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**Review Paper**

# Cyanobacteria and Its Application

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ABSTRACT

Cyanobacteria are characterized by rapid photoautotrophic growth and high speed of biomass accumulation. Cyanobacteria are widely distributed Gram-negative bacteria with a long evolutionary history and the only prokaryotes that perform plant-like oxygenic photosynthesis. Cyanobacteria possess several advantages as host for biotechnological applications, The use of photosynthetic cyanobacteria to directly convert carbon dioxide to biofuels are now considered as important renewable energy alternatives for petroleum-based fuels, like biofuels, biogas, bioethanol or biodiesel. Equipped with the ability to degrade environmental pollutants and remove heavy metals, cyanobacteria are promising tools for bioremediation and waste water treatment. In field of agriculture, cyanobacteria is used as nitrogen fixing bio fertilizer, bioremediation $CO_2$ sequestration and biofuel production. In this review, the potential of cyanobacteria as sources of energy, bioactive compounds, high-value chemicals and tools for aquatic bioremediation and recent progress in applications are discussed.

ALGAE are the important food links in the aquatic ecosystems. Being autotrophic and members of the first tropical level, their major role in water is to capture solar energy to drive the ecosystem. The magnitude of primary production is the leading factor in deciding the tropic structure of water bodies. Several species of algae have been found in tropical condition such as those in India. It provides favourable environment for luxuriant growth of these organisms in natural ecosystem such as different water bodies.

Cyanobacteria are common in eutrophic nature. Being favoured by stable and nutrient enriched water, they may constitute an important part of phytoplanton communities. The Indian subcontinent studies are limited to phytoplankton of large rivers and streams even though their spatial and temporal variations have been studied (Nantiyal *et al*., 1997).

The names cyanobacteria and blue-green algae (Cyanophyceae) are valid and compatible systematic terms. This group of micro-organisms comprises unicellular to multicellular prokaryotes that possess chlorophyll *a* and perform oxygenic photosynthesis associated with photosystems I and II (Castenholz and Waterbury, 1989).

Human society has an insatiable appetite for fuels and today's supply of liquid fuels worldwide is almost completely dependent on petroleum. Bioenergy production has recently become a topic of intense interest due to increased concern regarding limited petroleum-based fuel supplies and the contribution of the use of these fuels to atmospheric $CO_2$ levels. Finding sufficient supplies of clean energy for the future is society's one of the most daunting challenges and is intimately linked with global stability, economic prosperity and quality of life. This leads to interesting questions and debate over the choice of new fuels, produced from new raw materials, to complement or replace present petroleum-based fuels (Posten and Schaub, 2009).

## Taxonomy of Cyanobacteria

The cyanobacteria are amongst the most taxonomically challenging, yet species rich, lineages of microbes (Perkerson *et al.*, 2011). Originally classified based solely on morphology, wholesale revisions of the cyanobacteria were proposed by the International Code of Botanical Nomenclature, which relied on a series of papers published from 1886 to 1892 as a starting point for taxonomy.

In 1978, the Subcommittee on the Taxonomy of Phototrophic Bacteria of the International Committee on Systematic Bacteriology (ICSB) unanimously submitted to the ICSB a proposal according to which the nomenclature of cyanobacteria (blue-green algae) should be governed by the provisions of the International Code for Nomenclature of Bacteria (Bacteriological Code, ICNB) as of 1979. That date

was proposed as the deadline for the publication of a list of approved names for these prokaryotes (Stanier *et al*., 1978).

Two major attempts have been made to change the overall cyanobacterial classification system. One challenge in untangling the systematics of the cyanobacteria is the extensive phenotypic plasticity evidenced in some lineages. For eg., heterocystous species only produce heterocysts in nitrogen limited conditions, while, other morphological features may be altered in phosphorous limited conditions. Therefore, a cultured species may have a different phenotype from a field specimen, due to the environmental conditions in which it was cultured (Casamatta *et al.,* 2003). Hypothesizing that the vast biodiversity of the cyanobacteria was really only the result of a few taxa that exhibit a tremendous amount of phenotypic plasticity, Drouet and Daily (1956) used only a few simple morphological characteristics for taxonomy, resulting in the total number of proposed species of the day being reduced from over 2000 to only 62 and they proposed a greatly simplified taxonomic treatment of the group, largely based on an exhaustive comparison of published descriptions and herbarium specimens ; they recognized only six genera and 18 species.

Komarek and Anagnostidis (2005) proposed the other major revision to the classification system, suggesting many name changes, especially in the *Oscillatoriales*. They advocated a system of smaller, monophyletic genera identifiable using morphological, genetic or ecological apomorphies (Johansen & Casamatta, 2005). It is their revision which forms the basis of modern cyanobacterial systematics.

Komarek and Komarkova (2006) stated the application of modern ecological, ultra-structural and molecular methods, aided by the cultivation of numerous cyanobacterial morphotypes, has substantially changed our knowledge of these organisms. It has led to major advances in cyanobacterial taxonomy and criteria for their phylogenetic classification. Molecular data provide basic criteria for cyanobacterial taxonomy, however, a correct phylogenetic system can not be constructed without combining genetic data with knowledge from the previous 150 years research of cyanobacterial diversity. Thus, studies of morphological variation in nature and modern morphological, ultrastructural, ecophysiological and biochemical characters need to be combined in a polyphasic approach.

Taxonomic concepts for generic and infra generic ranks are re-evaluated in light of combined phenotypic and molecular criteria. Despite their usefulness in experimental studies, the limitations of using strains from culture collections for systematic and nomenclatural purposes are highlighted. The need for a continual revision of strain identification and proper nomenclatural practice associated with either the bacteriological or botanical codes is emphasized. Recent advances in taxonomy are highlighted in the context of prospects for understanding cyanobacterial diversity from natural habitats and the evolutionary and adaptational processes that cyanobacteria undergo.

Abed *et al.* (2002) described a new genus of moderately halophilic, halotolerant and thermophilic cyanobacteria with very thin trichomes. The four strains included in the genus were isolated from benthic microbial mats in a man-made hypersaline pond. Trichomes were around 1μm thick, with small constrictions at the crosswalls and diffluent colourless sheaths. Thylakoids were parallel to the cell wall, but thylakoids and nucleoid were often ex-centrically arranged within the cytoplasm with respect to the main trichome axis.

Information on cyanobacterial taxa present in rice fields and other agro-ecosystems in Europe is still scarce and differs significantly from that obtained in Asiatic countries, especially concerning different climatic conditions and pesticide application methodologies (Ariosa *et al*., 2006; Zancan *et al*., 2006). On the other hand, the diversity, ecology and genetic heterogeneity among planktonic Anabaena like and Aphanizomenon-like morphospecies require a deeper characterization, since there is neither a clear phylogenetic nor a morphological separation (Hindak, 2000; Rajaniemi *et al*., 2005; Stuken *et al*., 2009).

**Growth media and condition of Cyanobacteria**

Most cyanobacteria grow well in the laboratory both in liquid culture and on agar-solidified media. Because some strains do not produce colonies from

single cells with high efficiency on agar-solidified media, various modifications of procedures for the preparation of solid media have been developed in different laboratories (Allen, 1968).

The microalgal growth in pure culture is mainly determined by biotic and abiotic factors. Abiotic factors are like light, temperature, the concentration of nutrients, oxygen and $CO_2$, pH and mineral composition of the medium *etc.* while biotic factors influences algal growth in culture media like viruses,fungi and bacteria (Mata *et al*., 2010).

Chen and Zhang (1997) mentioned that mixotrophic culture is a potential mode for mass production of cyanobacteria by using heterotrophic capability of them. This type of culture medium can achieve high cell densities and synthesize light-induced products such as photosynthetic pigments and was especially suitable for the production of high value bioactive compounds (Ducat *et al*., 2011).

Abreu *et al*. (2012) also observed higher specific growth rates, final biomass concentrations and productivities of lipids, starch and proteins by *Chlorella vulgaris* under mixotrophic conditions using cheese whey powder as a carbon source when compared with photoautotrophic conditions.

To develop an effective process, a significant step is to search, sort and identify hyper-lipid-producing strains of cyanobacteria. Successful isolation can lead to the selection of appropriate cyanobacterial strains with relevant properties for specific culture conditions and products. Culture condition optimization of the selected strains is of fundamental importance to the success of the process. Patel *et al*. (2014) obtained 130.76 per cent more lipid production compared with the control by *Synechocystis* sp. PCC 6803 using optimized culture conditions.

**Isolation of cyanobacteria**

The extension of the techniques of microbiology to the study of blue-green algae has been slow and relatively few representatives of the group have so far been obtained in pure culture (Koch, 1964). The isolation of these organisms from natural sources would be facilitated if cultures could be enriched in them by methods which effectively counter-selected eucaryotic algae. One such method was discovered by Beijerinck (1902), who showed that blue-green algae of the Nostoc type can be selected by using a mineral medium devoid of a combined-nitrogen source.

Subsequent studies (Allen, 1952; Fogg, 1956) suggest that the ability to fix nitrogen is largely restricted to blue-green algae belonging to the Nostocaceae and is by no means universal in the members of this class. Consequently, Beijerinck's enrichment method, although completely effective in eliminating competition from eukaryotic algae, yields an extremely restricted fraction of the total blue-green algal microflora. Apart from the nitrogen-fixers, the blue-green algae seem to have nutritional requirements very similar to those of other algae, so that the possibility of devising other enrichment methods based on the principle of nutritional selection does not appear to be promising.

Wilson *et al.*(1993) described five marine cyanophages propagated on *Synechococcus* sp. strain VWH7803 were isolated from three different oceanographic provinces during the months of August and September 1992. The five cyanophage isolates were found to belong to two families, Myoviridae and Styloviridae, on the basis of their morphology observed in the transmission electron microscope. DNA purified from each of the cyanophage isolates was restricted with a selection of restriction endonucleases and three distinguishably different patterns were observed. DNA isolated from the Myoviridae isolate from Woods Hole had a unique restriction pattern. Southern blotting analysis revealed that there was a limited degree of homology among all cyanophage DNAs probed, but clear differences were observed between cyanophage DNA from the Myoviridae and that from the Styloviridae isolates. Polypeptide analysis revealed a clear difference between Myoviridae and Styloviridae polypeptide profiles, although the major, presumably structural, protein in each case was 53 to 54 kDa.

Traditional isolation techniques include the use of a micropipette for isolation under a microscope or cell dilution followed by cultivation in liquid media or agar plates (Duong *et al*., 2012).

Cyanobacteria are a highly diverse group in relation to form, function and habitat (Neilan *et al.,* 1995). Current cyanobacterial systematics relies on the observation of morphological characters. They designed general primers to the phycocyanin operon (*cpc* gene) and developed a PCR which allows the amplification of a region of this gene, including a variable intergenic spacer sequence. Because of the specificity of this PCR for cyanobacterial isolates, the assay is appropriate for the rapid and reliable identification of strains in fresh water samples. Successive restriction endonuclease digestion of this amplification product, with a total of nine enzymes, yielded many identifying DNA profiles specific to the various taxonomic levels of cyanobacteria. The restriction enzyme profiles for *Msp*I, *Rsa*I, and *Taq*I were conserved for strains within each of the eight genera (40 strains) studied and clearly discriminated among these genera. Intrageneric delineation of strains was revealed by the enzymes *Alu*I, *Cfo*I, and *Hae*III for members of the genus *Microcystis*, while strains of genus *Anabaena* were differentiated by the digestion patterns provided by *Alu*I, *Cfo*I, and *Scr*FI. Phenetic and cladistic analyses of the data were used to infer the genetic relatedness and evolution of toxic and bloom-forming cyanobacteria.

Despite the existence of morphologically diverse cyanobacteria in a wide variety of terrestrial and aquatic habitats, work with these bacteria has been restricted to a relatively few representatives. Castenholz (1988) suggested that the techniques normally used to isolate cyanobacteria may severely limit the number of cyanobacterial species which can be readily cultured.

Agar, which is routinely used as a solidifying agent in bacteriological media, is known to contain impurities Krieg and Gerhardt (1981), and some of these are suspected to be responsible for the repeated observation that agar is inhibitory to the growth of some cyanobacteria (Allen and Gorham, 1981). Different approaches have been used in an attempt to lower or eliminate the growth-inhibitory effects of agar. These have included the use of low agar concentrations (Allen and Gorham, 1968 and Shirai *et al.*, 1989), agar-washing procedures (Allen *et al.* (1981), Krieg and Gerhardt (1981), the separate sterilization of agar and nutrient solutions (Allen, 1968) and the substitution of agarose or other alternative solidifying agents (Shirai *et al.*, 1989 and Thiel *et al.*, 1989).

Algae are photosynthetic thallophytesor lower plants which grow in water or on soil saturated with water. Blue green algae are distributed worldwide to enhance the fertility of many agricultural ecosystems. Blue green algae are a group of microalgae that can fix the atmospheric nitrogen. Isolation of these cyanobacteria from natural sources in pure form is essential step for their efficient use as biofertilizer (Mulani and Pawar, 2015). The isolation of pure cultures were done by selecting a single colony from mix cultures grown on selected media like BG-11, bold basal media, ASN III media as different BGA strains can grow on different media. The same media in solid form is used for further purification and sub-culturing

## Identification of Cyanobacteria Species

### Based on Morphology

Cyanobacteria exhibit the most diverse and complex morphology among all prokaryotic groups, perhaps indicating that they would have been the dominant life forms at some period of the early earth. External gross appearance under aquatic and moist conditions is often gelatinous, slimy and occasionally filamentous clusters, with colours ranging from dark green, blue-green, yellow, brown to black, and rarely red (Kulasooriya, 2011).

Cyanobacteria can be classified on the basis of morphology, cellular differentiation, Biochemical, Physiological and Genetic criteria. The taxonomy of cyanobacteria until now has been based mainly on their morphology and according to it they are classified into five orders: Chroococcales (I), Pleurocapsales (II), Oscillatoriales (III), Nostocales (IV) and Stigonematales (V). However, the morphology and other phenotypic characteristics of cyanobacteria can be dramatically influenced by environmental factors and stage of development (Suda *et al*., 2002 and Rajaniemi *et al*., 2005). Thus, classifications based on phenotypic characteristics do not represent natural grouping based on genetic data analysed.

According to Castenholz (1989) and Komarek and Anagnostidis (1989), the order Nostocales includes

filamentous cyanobacteria that are capable of cell differentiation in heterocysts, akinetes or reproductive trichomes (hormogonia). The genera *Anabaena, Aphanizomenon* and *Nostoc* belong to the family Nostocaceae by traditional classification (Komarek and Anagnostidis, 1989; Komarek, 2010) and subsection IV according to bacteriological classification (Rippka *et al*., 1979; Castenholz and Waterbury, 1989). This family is characterized morphologically by (i) isopolar filaments, (ii) absence of any branching (with the exception of certain anomalies), (iii) presence of heterocysts (with the exception of secondary derived genotypes) and (iv) facultative presence of typical paraheterocytic or apoheterocytic akinetes (Komarek, 2010).

*Anabaena,* an environmentally important cyanobacterium has been identified mainly on the basis of morphological characteristics, such as shape and size of trichomes, cell types, size and location of heterocysts and akinetes and plane(s) of division (Rippka *et al*., 1979).

According to the accepted morphological and ecological descriptions by Desikachary (1959), the genus *Anabaena* is identified based on the Presence of uniform trichomes, absence of sheath or presence of more or less diffluent sheath forming free or floccose or soft mucilaginous thallus. Heterocyst's, generally intercalary and presence of a single or series of spores near the heterocyst or between the heterocyst's.

## Biodiversity

Cyanobacteria are genetically highly diverse, they occupy a broad range of habitats across all latitudes perhaps demonstrating the abilities of their pioneering ancestors as the earliest inhabitants of Earth. They are not only widespread in freshwater, marine and terrestrial ecosystems but also found in extreme habitats such as hot springs, hypersaline localities, freezing environments and arid deserts (Fogg *et al.*, 1973).

The majority of cyanobacteria are aerobic photoautotrophs. Their life processes require only water, carbon dioxide, inorganic substances and light. Photosynthesis is their principal mode of energy metabolism. In the natural environment, however, it is known that some species are able to survive long periods in complete darkness. Furthermore, certain cyanobacteria show a distinct ability for heterotrophic nutrition (Fay, 1965).

Cyanobacteria are often the first plants to colonise bare areas of rock and soil. Adaptations, such as ultraviolet absorbing sheath pigments, increase their fitness in the relatively exposed land environment. Many species are capable of living in the soil and other terrestrial habitats, where they are important in the functional processes of ecosystems and the cycling of nutrient elements (Whitton, 1992).

Diverse species having different ecological demands exhibit differential adaptations to the conditions at their source locality. The massive communities of *Prochlorococcus* in the oligotrophic deep oceans that live in close association with cyanophages enabling rapid lateral transfer of genomic material opens up new vistas on biological adaptation and evolution (Johnson *et al.,* 2006). The endolithic *Chroococcidiopsis* living as the only inhabitant in the extremely inhospitable habitat of the arid atacama desert provides a new tool for Astrobiology (Friedmann and Imre, 1982 and Wierzchos *et al*., 2006).

Microalgal biodiversity in of blue green algae or cyanobacteria in fresh and marine habitat has been investigated in India and abroad by many workers. The pioneer workers are Allen and Stanier (1967) who have cultured different aquatic blue green microalgae in laboratory.

Based on fossil records, Cyanobacteria have occurred as long ago as 2,600 to 3,500 million years (Myr), (Brocks *et al*., 1999). These earliest cyanobacteria are believed to have been played an important role in producing an oxygen-rich atmosphere on earth about 2,300 Myr ago (Blankenship, 1992). These organisms are identified according to their morphological characters such as morphology of vegetative cells, akinetes and heterocytes (Rajaniemi *et al*., 1992, Rippka *et al*., 1979).

### Molecular characterization

In recent years, the use of molecular markers for identification of cyanobacteria in diverse niches has gained considerable significance. Molecular

datasets can effectively complement morphological characterization. Molecular markers such as restriction fragment length polymorphism (RFLP) and 16S rRNA, have been employed in phylogenetic analysis and characterization of cyanobacterial diversity (Giovannoni *et al*., 1990).

Due to existence of changeable morphology in these organisms, other techniques such as molecular techniques are used to improve cyanobacterial taxonomy. Several properties of the 16S rRNA gene, such as evolutionary properties and ubiquity have allowed it to become the most commonly used molecular marker to distinguish and establish relationships between cyanobacterial genera and species (Case *et al*., 2007).

The presence of highly conserved repetitive sequences in the genomes of microorganisms makes them highly useful for strain differentiation and diversity analysis. Repeat elements, such as short tandemly repeated repetitive (STRR), long tandemly repeated repetitive (LTRR) sequences (Mazel *et al*., 1990) or palindromic sequences such as highly iterated palindrome (Hip1) have been found in a number of cyanobacteria, especially heterocystous genera. PCR fingerprinting techniques based on such sequences have proved valuable in the identification and analysis of symbiotic cyanobacteria (Rasmussen and Svenning,1998). Molecular techniques have also been utilized to ascertain the genetic relationship of the genus Anabaena with genera such as Aphanizomenon and Nostoc (Gugger *et al*., 2002).

Sequencing of 16S rRNA while confirming the existence of several morphologically uniform and well-defined traditional genera has also placed similar morphotypes in distant positions in phylogenetic trees. Molecular data provide basic criteria for cyanobacterial taxonomy, but to construct a comprehensive phylogenetic system of cyanobacteria a combination with knowledge on their morphology, physiology and biochemistry is essential (Komarek and Komarkova, 2006).

The shared simple morphological characters as well as limitations of cultivation have made microscopic studies usefulness. One way to better characterize these morphologically similar species is to use molecular diversity information. It should also be noted that in studies where near-complete 16S rRNA gene sequences have been used, conflicts between morphological and molecular identification of some cyanobacterial sequences have been found (Hongmei *et al*., 2005).

Molecular techniques based on PCR amplification targeting conserved regions inside the 16S rRNA gene have allowed determination of phylogenetic affiliations among cyanobacteria and development of modern cyanobacterial taxonomy (Komarek and Komarkova, 2006).

