Plant Viruses and Insect – Vector Interaction	1+1
PET 504	Insects & Pathogens of Seeds & Stored Grains	1+1
PET 601	Plant Biosecurity and Biosafety	2+0

PET 501 ***Integrated Pest & Disease Management*** **(2+1)**

Theory

Introduction, definition, concept and tools of disease management, components of integrated disease management-their limitations and implications. Development of IDM- basic principles, biological, chemical and cultural disease management. IDM in important crops- rice, wheat, cotton, sugarcane, chickpea, rapeseed, mustard, pearl millet, kharif pulses, vegetable crops and fruit crops.History and origin, definition and evolution of various related terminologies. Concept and philosophy, ecological principles, economic threshold concept and economic consideration. Tools of pest management and their integration-legislative, cultural, physical and mechanical methods; pest survey and surveillance, forecasting, types of surveys including remote sensing methods, factors affecting surveys; political, social and legal implications of IPM; pest risk analysis; pesticide risk analysis; cost-benefit ratios and partial budgeting; case studies of successful IPM programmes.

Practical

Application of biological, cultural, chemical and biocontrol agents, their compatibility and integration in IDM; demonstration of IDM in certain crops as project work. 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. Computation of EIL ETL; crop modeling; designing and implementing IPM system.

PET 502 ***Plant Quarantine*** **(2+0)**

Theory

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. Plant protection organization in India. Acts related to registration of pesticides and transgenics. History of quarantine legislations, PQ Order 2003. Environmental Acts, Industrial registration; APEDA, Import and Export of bio-control agents. Identification of pest/disease free areas; contamination of food with toxigens, microorganisms and their elimination; Symtomatic diagnosis and other techniques to detect pest/pathogen infestations; VHT and other safer techniques of disinfestations/ salvaging of infected material. WHO regulations; non-tariff barriers; Pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; Sanitary and Phytosanitary measures. Inspection procedures for import/export of plant material for research purposes at the point of entry/export stations, detection techniques for various plant pathogens. Treatment procedures and chemicals. Hints for researchers to import/export of plant genetic material.

PET 503 ***Plant Viruses and Insect – Vector Interaction*** **(1+1)**

Theory

Historical 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. Transmission of plant viruses and fungal pathogens. Relationship between viruses and their vectors. Mechanism of virus transmission by major insect vectors *viz*., leafhoppers, aphids, whiteflies, thrips and others . Transmission of mycoplasma and bacteria by leafhoppers and plant hoppers. Transmission of plant viruses by psyllids, beetles and mites. Epidemiology of major insect borne viruses,. Molecular aspects of virus-vector interaction. Management of vectors for controlling virus diseases, geospatial modeling for vector detection and surveillance Novel approaches in insect vector management *viz.* nanoparticles, vector -specific neurotoxins and endosymbionts

Practical

Study 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. Determination of virus vector relationship in any one specific virus-vector.

PET 504 ***Insects & Pathogens of Seeds & Stored Grains*** **(1+1)**

Theory

Introduction, significance of insect pests. Important pests namely insects, mites, rodents, birds and microorganisms associated with stored grain and field conditions including agricultural products. Types of insect pests and types of damage. Role of field and cross infestations. Identification, host range, biology, nature and extent of damage of stored rain pests. 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. Association of stored grain insects with fungi. Type of losses in stored seeds and is their effect on quality including biochemical changes. Stored grain deterioration process, physical and biochemical changes and consequences. Grain storage structures traditional, improved and modern storage structures. Ideal seeds and commodities storage conditions. 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 Stored Grain Insects: Preventive measures- Hygiene/sanitation, disinfestations of stores/ receptacles. Curative measures –Non- chemical control measures. Chemical control- prophylactic and curative. Historical development in seed pathology, terminologies. Disease and injury of seeds / grains. Role of microorganism in seed quality deterioration. Storage fungi and their losses. Seed structure and development in relation to seed infection and transmission in relation to host pathogen interaction. Seed transmission, establishment of infection and course of disease development. Mechanism of seed transmission. Importance of mycotoxins and mycotoxicoses. Principles of control seed borne diseases and management of seed borne pathogens. Phytosanitory requirements in seed trade, international regulations in respect to seed health standards