Lachance (1981) investigated the genetic relatedness of 45 strains of heterocyst forming cyanobacteria assigned to eight genera by Rippka *et al.* (1979) and 19 undescribed strains of the same group by *in vitro* reassociation of radioiodinated deoxyribonucleic acids. The members of the genera *Nodularia, Cylindrospermum, Chlorogloeopsis* and *Fischerella* formed discrete clusters and showed intergeneric relatedness of less than 40 per cent, results consistent with the classification proposed by Rippka *et al.* (1979). The genus *Nostoc* was heterogeneous; four strains previously assigned to *Anabaena* appeared to belong to *Nostoc.* The genus *Calothrix* comprised four clusters with various degrees of internal homogeneity and two strains which showed low relatedness to any others. The general relatedness (*i.e.*, relative binding) of heterocyst formers to various non-heterocystous cyanobacteria was on the order of 10 to 20 per cent.

The rapid and sensitive methods for the detection and genetic characterization of cyanobacteria have been developed based on DNA amplification techniques. Work describes the molecular methods that have been used to characterize cyanobacteria and their use as tools to identify toxin-producing strains. Different species and strains were compared using restriction fragment length polymorphism (RFLP) of amplified fragments of the phycocyanin gene and the 16S-23S rRNA internal transcribed spacer.

Kondo *et al.* (2002) stated that DNA base composition and DNA–DNA hybridization among the

cyanobacterial genus *Microcystis* were determined using nine axenic *Microcystis* strains, including the three 'morphological' species of *M. aeruginosa*, *M. viridis* and *M.wesenbergii*. These *Microcystis* spp. showed a similar DNA base composition (42<1–42<8 mol% GMC) and demonstrated more than 70 per cent DNA relatedness, confirming their synonym based on bacterial criteria.

Nubel *et al.* (1997) developed and tested a set of oligonucleotide primers for the specific amplification of 16S rRNA gene segments from cyanobacteria and plastids by PCR. PCR products were recovered from all cultures of cyanobacteria and diatoms that were checked, but, not from other bacteria and archaea. Gene segments selectively retrieved from cyanobacteria and diatoms in unialgal but nonaxenic cultures and from cyanobionts in lichens could be directly sequenced. In the context of growing sequence databases, this procedure allows rapid and phylogenetically meaningful identification without pure cultures or molecular cloning.

Sivonen *et al.* (1992) described that Hepatotoxins (microcystins) from seven freshwater *Anabaena* strains originating from three different Finnish lakes and one lake in Norway were isolated by high-performance liquid chromatography and characterized by amino acid analysis and fast atom bombardment mass spectrometry. All strains produced three to seven different microcystins. A total of 17 different compounds were isolated, of which 8 were known microcystins.

Barker *et al.* (1999) explained the filamentous diazotrophic cyanobacterium *Nodularia* forms water blooms each year in the Baltic Sea. Filaments isolated from such water blooms vary in their trichome width, degree of coiling, and properties of their gas vesicles. To test the validity of such a phenotypic classification, they determined the nucleotide sequences for a region of the phycocyanin locus that includes a noncoding intergenic spacer (PC-IGS), the IGS between two adjacent copies of the *gvpA* gene (which encodes the main structural gas vesicle protein) and the rDNA internal transcribed spacer (rDNA-ITS), for 13 clonal *Nodularia* isolates. The complete 16S-rDNA sequence was determined for three isolates and was found to be identical in each of them.

Suda *et al.* (2002) explained a polyphasic approach to clarify the taxonomy of the water bloomforming oscillatorioid cyanobacteria. Seventy-five strains of oscillatorioid cyanobacteria were characterized by 16S rDNA sequence analysis, DNA base composition, DNA–DNA hybridization, fatty acid composition, phycobilin pigment composition, complementary chromatic adaptation, morphological characters, growth temperature and salinity tolerance.

The recent study by Sanchez *et al.* (2005) shows that the cyanobacterium *Microcoleus chthonoplastes* forms a consortium with heterotrophic bacteria present within the cyanobacterial sheath. They showed that this consortium was able to grow in the presence of crude oil, degrading aliphatic heterocyclic organo-sulfur compounds as well as alkylated monocyclic and polycyclic aromatic hydrocarbons. They characterized the oil-degrading consortium through the analysis of the 16S rRNA gene sequences. They also performed the study in cultures of *Microcoleus* grown in mineral medium and in cultures of the cyanobacterium grown in mineral medium supplemented with crude oil. The results indicate that most of the clones found in the polluted culture correspond to well-known oil degrading and nitrogen-fixing microorganisms, and belong to different phylogenetic groups.

Ouellette *et al.* (2006) studied on algae blooms, which include the toxic cyanobacterium *Microcystis*, have reoccurred in the Laurentian Great Lakes, most commonly in the western basin of Lake Erie. Whereas, the western basin is the most impacted by toxic *Microcystis* in Lake Erie, there has historically been little effort focused on identifying the spatial distribution of *Microcystis* throughout this lake. Therefore, to address this lack of knowledge, they have employed a polymerase-chain-reaction-based detection of genes required for synthesis of the toxin microcystin (mcyD and mcyB), as well as 16S rDNA fragments specific to either all *Microcystis* or all cyanobacteria.

## Cultivation of cyanobacteria

Extensive studies have been carried out for the cultivation of different cyanobacteria and microalgae using a variety of cultivation systems ranging from closely-controlled laboratory methods to less predictable methods in outdoor tanks.

The most commonly used cultivation systems include shallow big ponds, tanks, circular ponds and raceway ponds (Oron *et al*., 1979). One of the major advantages of open ponds is that they are easier to construct and operate than most closed systems (Borowitzka, 1999). However, major limitations in open ponds include poor light utilization by the cells, evaporative losses, diffusion of $CO_2$ to the atmosphere and requirement of large amounts of water and land and low biomass productivity (Posten and Schaub, 2009).

Santillan (1982) identified an alternative to open ponds are closed ponds where the control over the environment is much better than that for the open ponds. Closed pond systems are more cost intensive than the open ponds, and considerably less than photobioreactors for similar areas of operation. It allows more species to be grown, it allows the species that are being grown to stay dominant, and it extends the growing season. Usually closed ponds are used in *Spirulina* cultivation

Closed bioreactors have some specific advantages (Pulz, 2001; Posten and Schaub, 2009). Firstly, they can distribute the sun light over a larger surface area, which can be up to 10 times higher than the footprint area of the reactor. Secondly, evaporation can be avoided. The only water loss is due to the water content in the wet cyanobacteria product. This allows for the cultivation of cyanobacteria also in arid areas, where classical terrestrial agriculture is not possible. Limiting factors are the high reactor costs and the need for auxiliary energy requirements. However, ongoing research in the reactor field is promising and will lead to cheaper and more energy-effective designs (Posten and Schaub, 2009).

The cultivation of cyanobacteria / microalgae in sewage and wastewater treatment plant is expected to bring double benefit to the environment since that they can be used to extract nutrients from waste water, and convert it to fats for biodiesel production and reduces pollution from the atmosphere. Unlike other algal-biofuel technologies this approach relies on 'wild algae' – *i.e.* algae that naturally colonize sewage ponds already (Metcalf and Eddy, 1980).

Matsunaga *et al*. (2005) stated that another economical way of cultivating cyanobacteria/ microalgae is sea water (salt water). The main nutrients needed for their growth is already present in seawater. Seawater is a solution of salts of nearly constant composition, dissolved in variable amounts of water. There are over 70 elements dissolved in seawater with six of them make up >99 per cent of all the dissolved salts; all occur as ions-electrically charged atoms or groups of atoms (Sodium, Chlorine, Magnesium, Potassium, Sulfate and Calcium).

Cyanobacteria are extensively cultivated for the production of biofertilizer, microbial protein, plant growth- promoting substances and rare chemicals such as carotein and enzymes. A chemostat constructed by Thomas (1973) was found suitable for the growth of filamentous photosynthetic microorganisms (e.g. *Anabaena).*

Large quantities of cyanobacterial biomass are needed to prepare biofertilizer for application to rice fields. Use of conventional fermenter vessels would result in cost escalation, whereas, open-air cultivation leads to the growth of unwanted microbes. To grow photoautotrophs one has to either use glass culture vessels with outside fights or use metal culture vessels provided with inside submersible lamps. Large volume glass vessels are very expensive.

The cultivation of algae involves optimization of various factors like pH, alkalinity, salinity, aeration, temperature, light etc. The pH of the culture medium is one of the important factors in algal cultivation. It determines the solubility of carbon dioxide and minerals in the medium and directly and indirectly influences the metabolism of algae (Becker, 1994). Algae exhibit a clear dependency on the pH of the growth medium and different species vary greatly in their response to the pH. Among soil properties pH is a very important factor in growth, establishment and diversity of Cyanobacteria, which can generally be reported to prefer neutral to slightly alkaline pH for optimum growth.

Ciferri and Tiboni (1985) mentioned that *Spirulina* sp. could thrive pH range 7 to 11.3. Numerous reports of cyanobacteria in fresh water and

soil indicated that their diversity and abundance were greatest at higher pH (Kanniayan and Kumar, 2004).

Cyanobacteria prefer an optimum temperature between 30 and 35°C. Ray and Bagchi (2001) optimized the culture conditions for growth of *Oscillatoria laetevirens*, at a temperature of 28 ± 2°C and illumination by cool white fluorescent lamps of intensity 25 $Wm^{-2}$.

**Biochemical Composition of Cyanobacteria**

Cyanobacteria are impressive ecosystem engineers with an evolutionary history stretching back at least 2.15 billion years (Hayes *et al*., 2007). These oxygenic photoautotrophic prokaryotes are widely distributed in natural environments and constitute a major component of microbial populations in terrestrial and aquatic habitats worldwide. They are often referred to as 'miniature factories' of the biological world and represent an alternative source of a variety of bioactive compounds, lipids/fatty acids, proteins, enzymes, pigments and compounds of pharmaceutical and nutraceutical.

Microalgae represent a valuable source of a wide spectrum of lipids with different potential applications. Especially interesting are the polyunsaturated fatty acids, including the essential fatty acids linoleic acid, a-linolenic acid (ALA), g-linolenic acid (GLA), arachidonic acid (AA), and eicosapentaenoic acid (EPA). Essential fatty acids are precursors of prostaglandins and, as such, are becoming increasingly important in the pharmaceutical industry (Borowitzka, 1988 and Becker, 1994).

Cyanobacteria or blue-green algae are photosynthetic microorganisms that can be used to produce high-value compounds (Vincent, 2009). These include high protein content; capacity to synthesize all amino acids (and provide the essential ones to humans and animals); presence of carbohydrates composed of starch, glucose, sugars and non-digestible polysaccharides (agar, carrageenan and alginate); lipids in the form of glycerol and fatty acids of the ù-3 and ù-6 families; and a valuable content of many essentials vitamins, minerals and antioxidant substances. With this biochemical composition is not a surprise that this microorganism can be used as a food source for animal and humans (Gantar and Svircev, 2008).

Gantar and Svircev (2008) reported that dried microalgal biomasses typically contain 46–63 per cent protein, 8–17 per cent carbohydrates, and 4–22 per cent lipids, as well as a wide range of vitamins and other biologically active substances such as bioactive peptides and pigments.

*Nostoc*, an edible blue-green alga, is a cyanobacterium that has been grown and cultivated for medicinal uses for centuries (Gantar and Svircev, 2008). Recent studies have indicated that *Nostoc* contains cryptophycin, a compound that inhibits cancer cell growth, as well as anti-viral compounds (Cunningham and Joshi, 2010).

Filamentous cyanobacteria *Nostoc*, *Spirulina*, *Arthrospira*, *Anabaena*, *Aphanizomenon*, *Rivularia,* and many others are particularly attractive for the production of high quality biomass, because they represent a source of protein and a variety of chemicals and pharmaceuticals (Gantar and Svircev, 2008).

Cyanobacteria are commercially exploited in several countries for their valuable constituents particularly for proteins, pigments and polyunsaturated fatty acids. *Spirulina* is known for its high protein content and quality, and is considered to be a rich source of single cell protein (Reed *et al*., 1985).

Most reports on fatty acids in cyanobacteria indicate an acyl chain length of 18 or fewer carbon atoms, with 16:0, 16:1, 18:2, and ALA present as the major fatty acids. Based on their fatty acid composition, cyanobacteria have been classified into four groups. Strains in the first group contain only saturated fatty acids (SAFAs) and monounsaturated fatty acids (MUFAs), whereas strains in the other groups contain polyunsaturated fatty acids (PUFAs) in addition to SAFAs and MUFAs. The second group is characterized by the presence of ALA, the third group by GLA, and the fourth group by 18:4. Therefore, cyanobacteria are quite variable in their fatty acid composition, with marked differences occurring even within the same genus (Kenyon, 1972, Murata *et al*., 1992).

Biochemical studies in cyanobacteria (Holton *et al*., 1968) demonstrated a significant correlation between the morphological complexity of species and their fatty acid composition.

Algae accumulate a variety of carbohydrates as reserve or storage materials; these are often found in large amounts in the cell: the carbohydrates are polyglucans (starch), ß-1,3glucans, fructosans, inulin, sucrose, and poly hydroxy alcohols (Craigie, 1974).

Cyanobacteria contain significant quantities of lipids and some of them are also rich in essential fatty acids such as linoleic and gamma linolenic acids. Besides nutritional value, the fatty acids of cyanobacteria are generally used to clarify taxonomical problems (Li and Liu, 2001).

Fatty acids, in general are of commercial value and many are pharmaceutical agents. The cyanobacterium *Spirulina* has commercially exploited in several countries. It has been used as food for many centuries in Central America. For the past two decades, *Spirulina platensis* has been a focus of interesting among researchers in various fields because of its commercial importance as a source of proteins, vitamins, essential amino acids and fatty acids and more recently, for its potential in therapeutic effects (Belay *et al*., 1993).

Venkataraman and Mahadevaswamy (1992) pointed out that good culture management with suitable strain is one of the basic needs to get promising yields with quality material on commercial scale. Mass cultivation of cyanobacteria is essentially a complex process involving a large number of variables for successful growth of essential requirements of the organism as possible. The limitations imposed in the cultivation process be due to physical factors like light, nutrients, temperature, pH and physiological (organism-environmental-interrelationship) and economic constraints.

## Beneficial effects of Cyanobacteria

Cyanobacteria also known as blue-green algae, exhibit diversity in metabolism and structure also along with morphology and habitat. Moreover, cyanobacteria and microalgae have simple growth requirements and use light, carbon dioxide and other inorganic nutrients efficiently. These organisms also capable of both oxygenic photosynthesis and hydrogen production. Photo-biological production of $H_2$ by microorganisms is of great public interest because it promises a renewable energy carrier from nature's most plentiful resources: solar energy and water. It has been investigated to produce different feed stocks for energy generation like hydrogen (by direct synthesis in cyanobacteria), lipids for biodiesel and jet fuel production, hydrocarbons and isoprenoids for gasoline production and carbohydrates for ethanol production (Ueda *et al.,* 1996).

Studies by Singh *et al*. (2005) have indicated that BGA have antiviral, antitumor, antioxidant, anti-inflammatory, antiallergic, antidiabetic, and antibacterial properties as well as lipid lowering effects. In particular, inhibitory effects of BGA on hyperlipidemia, inflammation, and oxidative stress can contribute to the prevention of the development of CVD and non alcoholic fatty liver disease (NAFLD).

## Cyanobacteria for food and nutritional value

Cyanobacteria are one of the beneficial organisms widely used in food industries and in few biotechnological applications. They store reserve food materials which can be used as the source of pigments, lipids, vitamins, proteins and certain secondary metabolites (Tan, 2007; Cardozo *et al*., 2007). In addition, cyanobacteria also have the capacity of fixing atmospheric nitrogen. These qualities make cyanobacteria the most successful and widespread group among the prokaryotes, occupying a wide range of terrestrial and aquatic environments.

Cyanobacterial protein has received worldwide attention for either as food supplement or as an alternative source of food. Some species of *Anabaena, Nostoc* and *Spirulina* are consumed as food due to their high protein and fibre content (Anupama, 2000).

The consumption of cyanobacterial and microalgal biomass as a human health food supplement is currently restricted to only a few species, e.g., *Spirulina* (Arthospira), *Chlorella*, *Dunalliella* and to a lesser extent, *Nostoc* and *Aphanizomenon* (Spolaore *et al*., 2006).

Alga has gained a particular interest as a bio-resource that can be used in food as well as energy production. Due to consisting of 60–70 per cent (wet basis) proteins, 12 amino acids, vitamins (A, B1, B2,

B6, B12, E, K) and minerals (iron, calcium, potassium, phosphorus, manganese, copper, zinc, magnesium), the microalgae is assumed to be useful for its nutritional qualities and curing properties (Dissa *et al*., 2010).

**Cyanobacteria as fertilizers**

Cyanobacterial and microalgal biomass are used as a plant fertilizer and to improve the water-binding capacity and mineral composition of depleted soils (Metting *et al*., 1990). Moreover the effluent generated during anaerobic digestion for biomethane production can also be used as a fertilizer.

Nitrogen (N) is generally the most difficult nutrient to manage for organic crop production, and N uptake is dependent on the amount of plant-available N supplied by the soil. In organic systems, the most important limiting factor appears to be N availability since soil N commonly exists in organic forms that are not available to plants. In managing plant nutrients over continuing crop cycles, farmers face the challenge of estimating the amount of the soil organic N resource that is made available for plant uptake overtime (Deenik, 2006).

**Cyanobacteria as biofuel**

Human society has an insatiable appetite for fuels and today's supply of liquid fuels world-wide is almost completely dependent on petroleum. Bioenergy production has recently become a topic of intense interest due to increased concern regarding limited petroleum-based fuel supplies and the contribution of the use of these fuels to atmospheric $CO_2$ levels. Finding sufficient supplies of clean energy for the future is society's one of the most daunting challenges and is intimately linked with global stability, economic prosperity and quality of life. This leads to interesting questions and debate over the choice of new fuels, produced from new raw materials, to complement or replace present petroleum-based fuels (Posten and Schaub, 2009).

Cyanobacteria can be developed as an excellent microbial cell factory that can harvest solar energy and convert atmospheric $CO_2$ to useful products. Fossil traces of cyanobacteria are claimed to have been found from around 3.5 billion years ago, and most probably played a key role in the formation of atmospheric oxygen, and are thought to have evolved into present-day chloroplasts of algae and green plants (Tamagnini *et al*., 2007).

Singh and Gu (2010) in their review article have compared the biodiesel yields from microalgae with other best oilseed crops. Biodiesel yield is 58,700 l/ha from microalgae containing only 30 per cent oil (w/w), compared to 1190 l/ha for rapeseed and canola. 1892 l/ha for jatropha, 2590 l/ha for karanj (*Pongamia pinnata*) 172 l/ha for corn; 446 l/ha for soybean; 1059 l/ha for peanut; 2689 l/ha for coconut; 5950 l/ha for oil palm.

Chisti (2007) discussed the economics and quality constraints of biodiesel from microalgae in his review paper. He pointed out that the cost of growing microalgae for biofuel production must be drastically reduced to compete directly with traditional energy sources. It is essential to consider the other roles cyanobacterial cultures can play concurrently with biofuel production and the long term benefits this entails.

Cyanobacteria have already been engineered to produce a number of different biofuel related compounds (Machado and Atsumi, 2012). In one of the first examples of biofuel production in cyanobacteria, *Synechococcus elongatus* sp. strain PCC 7942 (*S. elongatus*) was successfully engineered to produce ethanol through the addition of a pyruvate decarboxylase and an alcohol dehydrogenase, redirecting carbon from pyruvate (Deng and Coleman, 1999). Cyanobacterial production of ethanol has since been significantly improved (Dexter and Fu, 2009; Gao *et al*., 2012).

There are several aspects of cyanobacterial biofuel production that have combined to capture the interest of researchers and entrepreneurs around the world. These include: (1) They are able to perform oxygenic photosynthesis using water as an electron donor, (2) They grow to high densities and have high per-acre productivity compared to typical terrestrial oil-seed crops. Consequently, mass cultivation for commercial production of cyanobacteria can be performed efficiently, (3) They are non-food based feedstock resources, (4) They use otherwise non-

productive, non-arable land, (5) They utilize wide variety of water sources (fresh, brackish, seawater and wastewater) (Tamagnini *et al*., 2007), and (6) They produce both biofuels and valuable coproducts.