PET 601 ***Plant Biosecurity and Biosafety*** **(2+0)**

Theory

History of Biosecurity, Concept of Biosecurity, Components of biosecurity, Quarantine , Invasive Alien species, Bio warfare, Emerging / resurgence of pests and diseases. National Regulatory Mechanism and International Agreements/ Conventions viz., Agreement on Application of Sanitary and Phyto sanitary (SPS) Measures/ World Trade Organization(WTO) Convention on Biological Diversity (CBD), International Standards for Phyto sanitary measures , Pest Risk Analysis (PRA), risk assessment models, pest information system, early warning and forecasting system, use of 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 agro terrorism event, mitigating planning, integrated approach for biosecurity. Biosafety, policies and regulatory mechanism. Cartagena Protocol on Biosafety and its implications. Issue related to release of genetically modified crops / varieties

Practical

Collections, identification and familiarization with the stored grains/seed insects pests and nature of damage caused by them; detection of insects infestations in stored food grains; 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 material and their effect on seed quality. Field visits to central warehouse and FCI warehouse. Detection and identification of seed-borne pathogens by different techniques. Seed to plant transmission of seed borne pathogens. Location of the pathogen in infected seeds. Embryo extraction technique for the identification of internally seed borne pathogens. Estimation of spore loading by washing test. Seed treatment techniques for the control of seed borne pathogens. Visit to warehouses and seed pathology lab.

* **The above courses shall be offered by one of the Department under the direction of Dean (PGS), UAS, GKVK, Bengaluru.**

Group – II

GIS AND REMOTE SENSING
SOIL SCIENCE & AGRICULTURAL CHEMISTRY, SOIL & WATER ENGINEERING, AGRICULTURAL STATISTICS, FORESTRY & ENVIRONMENT SCIENCE

Course No.	Title	Credits
SAC 603 / SWE 506 / CSC 508 / EVS 505	Remote Sensing and GIS Techniques for Natural Resource Management	2+1

Theory

Introduction and history of remote sensing. Basic principles of remote sensing, Electromagnetic Spectrum, physics of remote sensing, atmospheric interactions with electromagnetic radiation, Energy interactions with earth's surface materials. Remote sensing platforms and sensors; optical, thermal and microwave. Fundamentals of aerial photographs. Spectral signatures of earth surface features, spectral characteristics of vegetation, soil and water. Aerial photo and Satellite image processing. Different types of data products and their characteristics. Satellite data acquisitions, storage and retrieval. Visual and digital image interpretation. GPS – Introduction, basic principles and its utility. Geographic information system (GIS) – Introduction, development, basic elements, components and benefits. Raster and vector data analysis. Spatial and non spatial data. Digital Elevation Models. Spatial interpolation techniques. Classical and Geostatistical techniques of evaluation of variability. GIS classification methods – multivariate analysis and classification. Application of remote sensing, GPS and GIS techniques – land use, soil survey, soil moisture studies, crop stress and yield forecasting, prioritization, management and monitoring of watershed, drought and flood assessment and management, wasteland identification and management.