**Cyanobacterial biomass**

Photosynthetic biomass is a promising resource for the generation of biofuels and other valuable bioproducts. However, rapid biomass production and high-yield conversion processes are essential for successful applications. Plant-derived lignocellulosic biomass is abundant but, due to the recalcitrant nature of this material, significant challenges have to be solved if this biomass is to be used for the microbial production of biofuels and bioproducts (Mamo *et al.,* 2013).

Whole-cell material from starch-enriched green microalgae and glycogen enriched cyanobacteria (Aikawa *et al*., 2013) has recently been used as feedstock for bioethanol production by yeast fermentation. These studies employed various enzymatic, chemical, and physical treatments (including drying, heating, acid and base-treatment) to liberate monomeric hexoses from the biomass.

Beyond that, the complete algal biomass can also be processed for syngas production followed by a fischer tropsch process, hydrothermal gasification for hydrogen or methane production, methane production by anaerobic digestion, and co-combustion for electricity production. Hence, cyanobacterial system could contribute to a sustainable bioenergy production. However, different biotechnical, environmental and economic challenges have to be overcome before energy products from this system can enter the market.

**Lipid content of cyanobacteria**

Oleaginous microorganisms (microalgae, fungi, yeast, and bacteria), with their ability to produce significant amounts of lipids, are an attractive source of oil suitable for biodiesel production (Bellou *et al*., 2014), especially since their fatty acid composition is often similar to that of common plants currently used as feedstock in biodiesel manufacturing (Vicente *et al*., 2009).

Cyanobacterial lipid could be one of the promising feedstocks for biodiesel production (Yang *et al*., 2011). As common photosynthetic prokaryotic organisms, cyanobacteria can be technologically developed as an excellent microbial cell factory that can harvest solar energy and transform atmospheric carbon dioxide to useful organic compounds (Parmar *et al*., 2011).

Cyanobacteria have basic growth requirements, and use carbon dioxide, light and other inorganic nutrients effectively (Parmar *et al*., 2011). However, some cyanobacteria and microalgae could use both organic carbon sources and carbon dioxide under mixotrophic conditions, and exhibit higher biomass and lipid yields.

The primary components of cyanobacterial biomass are proteins, carbohydrates, and lipids. Some species, such as *Spirulina* sp. and *Planktothrix rubescens*, are suitable for protein-rich biomass production, since their protein content is very high (Demirbas, 2011). Furthermore, some cyanobacteria-for example, *Nostoc muscorum*, are able to accumulate starch in high concentrations, and thus can be used as feedstock for hydrogen production. While the accumulation of lipids in cyanobacterial biomass is fairly low, their fatty acid composition is suitable for biodiesel production (Demirbas and Demirbas, 2011).

Fatty acids are used in membranes formation maintaining cell viability. Knowing the mechanisms of fatty acids synthesis provides a major economic effect on the achievement of the biotechnological processes in order to obtain the desired products. The importance as biotechnological objects and their use in biodiesel production was determined by the cyanobacteria specific fatty acids and their ability to modify lipid profile depending on the cultivation conditions. The biodiesel properties depends on the chemical structure of fatty acid methyl esters. Saturated fatty acids gives a more stable biodiesel than unsaturated fatty acids. Changing the cultivation conditions leads to fatty acids biosynthesis (Ludmila, 2006).

**Cyanobacteria in agriculture**

Cyanobacteria are important microorganisms in agricultural soils and especially in rice fields, where a large variety of them occur (Whitton, 2000). Cyanobacteria are oxygenic photoautotrophs and are known to produce a wide variety of secondary metabolites that may be important for a proper

functioning of agricultural soils. In particular, filamentous cyanobacteria play multiple roles in the enhancement of soil fertility and thus in the improvement of crop plants.

In the rhizosphere, cyanobacteria directly interact with plants through a variety of secondary metabolites. Phytohormones such as auxins are commonly used by rhizospheric microorganisms in order to interact with. In response, the plants secrete a chemically rich mixture of organic and inorganic compounds in the form of root exudates that mainly serve to attract and assist the growth of microorganisms in rhizosphere (Lambers *et al*., 2009).

Phototrophic, N-fixing cyanobacteria have been used as a biofertilizer in rice paddies for centuries and more recently, as a soil inoculum in dryland crops (Maqubela *et al*., 2010). Each season, paddy inoculation can add 30 kg of fixed N per hectare in flooded rice fields and increase grain yield by 10 to 20 per cent. In addition to supplying N, cyanobacteria can secrete plant growth hormones and build soil organic matter. The purpose of using cyanobacteria as an inoculum is to establish populations of cyanobacteria to increase biological N-fixation within the soil.

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**Research Papers**

# Modified Method of Screening Maize Inbred Lines to Late wilt Disease Caused by *Harpophora maydis*

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## Abstract

Development of rapid screening protocol and reliable scale for phenotyping breeding/germplasm lines for responses to LWD is a pre-requisite for identifying stable sources of resistance. We propose a rapid, dependable, labour and resource efficient screening protocol and reliable scale for phenotyping germplasm / breeding lines for responses to LWD. Using the proposed screening protocol, 155 maize inbred lines were phenotyped for their responses to LWD during 2014 and 2015 late rainy seasons. A wide range of response scores (3 to 8.5) suggested good discriminating ability of the proposed method. Significant rank correlation (0.86) indicated the consistency of responses of inbred lines evaluated across two years and also indicated the absence of genotype × environment interaction (GEI). Seven inbred lines were found resistant to LWD in both the years of evaluation. Identified sources of resistance are suggested for use in development of LWD resistant inbred lines / hybrids and segregating populations to map the genomic regions conferring LWD resistance using DNA markers.

Late wilt disease (LWD) of maize caused by *Harpophora maydis* is known to be an important biotic production constraint in Asia (India), Africa (Egypt) and Europe (Hungary, Portugal, Spain) (Chalkley, 2016). It is considered as endemic in major maize growing areas (Degani and Cernica, 2014). The LWD was first reported in Egypt in 1963 (Samra *et al*., 1963). Subsequently, LWD was reported from different maize growing areas *viz*., Tanzania, Pakistan, Hungary and Kenya (Freeman and Ward, 2004), Egypt and India (Ward and Bateman, 1990), Portugal and Spain (Molinero-Ruiz *et al*., 2010), Romanaia (Bergstrom *et al*., 2008), and Israel (Drori *et al*., 2013) and is distributed widely in Iberian Peninsula (Ortiz-Bustos *et al*., 2015). Substantial economic losses caused by LWD have been reported from various parts of the maize growing areas of the world. In Egypt, it is reported that some fields experienced 100% infection and in India 70% incidence and economic losses upto 51 per cent (Johal *et al*., 2004).

LWD symptoms generally appear when the plants are about to tassel. However, their appearance may vary from just prior to tasseling until shortly before maturity (Samra *et al*., 1963). Leaves of the infected plants turn pale green and roll inward and appear as though suffering from lack of water (Sabet *et al*., 1970) and eventually become dry (Samra *et al*., 1963). Drying symptoms ascends upwards and cause stem discoloration of the vascular bundles to a yellow-brown hue (Sabet *et al*., 1966). Rotting symptoms are also reported from lower inter-nodes and roots (Sabet *et al*., 1970). Because of the delay in appearance of initial symptoms until flowering, this disease has been designated as late wilt (Samra *et al*., 1963). The fungus is both soil (Samra *et al*., 1963) and seed borne (Mohammed *et al*., 1966; EL-Shafey and Claflin, 1999). Pathogen survives parasitically on Lupine under field conditions (Botros *et al*., 1990).

Genetic resistance is the most economical and eco-friendly approach to mitigate production losses caused by LWD. Development of maize cultivars resistant to LWD requires (among others) identification of stable sources of resistance. Development of an economic and rapid screening protocol and reliable scale for phenotyping breeding/ germplasm lines for responses to LWD is a pre-requisite for identifying stable sources of resistance. The method of screening and the scale used for phenotyping of breeding / germplasm lines for responses to stalk rots caused by *Macrophomina phaseolina* and *Fusarium moniliforme* also being used for LWD caused by *H. maydis* (Shekhar and Kumar, 2012). However, the LWD symptoms caused by *H. maydis* are different from those caused by other pathogens. In this article we propose a method of

inoculation of pathogen causing LWD different from that proposed by Shekhar and Kumar (2012). We also propose phenotyping scale modified from that proposed by Payak and Sharma (1983).

## Material and Methods

One hundred fifty five inbred lines representing heterotic groups which were developed in different breeding programs in India and across the globe by Monsanto were screened for responses to LWD. Ten seeds of the each inbred line were dibbled in a single row of 3 m length following randomized complete block design with two replications at Mega Breeding Station, Monsanto India Ltd. (MIL), India. The inbred lines were screened for their responses to LWD infection by artificial inoculation of known concentration of pathogen spores at 65 days after sowing (DAS) during 2014 and 2015 late rainy seasons.

### Isolation and mass multiplication of the pathogen (*H. maydis*)

Maize stalks showing symptoms typical to LWD were collected from the field. Infected stalks were split into small fiber tissue and surface sterilized in 4 *per cent* sodium hydrochloride solution. The same were washed twice in sterile distilled water, dried and plated on 39 per cent Potato Dextrose Agar (PDA) medium. Petri plates were incubated in Biological Oxygen Demand (BOD) incubator for 5 days for the development of pathogen colonies. The pathogen colonies were examined for morphological and fruiting body characteristics typical of *H. maydis* (Fig. 1). The mycelia of *H. maydis* were placed on Potato Dextrose Agar (PDA) for pure culture. The mycelia were aseptically transferred to sterile 24 per cent Potato Dextrose Broth (PDB) in conical flasks for mass multiplication. These conical flasks were incubated for 15 days for development of mycelia mat. On the 15th day, the mycelial mat was grounded and filtered to obtain pathogen spore suspension (Fig. 2).

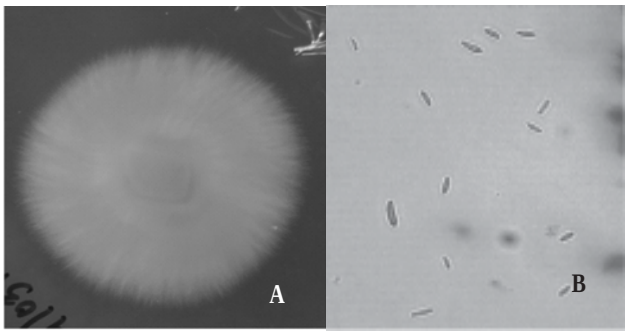


Fig. 1 : A) Characteristic rhizoidal growth of the mycelia of *H. maydis*
B) Pathogen suspension containing spores of *H. maydis* observed under microscope (10X)

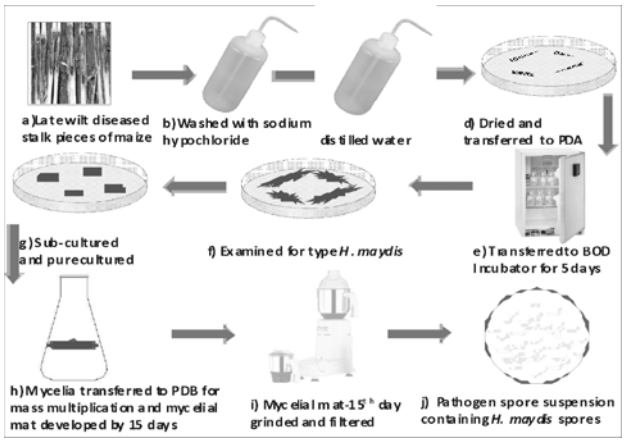


Fig. 2 : Schematic representation of isolation, mass multiplication and preparation of the suspension of the pathogen *H. maydis* for inoculation

### Preparation of Inoculum

The spore suspension was observed under microscope and the concentration was adjusted to $4\times10^6$ spores per ml was adjusted using Haemocytometer. Whenever spore concentration was high, it was diluted with sterile distilled water to maintain desired concentration of spores. Spore suspension containing $4 \times 10^6$ spores per ml of pathogen constituted the inoculum.

### Phenotyping responses of inbred lines to LWD

Two ml of the inoculum was injected to second inter-node from the base of 155 inbred lines' stalks using specialized injectors at 65 DAS. LWD symptoms were observed 20-25 days after inoculation. For disease phenotyping, inbred lines' stalks were split opened 30 days after inoculation. Disease severity and intensity was recorded on plot basis using 1-9 rating scale (Table I). The scoring pattern is developed based on spread of inter-node discoloration inside the maize stalks from the point of inoculation (Payak and Sharma, 1983). Higher the discoloration, higher is the rating. Unlike other stalk rot causing organisms, *H. maydis* apart from causing stem discoloration, also disintegrates

TABLE I

*Scale used for scoring maize inbred lines for their responses to late wilt caused by H. maydis (Modified from Payak and Sharma, 1983)*

| Scale | Description of response of inbred lines to LWD |
|---|---|
| 1 | Indicates 25 per cent of inoculated inter node discolored |
| 2 | 26 – 50 per cent of inoculated inter node discolored |
| 3 | 51 – 75 per cent of inoculated inter node discolored or 26 – 50 per cent discoloration with high disintegration of the stalk |
| 4 | 76 – 100 per cent of inoculated inter node discolored or 51 – 75 per cent discoloration with high disintegration of the stalk |
| 5 | Discoloration of less than 50 per cent of adjacent internodes or 76 – 100 per cent discoloration of inoculated inter node with high disintegration of the stalk |
| 6 | Discoloration of more than 50 per cent of adjacent internodes or less than 50 per cent discoloration with high disintegration of the stalk |
| 7 | Discoloration of more than two internodes or < 2 internodes but high disintegration of the stalk |
| 8 | Discoloration of more than three internodes or < 3 internodes but high disintegration of the stalk with complete fibrousness |
| 9 | Discoloration of more than 3 internodes and plants immaturely killed |

the plant tissue and make it fibrous and finally leaves the vascular bundle in a most disorganized state (Payak *et al*., 1970) (Fig. 3). Unlike macrophoemina, which spreads to lower internodes and reaches to cobs (Khokhar *et al*., 2014), *H. maydis* fungus rarely moves to next internodes. Hence, there is every possibility that the genotypes will be wrongly classified. Disintegration and fibrousness of the plant tissue in addition to discoloration upon inoculation were considered for assigning the scores and classifying the inbred lines. Based on the responses to LWD and the proposed phenotyping scale (Table I), the 155 inbred lines were classified into different response groups (Table II).

TABLE II

*Classification of inbred lines into different response groups based on their scores of responses to late wilt disease*

| Sl.No | Score | Response |
|---|---|---|
| 1 | 1 | Highly Resistant |
| 2 | >1 to 3 | Resistant |
| 3 | >3 to 6 | Tolerant / Moderately susceptible |
| 4 | >6 to 7 | Susceptible |
| 5 | >7 to 9 | Highly Susceptible |

Fig. 3: Split open plant stalks after inoculation with *H. maydis* fungus : A) Disintegration and fibrousness of the inter node plant tissue but the discoloration not spread to the next inter node, B) Fungus discolored the inter node completely but the stem tissue is intact – no disintegration and fibrousness, C) complete discoloration, disintegration and fibrousness of plat tissue in susceptible varieties and D) response of a resistant inbred line.

**Statistical analysis**

The inbred lines were ranked based on their ssigned score in each year. Spearman rank correlation coefficient ($r_s$) was calculated for assessing consistency of inbred lines for the disease responses

to LWD over two years as $r_s$ = 1- [{6 x ("$d_i^2$+CF)} / ($N^3$-N)], where, $d_i$ = (Rank of a inbred line screened during 2014 - Rank of that inbred line screened during 2015) and N = Number of paired observations; CF=" {($t^3$-t) / 12} with't' being the order of each tie.

The estimate of $r_s$ was examined for its statistical significance using 't' test. Pooled analysis of variance was performed to partition the total variability of inbred lines for their responses to LWD into those attributable to genotype, year and genotype x year for interaction responses to LWD.

**Method of inoculation**

Method of inoculation followed in the present study elicited good response of the inbred lines to LWD as indicated by the wide range of scores from 3 to 8.5 which suggested good discriminating ability of the method used in the present study. While Payak *et al*. (1970) suggested the use of only tooth pick method, Degani and Cernica (2014) suggested inoculation using both tooth pick and injection method for screening germplasm/breeding lines for responses to LWD. The reported soil inoculation (Sabet *et al*., 1966; Sabet *et al*., 1970; Abd El-Rahim *et al*., 1998) and other modified methods (Singh and Sriadhana, 1986) are cumbersome, highly demanding in terms of resources, time and labour. Inoculation of pathogen suspension into stalks as is followed in present study is not only labor and resource efficient but also large number of plants could be screened in less time.

## Results and Discussion

**Response of inbred lines for LWD**

The inbred lines differed significantly for their responses to LWD as indicated by the significant mean sum of squares attributable to inbred lines. Significance of mean sum of squares attributable to 'year' indicated possible differential influence of weather variables that prevailed during the crop growth period during 2014 and 2015 late rainy seasons on the responses of inbred lines to LWD. Non-significance of the mean squares attributable to 'inbred lines × year' interaction suggested the absence of genotype × environment interaction (GEI) (Table III). A fairly high and significant rank correlation (0.86) not only indicated consistency of the inbred lines for their response to LWD over two years but also confirmed the absence of GEI. These results suggested the effectiveness of selection of inbred lines for resistance to LWD.

The results suggested that none of the lines are highly resistant in both the years of evaluation. However, 9 and 13 inbred lines were resistant during 2014 and 2015, respectively. Fairly large a large number of inbred lines were tolerant to LWD in both 2014 and 2015. Pooled data indicated resistant response of only seven inbred lines and tolerance of 114 inbred lines (Table IV). The inbred lines that were found resistant to LWD in both the years are CV131061, CV183821, CV169435, CV239917, CV138811, CV270316 and CV266706 (Table V). The classification of inbred lines

Table III

*Pooled Analysis of variance of maize inbred lines for responses to late wilt disease caused by H. maydis*

| Source of replication | Degrees of freedom | Sum of squares | Mean sum of squares | Calc. F | Table. F |
|---|---|---|---|---|---|
| Replications | 1 | 26.014 | 26.01 | 38.74 | |
| Inbred lines | 154 | 946.01 | 6.14** | 9.15 | 1.37 |
| Years | 1 | 7.68 | 7.68** | 11.44 | 6.72 |
| Inbred lines*Years | 154 | 74.57 | 0.48 | 0.72 | 1.37 |
| Error | | 309 | 207.48 | 0.67 | |
| Total | | 619 | 1261.76 | | |

**Significant at P = 0.01

TABLE IV

*Number of inbred lines with different responses to late wilt disease caused by H. maydis*

| Score | Response | No. of inbred lines | | |
|---|---|---|---|---|
| | | 2014 | 2015 | Pooled |
| 1 | Highly Resistant | 0 | 0 | 0 |
| >1 to 3 | Resistant | 9 | 13 | 7 |
| >3 to 6 | Tolerant | 108 | 118 | 114 |
| >6 to 7 | Susceptible | 24 | 19 | 27 |
| >7 | Highly Susceptible | 14 | 5 | 7 |

TABLE V

*List of maize inbred lines found resistant to LWD dring2014 and 2015 late rainy seasons and across years*

| 2014 | | 2015 | | Pooled | |
|---|---|---|---|---|---|
| Identity of the inbred line | Mean disease score | Identity of the inbred line | Mean disease score | Identity of the inbred line | Mean disease score |
| CV131061 | 3 | CV196707 | 3 | CV131061 | 3 |
| CV183821 | 3 | CV331660 | 3 | CV183821 | 3 |
| CV169435 | 3 | CV131061 | 3 | CV169435 | 3 |
| CV239917 | 3 | CV204636 | 3 | CV239917 | 3 |
| CV216067 | 3 | CV183821 | 3 | CV138811 | 3 |
| CV138811 | 3 | CV169435 | 3 | CV270316 | 3 |
| CV282871 | 3 | CV239917 | 3 | CV266706 | 3 |
| CV270316 | 3 | CV212411 | 3 | | |
| CV266706 | 3 | CV138811 | 3 | | |
| | | CV198231 | 3 | | |
| | | CV270316 | 3 | | |
| | | CV266706 | 3 | | |
| | | CV325943 | 3 | | |

into five different response groups based on the proposed scale is amply justified by the significance of mean disease scores of the inbred lines classified under each response group as indicated by the 'F' test (Table VI).