Practical

Familiarization with different remote sensing equipments, GIS software's and data products, Study of maps and survey of India toposheets, projections and geo-referencing of map, Importing of Satellite data and preparation of False Colour Composite, Geo Referencing of Satellite images, Preparation of mosaic and subsetting of image, Visual Interpretation of satellite image, Map layout; scale bar, legend, north arrow, Generation of base map using SOI toposheet, Creation of vector features through digitization, Creation of data files in a database programme, Creation of attribute database and linking with spatial data, Use of GPS for collection of co-ordinates, Spatial interpolation using GIS, Methods of improving quality of digital data, Techniques of image classification – Supervised classification and un-supervised classification, Generation of DEM using contour information, image draping to view 3D, 3D spatial analysis for natural resource management

* **The above courses shall be offered by one of the Department under the direction of Dean (PGS), UAS, GKVK, Bengaluru.**

Group – III

PLANT BIOCHEMISTRY
PLANT BIOTECHNOLOGY, CROP PHYSIOLOGY AND SEED SCIENCE & TECHNOLOGY

Course No.	Title	Credits
PBT 512 / BCM 506	Immunology, Immunochemistry and Molecular Diagnostics	2+1
PBT 504 / CPH 508	Morphogenesis, Plant Tissue Culture and Genetic Transformation	2+1
PBT 503 / GPB 508	Molecular Cell Biology and Molecular Genetics	2+0

PBT 512 / BCM 506 ***Immunology, Immunochemistry and Molecular Diagnostics*** **(2+1)**

Theory

History and scope of immunology; Mechanisms of immunity-innate resistance and specific immunity; Components of immune system - organs, tissues and cells;Antigens;Haptens; Adjuvants; Immunoglobulins - chemistry, structure and function; Molecular organization of immunoglobulins and classes of antibodies; Antibody diversity and theories of generation of antibody diversity; Polyclonal antibodies, monoclonal antibodies, hybridoma, recombinant antibodies, vaccines; Complement system- classical and alternate; Major histocompatility complex; Cytokines, Allergiesand hypersensitive response; Immunoregulation; Immunological tolerance; Immunodeficiency; Antigen -antibody interactions; Immunological techniques- precipitation, agglutination, direct and indirect haemagglutination, complement fixation,immunodiffusion, immunoelectrophoresis; fluorescent antibody technique, enzyme linked immunosobent assay, immunological application in plant science - applications of ELISA in plant virus detection , uses of monoclonal antibodies;

Molecular diagnostics - Introduction to the basic principles of molecular technology and techniques used in pathogen detection; PCR based and hybridization based methods of detection, microarrays based detection, transgene detection in plants and processed food.

Practical

Production of polyclonal antibodies; Preparation of antigens and antisera;Quantitation of immunoglobulins by zinc sulphate method; Antigen- antibody interaction - Preparation of buffers and reagents, , Enzyme immunoassays - ELISA- plate and dot immunobinding assays - direct, indirect, sandwich– standardization and detection, Extraction and identification of DNA/RNA of pathogenic organisms, purification of immunogenic protein, western blotting, Immunoblotting

PBT 504 / CPH 508 ***Morphogenesis, Plant Tissue Culture and Genetic Transformation*** **(2+1)**

Theory

The cellular basis of growth and morphogenesis cytodifferentiation. The cell cycle- cell division and cell organization, cell structure, tissue and organ differentiation. Control of cell division and differentiation in selected in cell types, Introductory history, morphogenesis and cellular totipotencyHistory of plant tissue culture; culture media; Various types of cultures; callus, suspention, nurse,root, meristem, *etc*.; Invitro differentiation: Organogenesis and Somatic embryogenesis; Molecular basis of plant organ differentiation plant growth regulators; mode of action, effects on in vitro culture and regeneration;. Micropropagation; Anther and microspore culture; Somaclonal variation; in vitro mutagenesis; in vitro fertilization; in vitro germplasm conservation; Production of secondary metabolites; Synthetic seeds. Embryo rescuc and wide hybridization; Protoplast culture and regeneration. Somatic hybridization: protoplast fusion, cybrids, asymmetric hybrids *etc*. methods of plant transformation; Vectors of plant transformation; Genetic and molecular analysis of trasgenics; torget traits and transgenic crop.