The most practical method of controlling the disease in the field is the use of resistant varieties (Samra *et al*., 1963; El-Shafey *et al*., 1988). Identified sources of resistance to LWD are suggested for use in improving the parental lines of hybrids proven to be high yielders or can be used in deriving new resistant hybrids. The resistant sources can also be used for developing segregating populations to map the genomic regions conferring LWD resistance using DNA

TABLE VI

*Estimates of means disease scores of inbred lines classified based on their responses to late wilt disease*

| Classification | (<3) | (>3 - 6) | (>6 - 7) | (>7) | F | P-value |
|---|---|---|---|---|---|---|
| Count | 7 | 114 | 27 | 7 | 85.84 | 1.82E-32 |

markers. Once validated, linked markers could be used as surrogates of LWD resistance while breeding for resistant maize inbred lines / hybrids.

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# Identification of Superior Segregants through Exploitation of Genetic Variability in $F_3$ Families of Rice (*Oryza sativa* L.) under Aerobic Cultivation

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## ABSTRACT

The present study was conducted to evaluate 35 and 30 $F_3$ families derived from MAS145 x MAS946-1 cross and IR 64 x IM 192 cross respectively. The results revealed that there is presence of adequate variability for traits under study. Slight difference between GCV and PCV estimates observed for most of the traits witnessing the lower influence of environment for expression of these traits. Most of the traits showed moderate narrow sense heritability coupled with moderate or low GAM indicating involvement of both additive and non-additive genes hence selection is effective with little intense. Further, based on the yield per plant, duration wise superior segregants were identified and these lines after stabilization with appropriate selection with homogeneity with higher will be highly suitable for cultivation under aerobic condition as the parents of the crosses have either one or both the parents for aerobic condition.

RICE (*Oryza sativa* L.) is a highly domesticated crop, and domestication processes are reported to be accompanied by genetic erosion, which causes a reduction in genetic variation (Khare *et al.,* 2014).Improvement in any crop largely depends on the genetic variability and the extent to which the traits are heritable. Therefore, there is dire need for creation of variability through artificial way to meet the food requirement of increasing population and also to cope up with water shortage situations. Hybridization is one of the way through which enormous variability can be created. It has been hypothesised that progress in breeding programme depends on amount of variability created during hybridization (Kayande and Debaje 2010). Segregating populations are more important for improving plant types by operating selection (Kiran *et al*., 2013; Farhad Kahani and Shailaja Hittalmani 2015; Shantavva *et al.,* 2014). Therefore the knowledge of genetic parameters present in segregating population for the improvement of character under study has paramount importance. Phenotypic coefficient of variation(PCV), genotypic co-efficient of variation (GCV), heritability, genetic advancement will be useful for efficient exploitation of variability (Savitha and Usha kumara 2015a; Shantavva *et al*., 2014).The genotypic coefficient of variation measures the range of variability available in a crop and also enables to compare the amount of variability present in different characters. The phenotypic expression of the character is the result of interaction between genotype and environment. Hence, the total variance needs to be partitioned into heritable and non-heritable components to assess the inheritance pattern of the particular character under study. Heritability indicates the relative degree at which a character is transmitted from parent to offspring. Heritability estimates along with GA are normally more helpful in predicting the gain under selection than heritability estimates alone. As both will serve as important selection parameters (Ogunbayo *et al*., 2014). One of the main constraints of rice cultivation and production is water shortage during periods of low rainfall, which affects the vegetative growth rate and grain yield (Tao *et al*., 2006). Aerobic rice cultivation is one such choice wherein the water required is half of that of irrigated puddled rice, without compromising the productivity (Gandhi *et al*., 2011a, Gandhi *et al*., 2011b).In this context the present investigation was undertaken to evaluate the genetic variability present in $F_3$ segregating populations and also to identify superior segregants suitable for aerobic condition.

## MATERIAL AND METHODS

The experiment was carried out during *Kharif* season of 2013 at K block, GKVK, Bengaluru, representing the eastern dry zone which is located at the latitude of 12° 58' North; longitude 77° 35' East and altitude of 930 meters above mean sea level. The

experimental material for the present study composed of 35 and 30 $F_3$ families derived from MAS 145 x MAS 946-1 cross and IR 64 x IM 192 crosses, respectively. They were evaluated in an augmented design (Federer, 1961) in 10 blocks under aerobic condition. The salient features of parents and checks used in the present study are furnished in the Table I.

Twenty plants were selected at random for each line from each family under aerobic condition for recording observations as per Standard evaluation system for rice (Annon. 1996). The characters observed for eliciting the information are as follows, Plant height at 30 days after transplanting (cm), Plant height at maturity (cm), Days to 50 Per cent flowering, Days to maturity, Total number of tillers per plant, Productive tillers per plant, 1000 grain weight (g), Harvest index, Grain yield per plant (g), Panicle length (cm), Panicle exsertion (± cm), Spikelets per panicle, Biomass, Panicle weight, Spikelet fertility (%), Grain yield per day (mg per day). The average of observations recorded on these twenty plants was considered for statistical analysis.

The potentiality of a cross is measured not only by mean performance but also on the extent of variability. Knowledge on nature and magnitude of genotypic and phenotypic variability present in any crop species plays an important role in formulating successful breeding programmes (Savitha and Usha kumari 2015b). Rahman *et al*., (2015) also highlighted the importance of variability in early segregating generations and suggested that magnitude of genotypic coefficient of variability and phenotypic coefficient of variability should be given importance.

The statistical analysis on the mean values of twenty randomly selected plants from each of population was recorded under aerobic condition statistical analysis was carried out on individual characters following Augmented design (Federer, 1956) WINDOSTAT version 9.0 developed by indostat services, Hyderabad. Adjusted trait mean of each of the genotype accession were estimated (Federer, 1956) and the same were used for all subsequent statistical analysis. The following descriptive statistics mean, Range and standardized range, Skewness and Kurtosis were calculated as per Raghavendra and S.Hittalmani (2015). Based on the direction and magnitude of skewness (g1) and kurtosis (g2), nature of genetic control of growth yield was inferred (Pooni *et al.*, 1977).Genetic parameters such as genotypic co-efficient of variation (GCV), phenotypic co-efficient of variation (PCV), heritability, genetic advance as percent mean were estimated. Superior segregants have been identified by considering the yield per plant further percent improvement over checks calculated.

TABLE I

*Salient features of the parents and checks used in the study*

| Genotypes | Parentage | Special Feature | Source of seed |
|---|---|---|---|
| | | **Parents** | |
| MAS 946-1 | Cultivated variety (Aerobic) | High yielding under aerobic condition, WUE, Erect panicles | MAS LAB GKVK |
| IR 64 | Cultivated variety | Semi dwarf, drought susceptible. | MAS LAB GKVK |
| IM 192 | IR 50 X Moroberekan | Medium early maturing, drought tolerant | MAS LAB GKVK |
| MAS 145 | IR 78875-131-B-1-2/IR 78877-208-B-1-1 | Fine grain type, high yielding | MAS LAB GKVK |
| | | **Checks** | |
| Rasi | Cultivated variety | Drought resistant | MAS LAB GKVK |
| Moroberekan | Landrace | Drought resistant | MAS LAB GKVK |
| MAS 99 | Promising genotype | Aerobic rice | MAS LAB GKVK |

## RESULTS AND DISCUSSION

The mean performance of parents furnished in Table II indicated that they are contrasting for most of the traits under study. As it is the one of the important prerequisite for crop improvement through hybridization followed by selection (Savitha and Usha kumari 2015a).

*Genetic variability parameters for yield and yield attributing traits :*As evident from Table III, the analysis of variance are given for various morphological characters were statistically tested and found to be significant for all the characters in both the crosses derived $F_3$ progenies.

### MAS 145 / MAS 946-1

The estimates genetic variability parameters of for yield and its attributing traits in $F_3$ families of a) MAS145/MAS946-1cross are provided in the Table IV and Fig.1. The variability parameters revealed that highest PCV and GCV values recorded for panicle exertion (32.93 & 32.28%), followed by spikelet fertility (22.98 &20.87%) and panicle weight (21.71 & 20.67%) indicated that presence of adequate

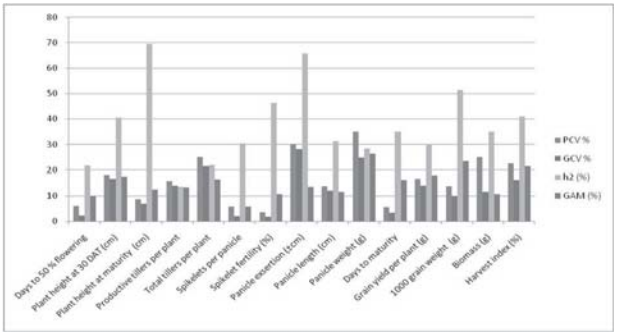


Fig. 1 : Genetic parameters for yield and its attributing traits in $F_3$ families derived from MAS145/MAS946-1 rice cross

TABLE II

*Mean performance of Parents and checks for grain yield and its components*

| Traits | MAS 145 | MAS 946-1 | IR 64 | IM 192 | Moroberekan | Rasi | MAS 99 |
|---|---|---|---|---|---|---|---|
| Days to 50 % flowering | 97.50 | 92.50 | 100.50 | 87.50 | 124.00 | 82.50 | 91.00 |
| Plant height at 30 days after transplanting (cm) | 25.23 | 40.00 | 33.0 | 27.50 | 31.00 | 33.00 | 32.00 |
| Plant height at maturity (cm) | 46.12 | 61.26 | 69.01 | 50.13 | 98.25 | 78.00 | 78.00 |
| Productive tillers plant $^{-1}$ | 13.00 | 21.00 | 12.00 | 28.16 | 7.00 | 15.00 | 21.00 |
| Total number of tillers plant$^{-1}$ | 15.00 | 23.00 | 13.02 | 15.32 | 8.00 | 17.00 | 24.00 |
| Spikelets per panicle | 100.00 | 117.00 | 80.00 | 113.00 | 81.00 | 100.00 | 82.00 |
| Spikelet fertility (%) | 83.00 | 67.35 | 82.35 | 68.40 | 86.00 | 96.00 | 88.00 |
| Panicle exsertion (± cm) | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 |
| Panicle length (cm) | 18.00 | 20.00 | 16.12 | 19.00 | 22.00 | 21.00 | 16.00 |
| Panicle weight (g) | 1.03 | 1.80 | 3.56 | 1.02 | 1.20 | 3.70 | 3.95 |
| Grain yield plant$^{-1}$ (g) | 18.50 | 23.60 | 20.01 | 25.50 | 20.64 | 30.21 | 37.25 |
| 1000-grain weight (g) | 18.60 | 28.20 | 31.00 | 36.12 | 25.60 | 36.50 | 35.60 |
| Days to maturity | 135.36 | 120.26 | 110.03 | 101.32 | 155.00 | 128.00 | 127.00 |
| Biomass (g) | 51.20 | 79.30 | 61.00 | 85.00 | 78.00 | 68.00 | 56.00 |
| Harvest index | 0.40 | 0.29 | 0.36 | 0.40 | 0.35 | 0.43 | 0.40 |

TABLE III

*Analysis of variance (mean sum of squares) for 15 quantitative characters in $F_3$ families derived from MAS 145 / MAS 946-1 (I) and IR64/ IM192 (II) crosses of Rice*

| Source of variation | Blocks | | Entries (check + progenies) | | Checks | | Progenies | | Check vs. progenies | | Non Genetic (Error) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | I | II | I | II | I | II | I | II | I | II |
| Degrees of Freedom (df) | 1 | 2 | 40 | 35 | 5 | 5 | 34 | 29 | 1 | 1 | 5 | 10 |
| Days to flowering | 0.02 | 6.54 | 85.39 | 125.7 | 447.57 | 513.59 | 17.32 * | 35.08 ** | 588.75 | 814.40 | 5.07 | 5.59 |
| Plant height at 30 DAT (cm) | 8.34 | 84.49 | 90.69 | 56.96 | 408.93 | 319.96 | 31.93 * | 103.25 ** | 497.36 | 9.56 | 0.93 | 8.36 |
| Plant height at maturity (cm) | 0.00 | 0.16 | 178.3 | 194.92 | 906.25 | 1050.93 | 69.60 * | 21.52 ** | 235.67 | 947.37 | 0.60 | 6.10 |
| Productive tillers plant $^{-1}$ | 0.08 | 8.72 | 11.97 | 19.23 | 72.88 | 107.02 | 2.98 ** | 16.53 * | 13.13 | 5.66 | 0.08 | 2.78 |
| Total no. of tillers plant $^{-1}$ | 0.33 | 13.72 | 12.49 | 25.48 | 80.53 | 141.15 | 2.80 * | 34.76 * | 1.69 | 47.94 | 0.13 | 2.38 |
| No. of Spikelets panicle$^{-1}$ | 0.08 | 0.05 | 90.65 | 81.46 | 599.15 | 441.65 | 5.71 * | 21.45 ** | 504.19 | 20.67 | 4.88 | 3.92 |
| Spikelet fertility (%) | 0.42 | 2.51 | 33.98 | 50.05 | 210.84 | 291.36 | 7.96 * | 6.65 * | 34.39 | 102.19 | 0.45 | 1.57 |
| Panicle exsertion (±cm) | 0.00 | 0.00 | 0.37 | 0.15 | 0.00 | 0.00 | 0.41 * | 0.10 * | 1.04 | 2.21 | 0.00 | 0.00 |
| Panicle length (cm) | 2.08 | 0.00 | 4.26 | 3.39 | 6.35 | 18.40 | 5.08 * | 0.54 * | 0.19 | 11.10 | 1.83 | 0.39 |
| Panicle weight (g) | 0.03 | 0.00 | 1.40 | 2.04 | 0.97 | 3.08 | 0.80 ** | 1.68 * | 24.08 | 7.12 | 0.05 | 0.65 |
| Days to maturity | 36.75 | 43.57 | 149.69 | 266.64 | 934.58 | 1355.64 | 41.36 * | 70.18 * | 74.62 | 518.92 | 35.34 | 38.89 |
| Grain yield plant$^{-1}$ (g) | 0.67 | 0.61 | 35.90 | 48.93 | 77.89 | 71.08 | 25.88 ** | 21.25 * | 166.54 | 740.91 | 0.30 | 12.79 |
| 1000-grain weight (g) | 15.98 | 0.22 | 50.84 | 39.50 | 162.93 | 81.89 | 4.49 * | 0.38 | 252.25 | 962.11 | 3.33 | 25.57 |
| Harvest index | 0.00 | 3.05 | 0.00 | 296.55 | 0.00 | 750.36 | 0.00 ** | 225.30 ** | 0.06 | 93.84 | 0.00 | 44.11 |
| Biomass (g) | 3.09 | 0.00 | 260.62 | 0.01 | 1091.78 | 0.00 | 143.74 ** | 0.01 * | 78.97 | 0.12 | 1.44 | 0.00 |

TABLE IV

*Estimates of genetic parameters for yield and its attributing traits in $F_3$ families of MAS145 / MAS 9461 of rice cross*

| Plant Traits | Range | | Standardized range | Mean ± S.E | Variance | PCV (%) | GCV (%) | $H^2$ (ns) % | GAM (%) |
|---|---|---|---|---|---|---|---|---|---|
| | Max. | Min. | | | | | | | |
| Days to 50 % flowering | 112.50 | 94.55 | 0.17 | 103.91 ± 0.70 | 17.33 | 5.39 | 3.39 | 32.26 | 6.92 |
| Plant height at 30 DAT (cm) | 56.45 | 24.95 | 0.86 | 36.71 ± 0.95 | 31.93 | 13.44 | 13.18 | 35.03 | 14.15 |
| Plant height at maturity (cm) | 93.70 | 56.35 | 0.54 | 69.36 ± 1.41 | 69.61 | 10.47 | 10.41 | 66.46 | 19.32 |
| Productive tillers per plant | 13.85 | 7.75 | 0.60 | 10.20 ± 0.29 | 2.99 | 14.79 | 14.52 | 17.82 | 18.62 |
| Total tillers per plant | 16.85 | 11.10 | 0.14 | 13.27 ± 0.28 | 2.81 | 11.06 | 10.71 | 19.05 | 17.39 |
| Spikelets per panicle | 94.75 | 86.35 | 0.09 | 90.47 ± 0.32 | 3.71 | 7.20 | 6.32 | 51.42 | 2.28 |
| Spikelet fertility (%) | 88.58 | 76.68 | 10.46 | 82.94 ± 0.47 | 7.96 | 22.98 | 20.87 | 61.42 | 7.83 |
| Panicle exsertion (± cm) | 2.95 | -0.65 | 0.51 | 0.34 ± 0.10 | 0.41 | 32.93 | 32.28 | 32.09 | 28.40 |
| Panicle length (cm) | 23.80 | 14.20 | 1.08 | 18.90 ± 0.34 | 4.08 | 9.75 | 7.69 | 38.11 | 16.02 |
| Panicle weight (g) | 6.00 | 2.10 | 0.43 | 3.63 ± 0.15 | 0.80 | 21.71 | 20.67 | 60.63 | 21.97 |
| Days to maturity | 146.45 | 122.55 | 0.78 | 135.65 ± 1.03 | 37.36 | 4.47 | 3.90 | 61.33 | 18.75 |
| Grain yield per plant (g) | 38.40 | 15.40 | 0.93 | 24.16 ± 0.86 | 25.89 | 18.33 | 15.19 | 51.42 | 17.65 |
| 1000 grain weight (g) | 42.29 | 22.21 | 0.95 | 30.51 ± 0.90 | 28.44 | 17.62 | 15.68 | 37.70 | 14.63 |
| Biomass (g) | 95.95 | 39.30 | 0.18 | 60.99 ± 2.06 | 14.74 | 17.11 | 17.00 | 63.67 | 24.58 |
| Harvest index (%) | 0.56 | 0.25 | 0.66 | 0.40 ± 0.01 | 0.01 | 17.08 | 16.97 | 66.73 | 24.53 |

| | | | |
|---|---|---|---|
| Min. | Minimum | $H^2$ (ns ) % | Narrow sense heritability |
| Max. | Maximum | GAM | Genetic advance as percent mean |
| S.E | Standard error | PCV (%) | Phenotypic coefficient of variation (%) |
| | | GCV (%) | Genotypic coefficient of variation (%) |

variability for these traits. Whereas, lowest PCV and GCV estimates for days to maturity (4.47 & 3.90%) and days to 50 Per cent flowering (5.39 & 3.39%) designated that presence of lower degree of variability for these traits. The narrow difference between PCV and GCV estimates for most of the traits studied indicated that slighter influence of environment for these traits. Which are in confirmatory with Gopal Reddy and Goud (1970), Bidhan *et al.* (2001), Thirugnana Kumar *et al.* (2007) and Kayande and Debaje (2010). High heritability coupled with high GAM was registered for panicle weight , biomass, harvest index, plant height at maturity, days to maturity suggested that preponderance of additive gene action in the expression of these characters. Therefore selection is effective for these traits. Which is in confirmatory with Kiran *et al.* (2013). Most of the traits shown moderate narrow sense heritability coupled with moderate or low GAM indicating involvement of both additive and non-additive genes. Selection is effective with little intense. These are in confirmatory with Shanthavva *et al.* (2014), Savitha and Usharani (2015a).

**IR 64 / IM 192**

The estimates genetic variability parameters of for yield and its attributing traits in $F_3$ families of IR64/ IM192 cross are provided in the Table V and Fig.2. Highest PCV and GCV estimates observed for panicle weight (34.96 & 24.80%) followed by panicle exertion

(30.06 & 28.62%) and total tillers per plant (24.98 & 21.54%) indicated the presence of high degree of variability for these traits. However lowest PCV and GCV estimates recorded for spikelet fertility (3.53 & 1.78%) and days to maturity (5.63 & 3.33%) suggested the presence of considerable degree of variability for these traits these results are in accordance with Chauhan (1996), Nath and Talekar, (1994), Rahman *et al*. (2015). The slighter difference between GCV and PCV estimates observed for most of the traits witnessing the lower influence of environment for expression of these traits. Most of the traits shown

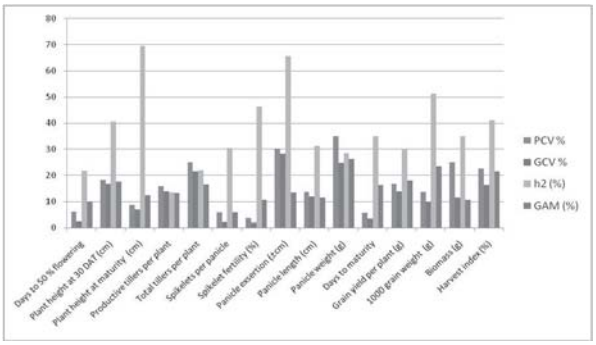


Fig. 2 : Genetic parameters for yield and its attributing traits in $F_3$ families derived from IR 64 / IM192 rice cross

TABLE V

*Estimates of genetic parameters for yield and its attributing traits in $F_3$ families of IR 64 / IM192 of rice cross*

| Plant Traits | Range | | Standardized range | Mean ± S.E | Variance | PCV (%) | GCV (%) | $H^2$ (ns) % | GAM (%) |
|---|---|---|---|---|---|---|---|---|---|
| | Max. | Min. | | | | | | | |
| Days to 50% flowering | 120.00 | 96.00 | 0.22 | 107.59 ± 1.08 | 35.09 | 6.06 | 2.29 | 21.64 | 10.06 |
| Plant height at 30 DAT (cm) | 41.05 | 24.85 | 0.47 | 34.58 ± 0.66 | 13.26 | 18.11 | 16.54 | 40.54 | 17.41 |
| Plant height at maturity (cm) | 79.00 | 62.30 | 0.24 | 69.16 ± 0.84 | 21.53 | 8.62 | 6.98 | 69.54 | 12.31 |
| Productive tillers per plant | 17.45 | 8.65 | 0.69 | 12.74 ± 0.39 | 4.57 | 15.67 | 14.01 | 13.43 | 13.36 |
| Total tillers per plant | 18.45 | 9.00 | 0.15 | 13.71 ± 0.39 | 4.76 | 24.98 | 21.54 | 21.86 | 16.36 |
| Spikelets per panicle | 94.70 | 75.35 | 0.22 | 88.76 ± 0.84 | 21.46 | 5.81 | 2.06 | 30.34 | 5.67 |
| Spikelet fertility (%) | 93.93 | 80.19 | -2.95 | 89.37 ± 0.47 | 6.65 | 3.53 | 1.78 | 46.24 | 10.60 |
| Panicle exsertion (±cm) | 0.15 | -1.15 | 0.16 | -0.44 ± 0.06 | 0.11 | 30.06 | 28.09 | 65.83 | 13.57 |
| Panicle length (cm) | 19.30 | 16.40 | 1.52 | 18.01 ± 0.13 | 0.54 | 13.67 | 11.89 | 31.24 | 11.58 |
| Panicle weight (g) | 6.30 | 1.30 | 0.69 | 3.29 ± 0.23 | 1.69 | 34.96 | 24.80 | 28.35 | 26.46 |
| Days to maturity | 152.35 | 118.80 | 1.00 | 136.02 ± 1.59 | 70.19 | 5.63 | 3.33 | 35.06 | 16.21 |
| Grain yield per plant (g) | 40.35 | 18.70 | 0.88 | 27.95 ± 0.84 | 0.38 | 16.70 | 13.86 | 30.05 | 18.01 |
| 1000 grain weight (g) | 23.78 | 20.82 | 0.77 | 22.09 ± 0.11 | 225.30 | 13.83 | 9.85 | 51.42 | 23.48 |
| Biomass (g) | 101.04 | 40.23 | 0.25 | 69.23 ± 2.74 | 21.25 | 24.99 | 11.56 | 34.92 | 10.64 |
| Harvest index | 0.69 | 0.26 | 0.13 | 0.42 ± 0.01 | 0.01 | 22.63 | 16.17 | 41.07 | 21.51 |

| | | | |
|---|---|---|---|
| Min. | Minimum | $H^2$ (ns ) % | Narrow sense heritability |
| Min. | Minimum | $H^2$ (ns ) % | Narrow sense heritability |
| Max. | Maximum | GAM | Genetic advance as percent mean S.E |
| Standard error | | PCV (%) | Phenotypic coefficient of variation (%) |
| | | GCV (%) | Genotypic coefficient of variation (%) |

moderate narrow sense heritability coupled with moderate or low GAM indicating involvement of both additive and non - additive genes.Selection is effective with little intense. These are in confirmatory with Panwar and Mathur (2007), Shanthavva *et al*. (2014), Savitha and Usharani (2015b).

*Third (skewness) and fourth (kurtosis) degree statistics in $F_3$ families' :* The study of distribution properties such as coefficients of skewness and kurtosis provides insight about the nature of gene action and number of genes controlling the traits respectively. They are more powerful than first and second degree statistics which reveal interaction genetic effects. The skewness and kurtosis values for 15 quantitative traits are presented in Table VI. It infers that the frequency distribution $F_3$ families for all traits shown positively skewed (+ve values) plautykurtic (<3) indicated the involvement of large number of genes controlling these traits with majority of them displaying complementary epistasis. Hence, intenseselection is required for rapid genetic gain for these traits (Pooni *et al*., 1977). Similar observations were reported by Kiran *et al*. (2013), Raghavendra and S. Hittalmani (2015). However spikelet's per panicle and grain yield per plant in MAS 145 / MAS 946-1 cross and plant height at 30 days, spikelet's per panicle, spikelet fertility, panicle exertion, panicle length in IR 64 / IM 192 cross shown negatively skewed (-ve values) plautykurtic (<3) distribution indicated that they may be under control of large no. of genes with duplicate epistasis. Hence, mild selection is expected to result in rapid genetic gain for these traits. Plant height at 30 DAT and panicle exertion in MAS 145 / MAS 946-1 cross derived progenies showed leptokurtic (>3) distribution suggested that few genes controlling these traits (Pooni *et al*., 1977).

*Identification of superior segregants in $F_3$ families :* The top five superior segregants for grain yield in early, mid, late duration and percent increase over check by $F_3$ progenies of MAS 145 X MAS 946-1and IR64/IM192 are presented in table VII and VIII

TABLE VI

*Description of frequency distribution of grain yield and its component characters in $F_3$ segregating progenies under study*

| Traits | MAS 145 x MAS 946-1 | | IR 64 x IM 192 | |
|---|---|---|---|---|
| | Skewness | Kurtosis | Skewness | Kurtosis |
| Days to 50% flowering | 0.057 | -0.247 | 0.508 | -0.057 |
| Plant height at 30 days after transplanting (cm) | 1.191 | 3.413 | -0.598 | 0.557 |
| Plant height at maturity (cm) | 0.536 | 0.788 | 0.411 | -0.573 |
| Productive tillers plant$^{-1}$ | 0.681 | -0.579 | 0.333 | 0.249 |
| Total number of tillers plant$^{-1}$ | 0.724 | -0.517 | 0.210 | 0.387 |
| Spikelets per panicle | -0.097 | -0.019 | -1.668 | 2.812 |
| Spikelet fertility (%) | 0.365 | 0.124 | -0.988 | 2.424 |
| Panicle exsertion (± cm) | 2.047 | 6.826 | -0.145 | -0.671 |
| Panicle length (cm) | 0.200 | 0.438 | -0.326 | -0.321 |
| Panicle weight (g) | 0.674 | 0.355 | 1.006 | 0.892 |
| Grain yield plant$^{-1}$(g) | -0.144 | -0.848 | 0.140 | -0.731 |
| Days to maturity | 0.103 | -0.898 | 0.407 | 0.824 |
| 1000-grain weight (g) | 1.014 | 1.817 | 0.184 | -0.650 |
| Harvest index | 0.876 | 2.051 | 0.682 | 0.813 |
| Biomass (g) | 0.037 | -0.555 | 0.577 | -0.209 |

TABLE VII

*The top five superior segregants for grain yield in early, mid and late duration and percent increase over check by $F_3$ progenies of MAS 145 x MAS 946-1 cross*

| Sl. No. | Duration | Plant No. | Duration (days) | Yield per plant (g) | Yield per Plant (g) per day (mg) |
|---|---|---|---|---|---|
| 1 | | 16-5 | 120 | 40.32 | 336.0 |
| 2 | | 24-11 | 120 | 38.50 | 320.8 |
| 3 | Early duration (120) days | 8-14 | 120 | 35.63 | 296.9 |
| 4 | | 3-5 | 120 | 34.13 | 284.4 |
| 5 | | 2-3 | 120 | 32.26 | 268.8 |
| Mean | | | 120 | 36.16 | 301.3 |
| Check | MAS 99 | | 120 | 35.21 | 293.4 |
| % increase over check | | | | 2.70 | 2.70 |
| 1 | | 11-6 | 130 | 40.32 | 310.1 |
| 2 | | 4-5 | 127 | 38.14 | 300.3 |
| 3 | Medium duration (120-130)days | 17-14 | 122 | 35.10 | 287.7 |
| 4 | | 18-7 | 120 | 31.26 | 260.5 |
| 5 | | 6-6 | 128 | 24.98 | 195.1 |
| Mean | | | 125.4 | 33.96 | 270.8 |
| Check | Rasi | | 125 | 28.20 | 225.6 |
| % increase | | | | 20.42 | 20.0 |
| 1 | | 15-8 | 132 | 44.26 | 335.3 |
| 2 | | 2-5 | 131 | 41.03 | 313.2 |
| 3 | Late maturing (>130) days | 21-5 | 140 | 40.59 | 289.9 |
| 4 | | 33-14 | 141 | 39.98 | 283.5 |
| 5 | | 35-4 | 142 | 32.06 | 225.7 |
| Mean | | | 138 | 39.58 | 286.8 |
| Check | Moroberekan | | 140 | 20.60 | 147.1 |
| % increase over check | | | | 92.13 | 94.96 |

TABLE VII

*The top five superior segregants for grain yield in early, mid and late duration and percent increase over check by $F_3$ progenies of MAS 145 x MAS 946-1 cross*

| Sl. No. | Duration | Plant No. | Duration (days) | Yield per plant (g) | Yield per Plant (g) per day (mg) |
|---|---|---|---|---|---|
| 1 | | 21-15 | 120 | 40.15 | 334.5 |
| 2 | | 12-6 | 120 | 35.65 | 297.0 |
| 3 | Early duration (120) days | 1-3 | 120 | 35.16 | 293.0 |
| 4 | | 5-18 | 120 | 34.16 | 284.6 |
| 5 | | 18-14 | 120 | 32.26 | 268.8 |
| Mean | | | 120 | 35.47 | 295.5 |
| Check | MAS 99 | | 120 | 35.21 | 293.4 |
| % increase over check | | | | 0.80 | 0.80 |
| 1 | | 14-6 | 128 | 45.32 | 354.0 |
| 2 | | 3-7 | 125 | 41.23 | 329.8 |
| 3 | Medium duration (>120-130)days | 2-7 | 125 | 40.00 | 320.0 |
| 4 | | 5-12 | 124 | 33.56 | 270.6 |
| 5 | | 27-16 | 130 | 28.39 | 218.3 |
| Mean | | | 124 | 37.77 | 304.5 |
| Check | Rasi | | 125 | 28.20 | 225.6 |
| % increase over check | | | | 34.0 | 35.0 |
| 1 | | 29-20 | 135 | 40.25 | 298.1 |
| 2 | | 24-11 | 140 | 32.56 | 232.5 |
| 3 | Late maturing (>130) days | 7-13 | 130 | 32.13 | 247.1 |
| 4 | | 4-7 | 132 | 30.50 | 231.1 |
| 5 | | 27-16 | 145 | 20.16 | 139.0 |
| Mean | | | 137 | 31.12 | 227.1 |
| Check | Moroberekan | | 135 | 20.60 | 152.5 |
| % increase over check | | | | 51.10 | 48.9 |

respectively. The percent yield increase over checks was highest for late maturing superior segregants followed by mid maturing and early maturing segregants respectively in both cross derived progenies.

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# Influence of Nutrient Levels on Growth, Yield, Quality and Economics of First Ratoon Crop in Kalmegh (*Andrographis paniculata* Nees.)

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## Abstract

The experiment was laid out in a Factorial Randomized Complete Block Design (FRCBD) with 9 treatments and replicated thrice. The application of FYM @ 25 t $ha^{-1}$ along with 75 per cent nitrogen and 100 per cent potassium resulted in maximum plant height, number of primary branches, plant spread, herb yield and andrographilide content and yield. The highest B:C ratio and maximum net returns was also recorded with the same nutrient level in first ratoon crop of Kalmegh.

Kalmegh is one of the most important medicinal plant, known for its preventive and curative properties (Farooqi and Sreeramu., 2010). It is a herbaceous plant belonging to the family Acanthaceae. Kalmegh native to India and Sri Lanka and is known as king of bitters in English meaning dark cloud and *Bhunimba* in Sanskrit, *Nelabevu* in Kannada, whereas, it is more commonly referred as Andrographis across the world. Kalmegh is an erect herb, grows to a height of 30–90 cm, leaves petiolated, 2-3 cm long and 0.5-1.0 cm broad, lanceolate, hairy on the upper part. Small whitish flowers borne on spreading racemes forms fruit, called capsule, 2 cm long and a few millimetres wide and contains several brownish yellow seeds. The leaves contain more than 2 per cent andrographolide before the plant blooms and accounts to less than 0.5 per cent after flowering. The stem contains 0.1-0.4 per cent of andrographolide (Bhattacharya *et al*., 2012)

*Andrographis paniculata* exists in the list of highly traded Indian medicinal plant and also positioned as the 17th crop among 32 prioritized medicinal plants of India with a production of 5000 tonnes annually from the States of Assam, Bihar, Karnataka, Kerala, Madhya Pradesh, Andhra Pradesh, Uttar Pradesh and West Bengal as per National Medicinal Plant Board (Anon, 2007).

The herb is known to have anti-inflammatory, anti-biotic, anti-malarial, anti-hepatitic and anti-pyretic properties, besides its general use as an immune stimulant, it is useful in curing dysentry, diarrhoea, cholera, fever, diabetes, bronchitis, itches, hypertension, piles, gonorrhoea. A recent study has documented its anti-HIV properties (Sajwan, 2008). The heavy demand of andrographolide in Indian as well as international markets has motivated Indian farmers to take up commercial cultivation of Kalmegh (Kanjilal *et al*., 2002).

Nutrient management is a critical issue that determine quantity and quality of the harvested produce. Although, plant takes the essential nutrients throughout its life cycle, the nutrients are applied at different dosage at one or more stages of the crop growth, depending on the requirement of the crops. Further, Kalmegh crop is known to express ratoonability, for which optimization of different nutrient levels for higher production at lower cost is the need of the hour. Looking into the medicinal importance of Kalmegh and its ratoonabilty, the present investigation has been conducted.

## Material and Methods

The field experiment was carried at College of Horticulture, University of Horticultural Sciences Campus, Gandhi Krishi Vignana Kendra, Bengaluru, during August, 2015 to February, 2016. The experiment was laid out in a Factorial Randomized Complete Block Design (FRCBD) with 9 treatments and replicated thrice using IIHR local variety in fairly leveled land of red sandy loam soil with medium fertility status. Nursery was raised and the seedlings were transplanted at 45 days after sowing at a spacing of 30 x 20 cm in 1.8 x 1.4 m plots. The recommended dosage of fertilizers and manures (75:75:50 kg N: $P_2O_5$: $K_2O$ $ha^{-1}$ and 25 t FYM $ha^{-1}$) was applied for the main

crop and protective irrigation was given through drip system The main crop was harvested at 60 days after transplanting when, 50 per cent of the plant population attained flowering. While harvesting the plants were cut to a height of 2.5 cm from the ground level to facilitate for next successive ratoon crop. The experiement involves 3 levels of nitrogen ($N_1$: 75 per cent recommended nitrogen, $N_2$: 50 per cent recommended nitrogen and $N_3$: 25 per cent recommended nitrogen) and 3 levels of potassium ($K_0$: no potassium, $K_1$: 50 per cent recommended potassium and $K_2$: 100 per cent recommended potassium) and no phosphorous. The nutrients were applied to ratoon crop as per treatment details viz., $T_1$ ($N_1K_0$), $T_2$ ($N_1K_1$), $T_3$ ($N_1K_2$), $T_4$ ($N_2K_0$), $T_5$ ($N_2K_1$), $T_6$ ($N_2K_2$), $T_7$ ($N_3K_0$), $T_8$ ($N_3K_1$) and $T_9$ ($N_3K_2$) at ten days after harvesting of the main crop.

Five representative plants in each treatment and in each replication, were randomly selected, tagged and observations were recorded. The mean data recorded on plant height, number of primary branches, plant spread, days to initiation of blooming and 50 per cent flowering, herb yield and andrographolide content and yield from five plants were used for statistical analysis. The Andrographolide content was analysed by using Soxhlet apparatus with analytical grade methanol, determined in HPLC (High Performance Liquid Chromatography) equipment using HPLC grade methanol and andrographolide standard (Agarwal and Murali., 2010). The cost of cultivation was worked out by considering market price of different inputs used, the labour charges and miscellaneous expenditures that were prevailing at the time of conducting the experiment.

## Results and Discussion

*Influence of nutrient levels (N & K) on growth attributes of Kalmegh in first ratoon crop* : In the first ratoon crop, the plants supplied with 75 per cent nitrogen (122.28 kg $ha^{-1}$) recorded significantly taller plants (26.01 cm), maximum number of primary branches (14.98), plant spread (408.13 $cm^2$) which was *at par* with 50 per cent nitrogen (81.52 kg $ha^{-1}$) Table I. Similar results were obtained by Ram *et al.* (2008) and Gudade (2013) in Kalmegh, The enhanced growth with 75 and 50 per cent nitrogen might be due to increased availability of nitrogen supply which would have promoted protein synthesis from reserved carbohydrate source leading to enhancement of growth parameters.

The 100 per cent potassium (83.33 kg $ha^{-1}$) recorded significantly maximum plant height (25.60 cm), number of primary branches (14.40), plant spread (396.91 $cm^2$) in first ratoon crop which was *at par* with 50 per cent potassium (41.66 kg $ha^{-1}$) (Table 1). The increased nutrient availability and higher uptake of nutrients perhaps enhanced the physiological activity, which might have resulted in better growth. These results are in line with the result obtained by Rasmia Ali *et al.* (2009) in Periwinkle. Nitrogen and potassium at all levels showed non-significant differences on days to initiation of blooming and days to 50 per cent flowering.

*Influence of nutrient levels (N & K) on yield and quality parameters in first ratoon crop of Kalmegh* : The plants fertilized with 75 per cent nitrogen and 100 per cent potassium recorded significantly maximum fresh and dry weights of leaves, stem and herb yield, andrographolide content and andrographolide yield which was *on par* with 50 per cent nitrogen and potassium (Table II). Better availability of nutrients would have resulted in maximum production of herb. Similar, results were reported by Tiwari. (2012) in Kalmegh who reported increased herb yield with higher dosage of 60 kg N $ha^{-1}$ applied through FYM along with 60 kg N $ha^{-1}$ through urea. This is due to the fact that, nitrogen is an essential constituent of chlorophyll, which helps in capturing the solar energy and production of more photosynthates. The potassium application at appropriate time and required concentration is known to increase the abscisic acid content, rendering closure of stomata causing reduction in transpiration rate which maintains higher water potential leading to increased fresh weight (Renata *et al.*, 2011).