Practical

Tissue culture laboratory lay out plan, facilities required, glassware, stock preparation, media preparation, aseptic manipulation in tissue culture lab, explants preparation for aseptic inoculation. In invitroculture of different explants such as leaf, stem, shoot apex, cotyledonary nodes. Callus induction and Organogenesis using model plants like tobacco, carrot *etc*., Hardening of in vitro produced plants; Cell suspension culture and production of secondary metabolites; Anther culture;

PBT 503 / GPB 508 — ***Molecular Cell Biology and Molecular Genetics*** — **(2+0)**

Theory

General Structure and constituents of Cell; Similarities and distinction between plant and animal cells; Cell wall, cell membrane; structure and composition of biomembranes, cell surface related functions. Structure and functions of major organelles: Nucleus, Chloroplast, Mitochondria, Ribosomes, Lysosomes, Peroxisomes, Endoplasmic reticulum, Microbodies, Golgi apparatus, Vacuoles *etc*. Organellar genomes and their manipulation; Ribosomes in relation to cell growth and division; Cytoskeletal elements. Cell division and regulation of cell cycle; Membrane transport: transport of water, ion and biomolecules; Signal transport mechanism; Protein targeting. Interphase nucleus- structure and chemical composition; Cell division and physiology of cell division. Historical background of molecular genetics; Genetic material in organisms; Structure and properties of nucleic acid, DNA transcription and its regulation-transcription factors and their role; Genetic code, regulation of protein synthesis in prokaryotes and eukaryotes – ribosomes, t-RNAs and translational factors. Transposable elements; Mechanisms of recombination in prokaryote; DNA organization in eukaryotic chromosomes – DNA content variation, types of DNA sequences – Unique and repetitive sequences; Organelle genomes; Gene amplification and its significance; Proteomics and Protein – Protein interaction; Signal transduction; Genes in development; Cancer and Cell aging. Morphological and gram staining of natural bacteria; Cultivation of bacteria in synthetic

medium; Determination of growth rate and doubling time of bacterial cells in culture; Demonstration of bacteriophage by plaque assay method; Determination of soluble protein content in bacterial culture. Isolation, purification and raising clonal population of a bacterium; Biological assay of bacteriophage and determination of phage population in lysate; Study of lytic cycle of bacteriophage by one step growth experiment; Determination of latent period and burst size of phages per cell; Quantitative estimation of DNA, RNA and protein in an organism; Numericals : problems and assignments.

* **The above courses shall be offered by one of the Department under the direction of Dean (PGS), UAS, GKVK, Bengaluru.**

Group – IV

SOCIAL SCIENCE
AGRICULTURAL ECONOMICS, AGRICULTURAL EXTENSION

Course No.	Title	Credits
AEX 504 / AEC 506	Research Methodology for Social Sciences	2+1

Theory

Introduction to Research: Research – Meaning, importance and characteristics. Meaning, concept, scope and problems in social research. Types of research – fundamental, applied and action research, exploratory, descriptive, diagnostic, evaluation, experimental, analytical, historical, survey and caste studies. Scientific method – Concepts and characteristics. Theories and process of scientific research and ethics in research.

Basics of Empirical Research: Review of literature – need, searching, sources and planning of review work. Selection of research problem – criteria for selection, statement of problem and theoretical orientation. Objectives – meaning types and criteria for judging objectives. Hypothesis – Meaning importance, functions, characteristics, types and testing of hypotheses. Variables – meaning, types and role in research. Concept and constructs – meaning role and formulation of conceptual frame work. Measurement – meaning, postulates, levels of measurement and appropriate statistics and criteria for measurement. Reliability and validity – meaning and methods of testing them. Sampling – Meaning, theories, methods / procedures, advantages, limitations, size and factors affecting sampling size and sampling errors.

Research Designs: Research designs – meaning, purpose, criteria, types, advantages and limitations of each design. Research Designs as Variance control – Maximization of

Experimental Variance, Control of Extraneous Variance and Minimization of Error Variance (MAXMINCON Principle) Ex-post Facto Research, Experimental Research, Interpretive Research, Survey research and case studies – meaning, methods, and steps in conducting, coding, editing and tabulation. Case Studies - meaning, types, steps in conducting, advantages and limitations.