The Nitrogen and potassium levels had a significant influence on quality parameters. The 75 and 50 percent dosage of N and K, might have resulted in better accumulation of assimilates, leading to improved quality. Potassium is responsible for energy production in the form of ATP and NADPH in chloroplasts by

TABLE I

*Influence of nutrient levels (N & K) on growth attributes of Kalmegh in first ratoon crop*

| Treatment | Plant height (cm) | Number of Primary branches | Plant Spread ($cm^2$) | Days to initiation of blooming | Days to 50 % flowering |
|---|---|---|---|---|---|
| $N_1$ | 26.01 | 14.98 | 408.13 | 29.53 | 42.42 |
| $N_2$ | 23.80 | 13.40 | 365.44 | 29.99 | 43.89 |
| $N_3$ | 22.14 | 12.47 | 325.96 | 29.16 | 44.27 |
| S.Em. ± | 0.73 | 0.50 | 13.96 | 1.21 | 1.58 |
| CD (P=0.05) | 2.18 | 1.50 | 41.85 | NS | NS |
| $K_0$ | 22.89 | 12.00 | 339.87 | 29.38 | 43.93 |
| $K_1$ | 23.30 | 12.86 | 354.76 | 29.52 | 43.23 |
| $K_2$ | 25.60 | 14.40 | 396.91 | 29.78 | 43.40 |
| S.Em. ± | 0.73 | 0.50 | 13.96 | 1.21 | 1.58 |
| CD (P=0.05) | 2.18 | 1.50 | 41.85 | NS | NS |
| $N_1K_0$ | 24.23 | 13.73 | 364.60 | 29.47 | 43.53 |
| $N_1K_1$ | 26.67 | 15.33 | 402.40 | 29.13 | 42.60 |
| $N_1K_2$ | 27.13 | 15.87 | 457.40 | 28.87 | 42.53 |
| $N_2K_0$ | 23.93 | 13.40 | 352.87 | 29.80 | 43.87 |
| $N_2K_1$ | 25.87 | 14.07 | 387.07 | 29.47 | 43.33 |
| $N_2K_2$ | 26.20 | 14.27 | 392.40 | 29.33 | 43.07 |
| $N_3K_0$ | 20.50 | 11.87 | 302.13 | 30.07 | 44.40 |
| $N_3K_1$ | 22.47 | 12.47 | 334.80 | 29.97 | 44.27 |
| $N_3K_2$ | 23.47 | 13.07 | 340.93 | 29.93 | 44.13 |
| S.Em. ± | 1.26 | 0.87 | 24.18 | 2.09 | 2.74 |
| CD (P=0.05) | NS | NS | NS | NS | NS |
| CV | 8.92 | 10.88 | 11.30 | 12.23 | 10.90 |

Note:

$T_1$ ($N_1K_0$) - Rec. dosage of FYM + 75 per cent N + 0 per cent K
$T_2$ ($N_1K_1$) - Rec. dosage of FYM + 75 per cent N + 50 per cent K
$T_3$ ($N_1K_2$) - Rec. dosage of FYM + 75 per cent N + 100 per cent K
$T_4$ ($N_2K_0$) - Rec. dosage of FYM + 50 per cent N + 0 per cent K
$T_5$ ($N_2K_1$) - Rec. dosage of FYM + 50 per cent N + 50 per cent K
$T_6$ ($N_2K_2$) - Rec. dosage of FYM + 50 per cent N + 100 per cent K
$T_7$ ($N_3K_0$) - Rec. dosage of FYM + 25 per cent N + 0 per cent K
$T_8$ ($N_3K_1$) - Rec. dosage of FYM + 25 per cent N + 50 per cent K
$T_9$ ($N_3K_2$) - Rec. dosage of FYM + 25 per cent N + 100 per cent K

**Factor A: Nitrogen levels**
$N_1$ : 75 per cent Nitrogen
$N_2$ : 50 per cent Nitrogen
$N_3$ : 25 per cent Nitrogen

**Factor B: Potassium levels**
$K_0$ : 0 per cent Potassium
$K_1$ : 50 per cent Potassium
$K_2$ : 100 per cent Potassium

TABLE II

*Influence of nutrient levels (N & K) on yield and quality parameters in first ratoon crop of Kalmegh*

| Treatment | Fresh weight of leaves (g) | Dry weight of leaves (g) | Fresh weight of leaves (g) | Dry weight of leaves (g) | Fresh weight of leaves (g) | Dry weight of leaves (g) | Andrographolide content (%) | Andrographolide yield (kg ha $^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| $N_1$ | 28.23 | 10.15 | 17.21 | 8.04 | 4.91 | 1.96 | 2.18 | 42.79 |
| $N_2$ | 25.12 | 9.41 | 15.66 | 7.61 | 4.47 | 1.80 | 1.93 | 37.45 |
| $N_3$ | 22.20 | 8.70 | 13.48 | 5.81 | 3.70 | 1.48 | 1.82 | 28.56 |
| S.Em. ± | 1.00 | 0.24 | 0.18 | 0.10 | 0.15 | 0.06 | 0.08 | 1.10 |
| CD (P=0.05) | 2.99 | 0.71 | 0.52 | 0.29 | 0.43 | 0.18 | 0.23 | 3.31 |
| $K_0$ | 22.26 | 8.37 | 14.33 | 6.59 | 3.95 | 1.54 | 1.75 | 28.70 |
| $K_1$ | 23.69 | 9.06 | 15.71 | 7.25 | 4.00 | 1.60 | 1.95 | 37.00 |
| $K_2$ | 26.91 | 9.86 | 16.30 | 7.60 | 4.51 | 1.80 | 2.23 | 40.36 |
| S.Em. ± | 1.00 | 0.24 | 0.18 | 0.10 | 0.15 | 0.06 | 0.08 | 1.10 |
| CD (P=0.05) | 2.99 | 0.71 | 0.52 | 0.29 | 0.43 | 0.18 | 0.23 | 3.31 |
| $N_1K_0$ | 26.23 | 9.64 | 15.80 | 7.64 | 4.68 | 1.87 | 1.91 | 35.71 |
| $N_1K_1$ | 27.83 | 10.34 | 17.43 | 8.12 | 4.85 | 1.94 | 2.29 | 44.42 |
| $N_1K_2$ | 30.63 | 10.47 | 18.40 | 8.35 | 5.19 | 2.07 | 2.33 | 48.23 |
| $N_2K_0$ | 25.93 | 9.40 | 14.80 | 7.14 | 4.00 | 1.60 | 1.81 | 28.96 |
| $N_2K_1$ | 26.40 | 9.84 | 15.97 | 7.78 | 4.32 | 1.72 | 2.19 | 37.66 |
| $N_2K_2$ | 26.93 | 10.19 | 16.20 | 7.90 | 4.49 | 1.79 | 2.22 | 39.73 |
| $N_3K_0$ | 20.60 | 8.46 | 12.40 | 5.00 | 3.50 | 1.40 | 1.53 | 21.42 |
| $N_3K_1$ | 22.83 | 8.73 | 13.73 | 5.86 | 3.73 | 1.49 | 2.09 | 31.14 |
| $N_3K_2$ | 23.17 | 8.92 | 14.30 | 6.56 | 3.86 | 1.54 | 2.15 | 33.11 |
| S.Em. ± | 1.73 | 0.41 | 0.33 | 0.32 | 0.27 | 0.10 | 0.13 | 1.91 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS |

NS : Non-Significant

TABLE III

*Economics of first ratoon crop of Kalmegh as influenced by nutrient levels*

| Treatment | Cost of Cultivation (Rs.ha$^{-1}$) | Gross Returns (Rs.ha$^{-1}$) | Net Returns (Rs.ha$^{-1}$) | B : C ratio |
|---|---|---|---|---|
| $T_1$ ($N_1K_0$) – Rec. dosage of FYM + 75%N + 0%K | 39834 | 112200 | 72366 | 1.81 |
| $T_2$ ($N_1K_1$) – Rec. dosage of FYM + 75%N + 50%K | 40626 | 116400 | 75774 | 1.86 |
| $T_3$ ($N_1K_2$) – Rec. dosage of FYM + 75%N + 100%K | 41417 | 124200 | 82783 | 1.99 |
| $T_4$ ($N_2K_0$) – Rec. dosage of FYM + 50%N + 0%K | 39589 | 96000 | 56411 | 1.42 |
| $T_5$ ($N_2K_1$) – Rec. dosage of FYM + 50%N + 50%K | 40381 | 103200 | 62819 | 1.55 |
| $T_6$ ($N_2K_2$) – Rec. dosage of FYM + 50%N + 100%K | 41172 | 107400 | 66228 | 1.60 |
| $T_7$ ($N_3K_0$) – Rec. dosage of FYM + 25%N + 0%K | 39345 | 84000 | 44655 | 1.13 |
| $T_8$ ($N_3K_1$) – Rec. dosage of FYM + 25%N + 50%K | 40136 | 89400 | 49264 | 1.22 |
| $T_9$ ($N_3K_2$) – Rec. dosage of FYM + 25%N + 100%K | 40927 | 92400 | 51473 | 1.25 |

Cost of dry leaf of Kalmegh per kg : Rs. 60.

maintaining balanced electric charges, which resulted in higher production of photosynthates may be the reason for increased andrographolide content and yield in Kalmegh. These results are in conformity with findings of Sanjutha *et al*. (2008) in Kalmegh where in the application of FYM @ 15 t ha$^{-1}$ + NPK @ 75:75:50 kg ha$^{-1}$ and panchagavya @ 3 per cent as foliar spray recorded maximum andrographolide content and andrographolide yield.

The interaction between nitrogen and potassium levels was found non-significant with respect to all the growth parameters and yield attributes in the ratoon crop at the time of harvest.

The highest B:C ratio of 1.99:1.00 and net return of Rs 82,783 was realised with combination of 25 tonnes FYM ha$^{-1.}$ + 75 per cent N + 100 per cent K. (Table III). The increase in the return may be attributed enhanced herb yield due to optimum level of nutrients supplied to meet the required demand of the crop. These findings are in line with study conducted by Aladakatti *et al*. (2012).

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*Economics of first ratoon crop of Kalmegh as influenced by nutrient levels* : The highest B:C ratio of 1.99:1.00 and net return of Rs 82,783 was realised with combination of 25 tonnes FYM ha$^{-1.}$ + 75 per cent N + 100 per cent K. (Table III). The increase in the return may be attributed enhanced herb yield due to optimum level of nutrients supplied to meet the required demand of the crop. These findings are in line with study conducted by Aladakatti *et al*. (2012).

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# An Ecofriendly IPM Module for the Suppression of *Diaphania pulverulentalis* (Hampson) (Lepidoptera : Pyralidae) in Mulberry

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## Abstract

A field investigation was carried out to evaluate the efficacy of an integrated pest management module against *Diaphania pulverulentalis* (Hampson) on mulberry during 2011 and 2012. The IPM module consisting of spray of 4 per cent NSKE at 15 to 20 days after pruning (DAP) + spray of *Dp*NPV @ 27.65 × $10^5$ PIBs/ml at 25 to 30 DAP+ release of *Trichogramma chilonis* Ishii @ 1 lakh/acre at 45 to 50 DAP was adopted. The pest infestation of 47.27, 40.13, 32.35, 22.28 and 11.55 per cent was recorded in IPM module imposed gardens in comparison with chemical control treated plots, wherein it was 45.66, 33.75, 23.28, 20.70 and 19.04 per cent, respectively at 15, 25, 35, 45 and 65 days after treatment (DAT). The larval population in the IPM module treated plots was found to be 5.61, 4.10, 2.95, 2.73 and 2.43 larvae per plant, respectively in comparison with chemical treated plots, wherein it was 5.15, 3.53, 2.70, 2.58 and 2.02 larvae per plant, respectively at 15, 25, 35, 45 and 65 DAT. Therefore, the IPM module was evidentially efficient over chemical control at 65 DAT. The cost of IPM intervention was found to be Rs. 350 per acre/crop in comparison with the chemical control (Rs. 500 per acre / crop). The net gain in case of IPM module was found to be Rs. 2,500 per acre / crop, as compared to the chemical control (Rs. 2,350 per acre/crop), thus, the cost-benefit ratio was found to be maximum in case of IPM module (1:7.14) as compared to the chemical control (1:4.70). The present study clearly revealed that the adoption of IPM module *i.e.,* spray of 4 per cent NSKE at 15 to 20 days after pruning (DAP) + *Dp*NPV @ 27.65 × $10^5$ PIBs/ml at 25 to 30 DAP+ release of *T. chilonis* @ 1 lakh/acre at 45 to 50 DAP against mulberry leaf roller was effective in reducing the pest infestation under field conditions, besides being silkworm friendly and eco-friendly as well as cost effective.

Sericulture is an important means of livelihood and socio-economic development of the farming community in general and Karnataka in particular. Insect and non-insect pests cause significant loss to the biomass and quality of mulberry leaf. Among the defoliators, the leaf roller, *Diaphania pulverulentalis* (Hampson) (Lepidoptera: Pyralidae) is causing serious damage to mulberry in South India in recent years (Siddegowda *et al*., 1995; Geethabai *et al*., 1997; Manjunath Gowda *et al*. 2005). The incidence of leaf-roller and mulberry leaf yield loss were recorded to be 70.30 and 25.20 per cent, respectively. It appeared during June and persisted upto February and the disappearance of this pest from March to May focused the possible pupal diapause (Rajadurai *et al*., 1999). In Karnataka, the incidence of *D. pulverulentalis* on mulberry ranged from 0 to 100 per cent, being severe in winter months (October to February) and reduced to 0 to 30 per cent in summer months (March to June) (Siddegowda *et al*., 1995). Indiscriminate application of chemical insecticides for suppression of *D. pulverulentalis* in mulberry is not a viable practice, keeping in view the health of the silkworm. Under the present circumstances, the integrated Pest Management (IPM) is an environmentally safe method that combines biological and non-biological techniques to suppress weeds, insects and diseases (Nordlund, 1997). Hence, the present investigations were taken up with the objective of evaluation of the IPM module against *D. pulverulentalis* under mulberry eco-system in the traditional sericultural districts of Karnataka.

## Material and Methods

The material used and methodologies adopted in conducting the studies on the evaluation of integrated pest management (IPM) interventions against mulberry leaf roller, *D. pulverulentalis* during 2010-11 to 2012-13 at selected mulberry gardens (in farmers' field situation) at Ramanagara and Chickballapur Districts. The mulberry plot sizes of 5×5 m, having 30 plants each was considered for imposition of IPM components and also for chemical and absolute controls. Seven such plots were considered for IPM and control as replications. In each replication / plot, 10 plants were randomly selected and labelled for

recording the number of shoots infested and larval population at 15, 25, 35, 45 and 65 DAT. The data was subjected to RCBD statistical analysis to draw the inference.

## RESULTS AND DISCUSSION

The results pertaining to the effect of eco-friendly IPM module on *D. pulverulentalis* consisting of spray of 4 per cent NSKE at 15 to 20 days after pruning (DAP) + spray of *Dp*NPV @ 27.65 × $10^5$ PIBs / ml at 25 to 30 DAP+ release of *T. chilonis* @ 1 lakh / acre at 45 to 50 DAP are presented hereunder. The pooled mean of the data on pest infestation at 15, 25, 35 and 45 DAT revealed that the chemical control (45.66, 33.75, 23.28 and 20.70 per cent, respectively) was found to be significantly superior than IPM treated plots; which was recorded to be 47.27, 40.13, 32.35 and 22.28 per cent, respectively. However, the rate of infestation was 57.44, 62.13, 65.03 and 67.63 per cent in the untreated mulberry gardens (Table I). Thus it is vivid that, the rate of infestation was reduced as DAT increased in both chemical and IPM treated mulberry plots, the difference between the latter two was not significant.

Pooled mean of the data on pest infestation from both the locations at 65 DAT revealed significantly minimum pest infestation in IPM module (11.55%),

TABLE I

*Effect of IPM module on infestation of D.pulverulentalis under field conditions*

| Location | Treatment | Per cent Infestation | | | | | |
|---|---|---|---|---|---|---|---|
| | | Before treatment | 15 DAT | 25 DAT | 35 DAT | 45 DAT | 65 DAT |
| | IPM module | 65.02 b | 51.64 a | 43.57 b | 32.80 b | 20.15 a | 8.92 a |
| | Chemical control | 66.23 b | 51.68 a | 37.70 a | 25.70 a | 22.63 b | 20.60 b |
| | Absolute Control | 158.00 a | 63.58 b | 68.10 c | 70.54 c | 73.09 c | 75.68 c |
| CSH | F - Test | * | * | * | * | * | * |
| | SEm± | 1.16 | 1.23 | 0.92 | 0.66 | 0.65 | 0.44 |
| | CD (P=0.05) | 3.77 | 4.00 | 3.01 | 2.14 | 2.13 | 1.42 |
| | CV (%) | 4.10 | 4.93 | 4.15 | 3.42 | 3.77 | 2.78 |
| | IPM module | 48.32 a | 42.90 b | 36.69 b | 31.78 b | 24.40 b | 14.18 b |
| | Chemical control | 49.52 a | 39.64 c | 29.75 c | 20.86 c | 18.78 c | 17.47 b |
| | Absolute Control | 44.11 b | 51.29 a | 56.15 a | 59.52 a | 62.18 a | 71.44 a |
| JSH | F - Test | * | * | * | * | * | * |
| | SEm± | 0.40 | 0.41 | 0.35 | 0.29 | 0.33 | 1.03 |
| | CD (P=0.05) | 1.31 | 1.34 | 1.14 | 0.94 | 1.08 | 3.36 |
| | CV (%) | 1.90 | 2.06 | 1.91 | 1.73 | 2.12 | 6.70 |
| | IPM module | 56.67 b | 47.27 b | 40.13 b | 32.35 b | 22.28 b | 11.55 a |
| | Chemical control | 57.87 b | 45.66 a | 33.75 a | 23.28 a | 20.70 a | 19.04 b |
| | Absolute Control | 51.06 a | 57.44 c | 62.13 c | 65.03 c | 67.63 c | 73.56 c |
| Pooledmean | F - test | * | * | * | * | * | * |
| | SEm± | 0.38 | 0.45 | 0.36 | 0.26 | 0.26 | 0.37 |
| | CD (P=0.05) | 1.25 | 1.46 | 1.17 | 0.85 | 0.85 | 1.22 |
| | CV (%) | 1.55 | 2.00 | 1.77 | 1.45 | 1.58 | 2.41 |

Note: *5 per cent level of significance

Means followed by the same alphabet are not significantly different

IPM module – 4% NSKE spray at 15 - 20 DAP + *Dp*NPV spray @ 27.65 × $10^5$PIBs / ml at 25 – 30 DAP + *T. chilonis* release @ 1 lakh / acre at 45 – 50 DAP

DAP – Days of pruning; DAT – Days after treatment; CSH-Chikkasadenahalli; JSH-Jangamaseegenahalli

followed by that in case of chemical control (19.04%). However, significant maximum infestation was recorded in absolute control (73.56%). The pooled analysis of the data of both the locations revealed the significant superiority of IPM module over chemical control at 65 DAT (Table I). The present findings are similar to those of Muthuswami (2004), who reported that an IPM module consisting of irrigation of mulberry garden (on the day of pruning), releasing *Tetrastichus howardii* @ 50,000/ha (one day after pruning) and *T. chilonis* @ 5cc/ha (10 days after pruning), spraying of dichlorvos @ 1ml/lit (30 days after pruning), mechanical clipping and burning of affected shoots (40 days after pruning) was effective in leaf roller management. Similarly, demonstration of IPM practice against *D. pulverulentalis* taken up in farms of Karnataka, adopting three IPM components *viz*., spray of DDVP 0.076 %, release of egg parasitoid and pupal parasitoid resulted in suppression of pest incidence by 47 to 53 per cent over the control (Anon. 2008). Similarly at RSRS, Chamarajanagara, Karnataka and RSRS, Salem (Tamil Nadu), 2.54 to 7.35 per cent and 3.0 to 16.22 per cent reduction in the pest incidence was achieved when IPM package was adopted (Anon. 2000). Further, Gururaj and Choudhury (2001) reported that percentage reduction was significantly highest in IPM (79 %), followed by chemical control (67 %) and least in physical control (35 %) and they opined that IPM module can be advocated for management of leaf roller in mulberry.

Analysis of the pooled data on larval population as influenced by the effect of IPM module, in both the locations, revealed that larval population of 15, 25, 35 and 45 DAT was 5.61, 4.10, 2.95 and 2.73 larvae / plant, respectively as against chemical control (5.15, 3.53, 2.70 and 2.58 larvae / plant, respectively) and absolute control (5.82, 6.15, 6.00 and 6.95 larvae / plant, respectively) (Table II). In the IPM and chemical treated mulberry plots, the larval population was decreased as the DAT increased, as compared to larval population before imposition of treatments as well as in absolute control.

Pooled mean analysis of the data of both the locations at 65 DAT, revealed that significant differences existed between the three treatments. Significantly minimum larval population of *D. pulverulentalis* was recorded in chemical control (2.02 larvae/plant), whereas, it was significantly maximum in case of absolute control (7.58 larvae/ plant). It was slightly higher in IPM module when compared to chemical control (2.43 larvae/plant) (Table II), but chemical control was superior than IPM module. Earlier workers like Velavan (2001) reported that when the parasitoids, *Tetrastichus howardii* and *Trichogramma chilonis* were integrated with spray of propoxur (0.1%), the larval population was reduced to 2.46 larvae / plant, as against 60.37 in untreated control. Integration of natural enemies *viz*., egg parasitoids at 5 cubic centimeter / ha (@ 30 days after pruning (DAP)) and pupal parasitoid at 0.25 million adults/ha (53 DAP) with chemical propoxur 20 EC at one per cent (45 DAP) showed significant reduction in leaf webber larval population by 61.38 per cent as well as shoot damage by 41.39 per cent over control. Similarly, Manjunath Gowda *et al*. (2005) reported that clipping and burning of affected plant parts and spraying 0.2 per cent dichlorvos (76% EC) reduces the larval population of leaf roller. Installation of light traps and providing bird perches in mulberry garden has been recommended for the suppression of the pest. Other insecticides like monocrotophos (0.072%), neem seed kernel extract and neem oil have also been found to be effective against the pest.

The cost of IPM intervention was found to be Rs. 350 per acre/crop in comparison with the chemical control (Rs. 500 per acre/crop) (Table III). The net gain in case of IPM module was found to be Rs. 2,500 per acre/crop, as compared to the chemical control (Rs. 2,350 per acre/crop). Therefore, the cost - benefit ratio was found to be maximum in case of IPM module (1:7.14) as compared to the chemical control (1:4.70).

Therefore, the IPM module evaluated against *D. pulverulentalis* has proved to be on par with chemical control, not only in its efficacy, besides safeguarding the health of silkworm. However, IPM module has proved its cost-worthiness by virtue of its higher cost-benefit ratio than chemical control.

TABLE II

*Effect of IPM module on larval population of D. pulverulentalis under field conditions*

| Location | Treatment | Larval population (No. / plant) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Before treatment | 15 DAT | 25 DAT | 35 DAT | 45 DAT | 65 DAT |
| | IPM module | 9.85 b | 3.45 a | 1.75 a | 0.58 a | 1.92 b | 3.11 b |
| | Chemical control | 9.97 b | 3.81 a | 1.55 a | 0.50 a | 1.18 a | 2.03 a |
| | Absolute Control | 4.55 a | 5.81 b | 6.11 b | 6.28 b | 6.65 c | 7.31 c |
| CSH | F - Test | * | * | * | * | * | * |
| | SEm± | 0.11 | 0.11 | 0.11 | 0.11 | 0.12 | 0.17 |
| | CD (P=0.05) | 0.37 | 0.36 | 0.34 | 0.36 | 0.39 | 0.54 |
| | CV (%) | 3.17 | 5.73 | 7.47 | 10.00 | 8.23 | 8.97 |
| | IPM module | 9.12 b | 7.78 c | 6.48 b | 5.31 b | 3.55 a | 1.75 a |
| | Chemical control | 9.23 b | 6.47 b | 5.51 a | 4.96 a | 3.98 b | 2.01 b |
| | Absolute Control | 4.78 a | 5.82 a | 6.18 b | 6.75 c | 7.25 c | 7.85 c |
| JSH | F - Test | * | * | * | * | * | * |
| | SEm± | 0.12 | 0.10 | 0.10 | 0.09 | 0.10 | 0.08 |
| | CD (P=0.05) | 0.40 | 0.31 | 0.31 | 0.29 | 0.33 | 0.25 |
| | CV (%) | 3.53 | 3.22 | 3.53 | 3.52 | 4.56 | 4.48 |
| | IPM module | 9.48 b | 5.61 b | 4.10 b | 2.95 a | 2.73 a | 2.43 b |
| | Chemical control | 9.60 b | 5.15 a | 3.53 a | 2.70 a | 2.58 a | 2.02 a |
| | Absolute Control | 4.67 a | 5.82 b | 6.15 c | 6.00 b | 6.95 b | 7.58 c |
| Pooledmean | F - Test | * | * | * | * | * | * |
| | SEm± | 0.12 | 0.10 | 0.09 | 0.10 | 0.11 | 0.11 |
| | CD (P=0.05) | 0.38 | 0.33 | 0.30 | 0.32 | 0.35 | 0.35 |
| | CV (%) | 3.33 | 4.06 | 4.54 | 5.33 | 5.81 | 5.91 |

Note : *5 per cent level of significance

Means followed by the same alphabet are not significantly different

IPM module – 4% NSKE spray at 15 - 20 DAP + *Dp*NPVspray @ $27.65 \times 10^5$ PIBs / ml at 25 – 30 DAP + *T. chilonis* release @ 1 lakh / acre at 45 – 50 DAP

DAP – Days of pruning; DAT – Days after treatment; CSH-Chikkasadenahalli; JSH-Jangamaseegenahalli

TABLE III

*Economics of application of IPM module for mulberry leaf-roller management under field conditions*

| Particulars | IPM module (per acre / crop) | Chemical control (per acre / crop) |
|---|---|---|
| Yield loss due to pest attac | 475 kg* | 475 kg* |
| Monetary loss due pest attack (@ Rs.10/kgmulberry leaf)* | Rs.2850 | Rs.2850 |
| Cost of management | Rs.125+175+ 50= 350 | Rs. 250 × 2 sprays = 500 |
| Net gain (2-3) | Rs. 2500 | Rs.2350 |
| Cost benefit ratio (4/3) | 1:7.14 | 1:4.70 |

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# Estimation of Regression Parameters in Bootstrapping - An Application on Non-farm Income

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## ABSTRACT

An attempt has been made to estimate the regression parameters using bootstrap procedure for the response variables non-farm income,investmentmadeand employment in Cauvery command area of Vishweshwaraiah canal region of Mandya district of Karnataka.The explanatory variables such as age, farm income, type of nonfarm activity, seasonality of nonfarm produce and other income sources are observed to be having significant effect on employment generation. Among these the type of nonfarm activity and seasonality of the nonfarm produce are found to be more effective on employment. The income is influenced by seasonality of the nonfarm produce and the reason for taking nonfarm activityas a source of additional income for the house hold. The investment is affected by farm income and seasonality of the non farm produce.

REGRESSION models are very useful and widely used tool. They allow relatively simple analysis of complicated situations, where it is attempted to sort out the effects of many possible explanatory variables on a response variable (Fox, 2008). This regression procedure can also be used in resampling procedures. One of the frequently used resampling techniques is bootstrapping. Bootstrapping (Efron and Tibshirani,1993) is a general approach to statistical inference based on building a sampling distribution for a statistic by resampling from the data on hand. This approach uses computer based methods to provide estimates and measures of precision without theoretical models or restrictive assumptions of the sampled populations. Regression procedure used with this resampling technique is known as bootstrapping regression (Bose and Chatterjee, 2002; Sahinler and Gorgulu, 2003). There are very few studies (Assif and Mathwie, 2010, Berezowski, *et.al.,* 2004; Sahinler and Gorgulu, 2003) on application of this technique in agriculture and hardly any study for the socio-economic data. This paper is about the application of this technique for the socio-economic data (Schroeder, 1992; Smith, 2000; Takeshita, 1999). The study makes use of the data generated on non-farm income, investment and employment generated for Cauvery command area in Karnataka the details of which are given in the next section.

This study focuses on illustration and application of resampling techniques inregression analysis. Some hierarchical algorithms of concerning techniques in regression analysis are demonstrated. The basics of the bootstrap techniques and their applications to the real numerical example that can be described by linearregression model are discussed.

## MATERIAL AND METHODS

The secondary data used is from the project on role and contribution of irrigation towards rural nonfarm activity-A case of Cauvery command area in Karnataka. The study area has 418 households having non farm activities and the data consist following socio economic characters from each of the households as the independent variable. They are $X_1$: Age, $X_2$: Family type (categorical variable), $X_3$: Family size, $X_4$: Number of working adults, $X_5$: Annual farm income, $X_6$: Type of nonfarm activity (categorical variable), $X_7$: Seasonality of the produce (categorical variable), $X_8$: Otherincome sources (categorical variable), $X_9$: Additional income (categorical variable), $X_{10}$: Resource diversification (categorical variable). The dependent variables are Y: Employment generation, Income generation and investment made on nonfarm activity.The statistical packageSAS(Version 9.3 Module Base SAS) is usedfor the statistical analysis of these data.

To describe the resampling methods start with an n sized sample *Wi=(Yi,Xi)* and assume that $w_i$'s are drawn independently and identically, where $Y_i = (y_1, y_2, ..., y_n)'$ contains the responses, $X_{ji} = (x_{j1}, x_{j2}, ..., x_{jn})$ is a matrix of dimension n x k, where j=1,2,...k, i=1,2,3,...,n.

*Method of drawing bootstrap samples :* Multiple linear regression was fitted to response variable Y and all the explanatory variables considered. 1000 samples each of size 418 are drawn with replacement.

*Bootstrapping regression algorithm based on the resampling observations :* This approach is usually applied when the regression models built from data have regressors that are as random as the response. Let the (k+1) x1 vector $w_i = (y_i, x_{ji})'$ denote the values associated with $i^{th}$ observation. In this case, the set of observations are the vectors $(w_1, w_2, ..., w_n)$. The bootstrap procedure based on the resampling observations is as follows :

1. Draw a n sized bootstrap sample $(w_1^{(b)}, w_2^{(b)}, \ldots, w_n^{(b)})$ with replacement from the observations giving 1/n probability to each $w_i$ values and label the elements of each vector as follows $w_i^{(b)} = (y_i^{(b)}, x_{ji}^{(b)})'$ where j= 1,2,…,k and i= 1,2,…,n. From these form the vector $Y_i^{(b)} = (y_1^{(b)}, y_2^{(b)}, ..., y_n^{(b)})'$ and the matrix $X_{ji}^{(b)} = (x_{j1}^{(b)}, x_{j2}^{(b)}, ..., x_{jn}^{(b)})'$

2. Calculate the OLS co-efficients from the bootstrap sample: $\hat{\beta}^{(b1)} = (X^{(b)'} X^{(b)})^{-1} X^{(b)'} Y^{(b)}$

3. Repeat the steps 1 and 2 for r = 1, 2,…, B where, B is the number of repetitions.

4. The bootstrap estimate of regression coefficient is the mean of the coefficients and it is given by

$$\hat{\beta}_i^{(b)} = \frac{\sum_{r=1}^{B} \hat{\beta}_i^{(br)}}{B}$$

where, i= 1,2…k

Thus, the bootstrap regression equation is $\hat{Y} = X\hat{\beta}^{(b)}$ where, $\hat{\beta}^{(b)}$ is the unbiased estimator of $\hat{\beta}$(Shao, 1995).

**The bootstrap bias, variance, confidence and percentile interval**

The bootstrap bias equals,

$$bias_b = \hat{\beta}^{(b)} - \hat{\beta}$$

The bootstrap variance is calculated by

$$\mathrm{var}(\hat{\beta}^{(b)}) = \frac{\sum_{r=1}^{B} [(\hat{\beta}^{(br)} - \hat{\beta}^{(b)})(\hat{\beta}^{(br)} - \hat{\beta}^{(b)})']}{B-1}$$

where, r = 1,2,...,B

The bootstrap confidence interval by normal approach is obtained by

$$\hat{\beta}^{(b)} - t_{n-p,\alpha/2} * S_e(\hat{\beta}^{(b)}) < \beta < \hat{\beta}^{(b)} + t_{n-p,\alpha/2} * S_e(\hat{\beta}^{(b)})$$

Where, $t_{n-p,\alpha/2}$ is the critical value of t with probability á/2 the right for n-p degrees of freedom and $S_e(\hat{\beta}^{(b)})$ is the standard error of the $\hat{\beta}^{(b)}$

$$S_e(\hat{\beta}^{(b)}) = \sqrt{\frac{\sum_{r=1}^{B} [(\hat{\beta}^{(br)} - \hat{\beta}^{(b)})(\hat{\beta}^{(br)} - \hat{\beta}^{(b)})']}{B-1}}$$

## RESULTS AND DISCUSSION

*Summary statistics of bootstrap regression for the entire study area :* Table I represents the summary statistics of the bootstrapping regression coefficients for entire study area, where it estimates the effect of 10 explanatory variables with the respective response variables. The age, annual farm income,other income sources are found to be statistically significant at 5 per cent level of significant and type of nonfarm activity, seasonality of nonfarm produce are observed statistically significant at 1 per cent level of significant for the dependent variable employment. When income is taken as dependent variable, the seasonality of nonfarmproduce and additional income are found to be statistically significant at 5 per cent level of significance. Annual farm income and seasonality of nonfarmproduce are found to be statistically significant at 5 per cent level of significance for the response variable investment.

*Confidence interval for bootstrapping regression for the entire study area :* Table II gives the confidence interval for the coefficients at 95 per cent level of confidence.

Among the ten independent variables considered to find their impact on the response variables such as employment, income and investment some are found to have significant effect, and these are discussed in the following paragraph with respect to the entire command area.

For the entire command area the explanatory variables such as age, farm income, type of nonfarm activity, seasonality of nonfarm produce and other income sources are observed to be having significant effect on employment generation. Among these, the type of nonfarm activity and seasonality of the nonfarm

TABLE I

*Summary statistics of bootstrap regression for the entire study area*

(n=418, B=1000)

| Coefficients | Dependent variables | | |
|---|---|---|---|
| | Employment | Income | Investment |
| $\beta_0$ | 0.822 | -151.9 * | -96.51 |
| | (1.36) | (69.84) | (89.0) |
| $\beta_1$ | -0.036 * | 1.692 | 0.950 |
| | (0.014) | (0.876) | (1.045) |
| $\beta_2$ | -0.038 | -1.255 | 10.393 |
| | (0.571) | (31.82) | (48.97) |
| $\beta_3$ | 0.266 | -0.170 | 2.365 |
| | (0.161) | (4.35) | (6.973) |
| $\beta_4$ | 0.056 | 10.375 | -13.93 |
| | (0.208) | (11.21) | (11.66) |
| $\beta_5$ | 0.011 * | 0.577 | 2.084 * |
| | (0.004) | (0.343) | (1.011) |
| $\beta_6$ | 0.508 ** | 11.599 | -0.601 |
| | (0.119) | (5.955) | (8.499) |
| $\beta_7$ | -0.28 ** | 2.923 * | 7.659 * |
| | (0.08) | (1.436) | (2.966) |
| $\beta_8$ | -0.909 * | -31.27 | -17.33 |
| | (0.391) | (18.87) | (24.32) |
| $\beta_9$ | 0.219 | 29.47 * | 23.477 |
| | (0.505) | (14.44) | (26.72) |
| $\beta_{10}$ | 0.542 | 36.755 | 50.920 |
| | (0.408) | (20.15) | (53.52) |

Note: *Significant at 5 per cent, **Significant at 1 per cent, n represents sample size; B represents number of bootstrap replications. Values indicated inside the parentheses represent standard error.

produce are found to be more effective on employment. The income is influenced by seasonality of the nonfarm produce and the reason for taking non farm activityas a source of additional income for the house hold. The investment is affected by farm income and seasonality of the non farm produce.

Investment on non-farm activities is influenced significantly by farm income and seasonality of the non farm produce. Income is significantly affected by other income sources and resource diversification.

TABLE II

*Confidence interval for bootstrapping regression for the entire study area*

(n=418, B=1000)

| Co-efficients | C. I. at 95% level of confidence | | | | | |
|---|---|---|---|---|---|---|
| | Dependent variables | | | | | |
| | Employment | | Income | | Investment | |
| | Lower | Upper | Lower | Upper | Lower | Upper |
| $\beta_0$ | -1.852 | 3.495 | -289.2 | -14.68 | -271.5 | 78.441 |
| $\beta_1$ | -0.008 | 0.065 | -0.03 | 3.413 | -1.103 | 3.003 |
| $\beta_2$ | -1.162 | 1.085 | -63.81 | 61.304 | -85.88 | 106.66 |
| $\beta_3$ | -0.051 | 0.583 | -8.722 | 8.381 | -11.34 | 16.07 |
| $\beta_4$ | -0.353 | 0.466 | -11.66 | 32.416 | -36.86 | 8.989 |
| $\beta_5$ | 0.003 | 0.019 | -0.096 | 1.251 | 0.096 | 4.072 |
| $\beta_6$ | 0.274 | 0.741 | -0.106 | 23.304 | -17.3 | 16.105 |
| $\beta_7$ | -0.443 | -0.127 | 0.1 | 5.747 | 1.828 | 13.49 |
| $\beta_8$ | -1.678 | -0.14 | -68.38 | 5.831 | -65.15 | 30.476 |
| $\beta_9$ | -0.774 | 1.213 | 1.074 | 57.873 | -29.05 | 76.007 |
| $\beta_{10}$ | -0.26 | 1.345 | -2.867 | 76.378 | -54.29 | 156.13 |

Note: C. I. = indicate confidence interval
n = represents sample size
β = represents number of bootstrap replications

Employment is influenced very significantlyby seasonality of nonfarm produce, other income sources and significantly bytype of nonfarm activity, additional income.

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# Performance of different Bi-intensive Need Based Cropping Systems under Irrigated Condition

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## Abstract

A field experiment conducted at Kuthulia farm, College of Agriculture, Rewa under All India Coordinated Research Project on Integrated Farming System during 2010-11 to 2013-14. The study reveals that grain yield of rice was maximum 50.55 q per ha in rice-berseem followed by 48.73 q per ha in rice-pea-wheat and 48.27 q per ha in rice-lentil-green manure cropping system. These cropping systems gave 16.39 per cent to 21.89 per cent higher grain yield of rice as compared to existing rice-wheat cropping system. The rice equivalent yield was maximum in rice-garlic (186.93 q per ha) followed by rice-toria-onion (173.98 q per ha). The net profit of Rs. 1,47,580/- per ha with benefit cost ratio 3.65 was maximum in rice-berseem followed by Rs. 1,38,989/- per ha in rice-garlic cropping system. Benefit cost ratio 3.65 was maximum in rice-berseem and 3.33 in rice-green pea-wheat cropping system. These cropping systems were found to be more remunerative than existing rice-wheat and rice-chickpea cropping system in Rewa region of Madhya Pradesh under irrigated condition.

Rice is an important crop in Rewa region of Madhya Pradesh which occupy an area of 5.83 lakh ha. The average productivity of rice in Rewa region is 1237 kg per ha, which is less than state average. Rice-wheat, rice-chickpea and rice-lentil are the major cropping systems which are widely adopted by the farmers due to stable production and less labour requirement (Kumar *et al*, 2001). But, continuous adoption of these cropping systems have lead to the problem of specific weeds, reduced soil fertility in root zone, development of soil sickness and infestation of similar kind of pest and diseases which ultimately resulted in decline in the efficiency and productivity of this cropping system (Katyal, 2003 and Kumar and Yadav, 2005).