Data Collection: Data collection devices / techniques – Interview Schedule, questionnaires, Forms, schedules – differences, types – structured/unstructured, open ended / closed.Steps in scale construction and testing, advantages and limitations. Rating scales – meaning, types, limits in construction, advantages and limitations.Analytical and operational framework for solving problems of location, transportation – media selection, distribution of salesman. Consumer behavior modes – regression analysis. Market segmentation techniques.

Data Analysis and Report Writing: Processing and analysis of data – Qualitative and quantitative analysis – descriptive and inferential statistics, choosing appropriate statistics and statistical packages. Discriminate analysis, factor analysis, cluster analysis, Bayesian classificatory procedures. Interpretation of results. Report writing – meaning, guidelines in scientific writing of reports, thesis, bibliography and research articles.

Practicals

Selection and formulation of research problem – Formulation of objectives and hypothesis

Selection of variables based on objectives – Developing the conceptual frame work of research.

Operationally defining the selected variables.

Development of data collection devices.

Testing the validity and reliability of the data collection instruments (Pre-testing).

Data processing.

Hands on experience on SPSS and other statistical packages.

Coding, tabulation and analysis.

Formulation of secondary tables based on objectives of research articles.

Writing report.

Writing of thesis and research articles.

Presentation of reports.

Field Visits

- For identification, analysis and formation of researchable problems.
- Pre – testing of data collection instruments.

References

Goode W.J. and Paul, K. Hatt, 1952, **Methods in social research**, McGraw-Hill Book Company. Inc. Tokyo.

Kerlinger F.N., 2014, **Foundations of Behavioral Research**, Holt, Rinehart and Winston, Inc. USA.

*** The above courses shall be offered by one of the Department under the direction of Dean (PGS), UAS, GKVK, Bengaluru.**

COMPULSORY NON-CREDIT COURSES

(Compulsory for Master's programme in all disciplines; Optional for Ph.D. scholars)

Course No.	Title	Credits
PGS 501	Library and Information Science	0+1
PGS 502	Technical Writing and Communication Skills	0+1
PGS 503 (e-Course)	Intellectual Property and its Management in Agriculture	1+0
PGS 504	Basic Concepts in Laboratory Techniques	0+1
PGS 505 (e-Course)	Agricultural Research, Research Ethics and Rural Development Programmes	1+0
PGS 506 (e-Course)	Disaster Management	1+0

PGS 501 ***Library and Information Services*** **(0+1)**

Theory

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; eresources access methods.

PGS 502 ***Technical Writing and Communications Skills*** **(0+1)**

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.

PGS 503 (e-Course) ***Intellectual Property and its Management in Agriculture*** **(1+0)**

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.

PGS 504 ***Basic Concepts in Laboratory Techniques*** **(0+1)**

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; Neutralisation 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, sandbath, waterbath, oilbath; 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

PGS 505 (e-Course) ***Agricultural Research, Research Ethics and Rural Development Programmes*** **(1+0)**

Theory

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. Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics. 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.

PGS 506 ***Disaster Management*** **(1+0)**
(e-Course)

Theory

Natural Disasters-Meaning and nature of natural disasters, their types and effects. Floods, Drought, Cyclone, Earthquakes, Landslides, Avalanches, Volcanic eruptions, Heat and cold Waves, Climatic Change: Global warming, Sea Level rise, Ozone Depletion Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire. Oil fire, air pollution, water pollution, deforestation, Industrial wastewater pollution, road accidents, rail accidents, air accidents, sea accidents. Disaster Management - Efforts to mitigate natural disasters at national and global levels. International Strategy for Disaster reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, Community-based organizations, and media. Central, State, District and local Administration; Armed forces in Disaster response; Disaster response: Police and other organizations.