Development of soil sickness for rice and wheat crop has also been observed due to continuous cropping system (Kharub *et al*, 2003). The soil productivity is declining day by day because both crops are exhaustive (Choudhary and Singh Yogeshwar, 2007).The rice-wheat cropping system needs diversification particularly in *rabi* season with need based high value crops like chickpea, onion, mustard, berseem, potato, garlic, pea and other crops to different group of farmers which are most compatible, remunerative and stable in rice based cropping sequence. The rice followed legume crop sequence have the ability to improve soil fertility by fixing atmospheric nitrogen. Cultivation of berseem after early duration rice has been found more remunerative than wheat after rice in rice based cropping sequence (Upadhyay *et al*, 2007).

Rice is predominant crop in Rewa region of Madhya Pradesh and it is difficult to replace rice by any other crop in *rainy* season due to soil and climatic conditions. Hence, only option left is to replace the wheat and chickpea in winter season for double and multiple cropping systems in Rewa region which have not been studied.

## Material and Methods

The present field experiment was conduct during 2010-11 to 2013-14 at JNKVV farm Kuthulia, Rewa (M.P.) under All India Coordinated Research Project on farming system. The soil of experimental field was silty clay loam in texture, neutral in reaction (pH 7.25), medium in organic carbon (0.56%) and low in available nitrogen (224 kg per ha) and phosphorus (8.2 kg per ha) and high in potash (315 kg per ha). Ten cropping systems (rice-wheat, rice-chickpea, rice-berseem, rice-potato-wheat, rice-garlic, rice-tori-onion, rice-lentil-green manure, rice-pea-wheat, rice-chickpea + linseed and rice-mustard-green manure) were laid out in randomized complete block design

with four replications. The rice variety Danteshwari was transplanted at the spacing of 20 cm × 15 cm. Fertilizer dose was kept 120 kg N per ha, 60 kg $P_2O_5$ per ha, 40 kg $K_2O$ per ha for rice under all the treatments. All the recommended package of practices for different *rabi* crops were adopted for irrigated condition of Rewa region of Madhya Pradesh.

## Results and Discussion

*Performance of rice :* Grain yield of rice under different cropping systems is presented in Table I. It is evident from the results that grain yield of rice was maximum 50.55 q per ha in rice-berseem followed by 48.73 q per ha in rice-pea-wheat and 48.27 q per ha in rice-lentil-green manure cropping systems. These cropping systems gave 16.39 per cent to 21.89 per cent higher grain yield of rice as compared to rice grown after wheat. It may be due to increase in residual soil organic carbon by 17.85 per cent, available nitrogen 12.05 per cent and available phosphorus by 12 per cent as compared to initial status. Increase in soil fertility in soil resulted in higher growth and yield contributing characters of rice which enhanced the grain yield of rice in rice-berseem, rice-pea-wheat and rice-lentil-green manure cropping system. Upadhyay *et al*, (2007) have also reported the similar finding from Jabalpur. The present experiment was started in the year 2006-07 therefore the crops like berseem, lentil, pea-wheat have good residual effect on succeeding rice by which rice yield was increased by 16.89 per cent to 21.89 per cent over existing rice-wheat cropping system. The grain yield of rice was found at par to existing rice-wheat cropping system in rice-chickpea, rice-potato-wheat, rice-garlic, rice-toria-onion, rice-chickpea + linseed and rice- mustard-green manure cropping systems.

Table I

*Economical yield of crops under different cropping systems*

| Sl. No. | Treatments | *Kharif* Rice yield q per ha | | | Mean | Yield of *rabi* crops q per ha | | | Mean | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 2011-12 | 2012-13 | 2013-14 | | 2011-12 | 2012-13 | 2013-14 | | |
| $T_1$ | Rice-Wheat (GW273) | 40.07 | 45.85 | 38.49 | 41.47 | 64.35 | 50.47 | 49.34 | 54.72 | |
| $T_2$ | Rice-Chickpea (JG 322) | 42.67 | 49.33 | 39.28 | 43.76 | 20.52 | 17.32 | 4.49 | 14.11 | |
| $T_3$ | Rice-Berseem (F)/S | 46.93 | 55.76 | 48.98 | 50.55 | 857.85 | 738.27 | 656.29 | 749.8 | F |
| | | | | | | 5.37 | 3.74 | 2.55 | 3.88 | (S) |
| $T_4$ | Rice-Potato-Wheat (HD 2864) | 42.83 | 50.63 | 42.95 | 45.47 | 115.62 | 116.41 | 95.59 | 109.20 | PT |
| | | | | | | 49.05 | 44.78 | 35.84 | 43.22 | (W) |
| $T_5$ | Rice-Garlic | 41.09 | 41.8 | 4358 | 42.15 | 65.07 | 70.35 | 76.66 | 70.69 | |
| $T_6$ | Rice-Toria-Onion | 42.35 | 49.52 | 44.5 | 45.45 | 6.6 | 7.25 | 14.19 | 9.34 | T |
| | | | | | | 288.52 | 259.32 | 53.44 | 200.42 | (O) |
| $T_7$ | Rice-Lentil-Green mannuring | 43.46 | 53.32 | 48.04 | 48.27 | 15.61 | 12.62 | 4.73 | 10.98 | L |
| | | | | | | 87.39 | 150.8 | 91.49 | 109.89 | GM |
| $T_8$ | Rice-Green Pea-Wheat (HD 2864) | 44.45 | 53.48 | 48.27 | 48.73 | 37.14 | 35.57 | 34.89 | 35.86 | P |
| | | | | | | 58.44 | 45.9 | 37.54 | 47.29 | W |
| $T_9$ | Rice-Chickpea + linseed (3:1) | 45.43 | 47.01 | 42.51 | 44.98 | 16.55 | 11.04 | 2.08 | 9.89 | G |
| | | | | | | 7.01 | 8.36 | 8.51 | 7.96 | Ln |
| $T_{10}$ | Rice-Mustard-Green mannuring | 45.67 | 45.43 | 47.23 | 46.11 | 12.93 | 27.76 | 18.04 | 19.57 | M |
| | | | | | | 95.43 | 153.09 | 88.34 | 112.28 | GM |
| SEm± | | 1.42 | 2.26 | 1.86 | 1.84 | - | - | - | - | |
| CD at 5% | | 4.10 | 6.58 | 5.40 | 5.36 | - | - | - | - | |

F = Fodder (berseem), S = Berseem seed ,G = Gram ,L = Lentil, Ln = Linseed, PT= Potato tuber, W = Wheat, GM = Green manure, P = Pea pod, M = Mustard, T = Toria and O = Onion bulb.

*Rice equivalent yield under different cropping system :* The rice equivalent yield under different cropping systems is presented in Table II reveals that, rice-garlic cropping system gave 186.93 q per ha of rice equivalent yield followed by rice-toria-onion 173.98 q per ha which were significantly superior to rest of the cropping systems. Other cropping systems like rice-potato-wheat, rice-berseem and rice-green pea-wheat were found superior than existing rice-wheat system. These cropping systems gave 39.88 per cent to 51.54 per cent higher rice equivalent yield as compared to existing rice-wheat cropping system. It may be due to higher productivity of these crops having higher market rate as compared to rice-wheat cropping system. Similar findings were also reported by Sharma *et al*, (2004) and Upadhyay *et al,* (2007). The cropping systems rice-chickpea, rice-lentil-green manure, rice-chickpea + linseed and rice-mustard-green manure were found inferior than rice-wheat system. It may be due to lower productivity of gram, linseed and lentil as compared to wheat by which these systems were not found much remunerative than rice-wheat existing system. The present results were in conformity with Tarwariya (2012) who has also reported the similar findings.

*Economics :* The net profit and benefit cost ratio of different cropping systems is presented in Table II which reveals that, net profit of Rs. 147580 per ha with B:C ratio 3.65 was maximum in rice-berseem followed by Rs. 138989 per ha in rice-garlic. These cropping systems were found more remunerative than all other cropping systems. The cropping system rice-chickpea, rice-lentil, rice-chickpea + linseed were found less remunerative than existing rice-wheat cropping system. The benefit cost ratio 3.65 was maximum in rice-berseem followed by 3.33 in rice-green pea-wheat cropping system. Rice-chickpea, rice-potato-wheat, rice-toria-onion and rice-lentil recorded less benefit cost ratio as compared to existing rice-wheat cropping system. These finding are in conformity with the findings of Dubey (2010).

TABLE II

*Rice Equivalent Yield (q per ha), Net profit (Rs per ha) and benefit cost ratio under different cropping systems.*

| Sl. No. | Treatments | Rice equivalent yield q per ha | | | Mean | Net profit Rs per ha | B:C ratio |
|---|---|---|---|---|---|---|---|
| | | 2011-12 | 2012-13 | 2013-14 | | | |
| $T_1$ | Rice-Wheat (GW273) | 117.29 | 99.87 | 93.29 | 103.48 | 87247 | 2.64 |
| $T_2$ | Rice-Chickpea (JG 322) | 995 | 90.3 | 49.11 | 79.63 | 62076 | 2.37 |
| $T_3$ | Rice-Berseem (F)/S | 159.98 | 135.18 | 165.79 | 153.62 | 147580 | 3.65 |
| $T_4$ | Rice-Potato-Wheat (HD 2864) | 165.41 | 151.55 | 153.5 | 156.82 | 115019 | 2.25 |
| $T_5$ | Rice-Garlic | 219.84 | 155.77 | 185.2 | 186.93 | 138989 | 2.48 |
| $T_6$ | Rice-Toria-Onion | 220.6 | 180.82 | 120.29 | 173.9 | 121504 | 2.27 |
| $T_7$ | Rice-Lentil-Green mannuring | 92.47 | 84.99 | 72.19 | 83.21 | 53269 | 1.95 |
| $T_8$ | Rice-Green Pea-Wheat (HD 2864) | 148.72 | 143.9 | 141.63 | 144.75 | 134869 | 3.33 |
| $T_9$ | Rice-Chickpea + linseed (3:1) | 112.05 | 91.96 | 69.26 | 91.09 | 74082 | 2.67 |
| $T_{10}$ | Rice-Mustard-Green mannuring | 83.39 | 111.23 | 106.97 | 100.53 | 89910 | 2.98 |
| SEm±6.50 | | 3.30 | 4.14 | 4.64 | - | - | |
| CD at 5% | | 18.39 | 9.58 | 12.03 | 13.33 | - | - |

TABLE III

*Changes in chemical properties of soil after completion of 8 years of different cropping systems*

| Sl. No. | Treatments | Soil pH | Soil EC Mmhos per cm | OC % | Available N kg per ha | Available $P_2O_5$ kg per ha | Available $K_2O$ kg per ha |
|---|---|---|---|---|---|---|---|
| $T_1$ | Rice-Wheat (GW273) | 7.32 | 0.55 | 0.63 (12.5%) | 236 (5.35%) | 8.96 (9.26%) | 293 (-6.98%) |
| $T_2$ | Rice-Chickpea (JG 322) | 7.19 | 0.45 | 0.65 (16.07%) | 248 (10.71%) | 9.28 (13.17%) | 280 (-11.11%) |
| $T_3$ | Rice-Berseem (F)/S | 7.25 | 0.47 | 0.66 (17.85%) | 251 (12.05%) | 9.17 (11.82%) | 296 (-6.03%) |
| $T_4$ | Rice-Potato-Wheat (HD 2864) | 7.23 | 0.48 | 0.65 (16.07%) | 231 (3.12%) | 8.91 (8.65%) | 294 (-6.66%) |
| $T_5$ | Rice-Garlic | 7.24 | 0.55 | 0.66 (17.85%) | 231 (3.12%) | 8.79 (7.19%) | 295 (-6.34%) |
| $T_6$ | Rice-Toria-Onion | 7.22 | 0.45 | 0.64 (14.28%) | 241 (7.58%) | 9.20 (12.19%) | 295 (-6.34%) |
| $T_7$ | Rice-Lentil-Green mannuring | 7.37 | 0.47 | 0.66 (17.85%) | 253 (12.94%) | 8.96 (9.26%) | 294 (-6.66%) |
| $T_8$ | Rice-Green Pea-Wheat (HD 2864) | 7.33 | 0.48 | 0.65 (16.07%) | 239 (6.69%) | 9.07 (10.60%) | 284 (-9.84%) |
| $T_9$ | Rice-Chickpea + linseed (3:1) | 7.35 | 0.47 | 0.64 (14.28%) | 243 (8.48%) | 8.87 (8.17%) | 287 (-8.88%) |
| $T_{10}$ | Rice-Mustard-Green mannuring | 7.34 | 0.48 | 0.64 (14.28%) | 237 (5.80%) | 8.86 (8.04%) | 275 (-12.69%) |
| initial value | | 7.25 | 0.46 | 0.56 | 224 kg | 8.2 kg | 315 kg |

*Effect of chemical properties of soil :* After harvest of *rabi* crops the soil samples were collected and analysed for different chemical properties of soil which are presented in TableIII. After perusal of the result it is clear that soil pH and electrical conductivity of soil was unaffected as compared to initial status.

The organic carbon status was increased by 12.5 per cent to 17.85 per cent under different cropping system and maximum increase in organic carbon status was noted in rice-berseem, rice-garlic and rice-barley-green manure cropping system. Available nitrogen status was increased by 3.12 per cent to 12.94 per cent under different cropping systems and maximum available nitrogen was observed in rice-barley-green manure followed by rice-berseem cropping system. Available phosphorous status was increased by 7.19 per cent to 13.17 per cent under different cropping systems. Available phosphorus was maximum in rice-chickpea followed by rice-toria-onion cropping systems. Available potassium status after eight year of different cropping systems had decreased by 6.03 per cent to 12.69 per cent. The maximum decrease in available potassium was observed in rice-mustard-green manure followed by rice-chickpea cropping system. It may be due to heavy depletion of potassium from soil by different intensive cropping systems. Tarwariya and Maurya (2013) also reported the decrease in potassium status in soil due to adoption of intensive cropping.

From the above study, it is concluded that rice crop perform better in rice-berseem, rice-pea-wheat and rice-lentil-green manure cropping systems. Rice-garlic, rice-toria-onion and rice-berseem cropping systems are better than existing traditional rice-wheat and rice-gram cropping systems in Rewa region of Madhya Pradesh.

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# Development of Shelf Stable Fermented Vegetable Products

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## Abstract

In the present study, attempts were made to develop shelf stable fermented products from vegetables. Sauerkraut like fermented products using indigenous vegetables like Bitter gourd (BGS), Drumstick leaves (DLS), Chakramuni leaves (CLS) and Gogu leaves (GLS) were developed. Control sauerkraut was standardized with 100 per cent cabbage. Experimental sauerkrauts were standardized using vegetables in different proportions (5 per cent, 25 per cent and 50 per cent) with cabbage. Among the variations, sauerkraut with 75 per cent cabbage + 25 per cent vegetable combination was more acceptable and selected for further study. Scores for the developed fermented products were in the range of liked slightly to liked moderately. Two sauerkraut samples (DLS and BGS) were incorporated in fillings and were accepted up to 50 percent for chapathi rolls and up to 25 per cent for stuffed breads. Nutritional analysis of sauerkraut combinations showed that CLS had higher content of protein (1.85 g/100 g), fat (1.02 g/100 g) and energy (36.03 Kcal/ 100 g). Total ash and crude fibre were found higher in DLS. The calcium, iron and zinc composition of sauerkraut ranged from 30.90 to 102.00 mg/100 g, 0.93 to 1.12 mg/100 g and 0.28 to 0.39 mg/100 g per gram respectively. Vitamin C and vitamin B12 were found higher in CLS and BGS respectively. Storage study results revealed that the developed fermented products can be successfully stored for twenty one days at room temperature. Thus, shelf - stable as well as acceptable value added products can be developed from vegetables by fermentation.

Vegetables are considered as essential for well-balanced diets since they supply vitamins, minerals, dietary fiber, and phytochemicals. India is the world's largest producer of fruits and vegetables, next only to China with a production of 66 million tons/ annum. But less than 2 per cent of fruits and vegetables are processed in the country, as compared to 30 per cent in Thailand, 70 per cent in Brazil and 80 per cent in Malaysia (Ravindranath, 2005). Average household consumption of fruits and vegetables in India is 149g to 152 during this decade though far below the recommended intake but slightly better from the previous survey (120-140 g/capita/day) (Sandeep *et. al.,* 2013). Preservation of these vegetables can prevent huge wastage as well as making them available in lean season.

Fermentation is one of the oldest means of food preservation and reduces the risk of food borne illness and food spoilage. The fermentation process for vegetables can result in nutritious foods that may be stored for extended periods, one year or more, without refrigeration. The preservation of vegetables by fermentation is thought to have originated before recorded history and the technology was developed by trial and error. Lactic acid fermentation is considered as the simple and valuable biotechnology and one of the most practical and widely applied empirical methods for preserving and often enhances the organoleptic, nutritional quality, sensory and shelf life properties of vegetables and fruits (Tamang *et al*., 2005). Sauerkraut called as 'sour cabbage' in German is made by the fermentation of cut and salted cabbage by naturally occurring lactic acid bacteria (Johanningsmeier et al., 2005). Fermentation of white cabbage into sauerkraut is an ancient preservation method (Wiander and Ryhanen, 2005). Sauerkraut is a traditional fermented vegetable food which is widely consumed in many regions of China (Xiong *et al*., 2014). In 2001 three billion pounds of cabbage consumed in the United States, twelve percent was consumed as processed cabbage, mainly sauerkraut (Uva *et al*., 2005). Sauerkraut has many health benefits offered by the cruciferous vegetables such as cauliflowers, brussel sprouts and cabbage, with the probiotic benefits derived from fermentation process due to lactic acid bacteria (Lactobacilli) produced as a bye-product of the pickling process. The glucosinolate moieties in sauerkraut induce the body's antioxidant enzymatic activity and the flavonoid components confer protection to blood vessels from oxidative damage. Also, lacto-fermented sauerkraut provides an

array of lactobacilli probiotics and vitamin C. Thus, in a study entitled Development of shelf stable fermented vegetable products an attempt was made to standardize process of sauerkraut like fermentation using indigenous vegetables like Bitter gourd (Momordica charantia), Drumstick leaves (Moringa oleifera), Chakramuni leaves (Sauropus androgynous) and Gogu leaves (Hibiscus cannabinus). Evaluation of these products and also storage stability was undertaken.

## Material and Methods

### Procurement of vegetables

The vegetables required for the research work were procured from local vegetable market and Department of Horticulture, UAS, GKVK, Bengaluru, and used for research purpose.

### Standardization and development of fermented vegetable sauerkraut variations

Fermented vegetable product sauerkraut was standardized with 100 Per cent cabbage and considered as control (Cs) (Holzapfel et al, 2008 and Swain et al., 2014). Experimental fermented vegetable sauerkraut variations were developed using different vegetables [Bitter gourd (BGS), Drumstick leaves (DLS), Chakramuni leaves (CLS) and Gogu leaves (GLS)] in different proportions (5%, 25% and 50%) with cabbage (95%, 75% and 50%) respectively similar to sauerkraut and the procedures were standardized (Table I). Among different combinations for all the four vegetables variations, the experimental sauerkraut with 75 per cent cabbage and 25 per cent other vegetable combination were found to be acceptable. Hence 25 per cent incorporation with 75 per cent cabbage combination for all four vegetables was selected for the further evaluation. Common products like stuffed chapathi rolls and stuffed bread were prepared using fermented vegetable sauerkraut variations and given for sensory evaluation.

### Sensory evaluation of developed products

The products developed were evaluated for organoleptic qualities by 20 semi trained sensory panelist using 9 point hedonic scale.

### Physical characteristics of the developed products

The colour of developed sauerkraut combinations was assessed by Munsell colour Chart. The texture of the developed products was determined by using Texture Analyzer (Stable Micro Systems, UK).

### Nutrient composition of the developed products

Moisture, protein, fat, fibre, carbohydrate Energy, total ash, calcium, iron, zinc, carotene were estimated using standard protocol. pH, titrable acidity, vitamin C and vitamin $B_{12}$, oxalates were also estimated following standard procedures.

### Shelf-life study of developed products

Shelf-life study was conducted for 21 days for the samples stored in sterilized glass jars which were kept at ambient temperature (28ºC) for the sensory characteristics, microbial load, moisture content, pH and titrable acidity parameters.

The suitable statistical package was used to analyze the consolidated data.

## Results and Discussion

*Sensory evaluation of the developed fermented vegetable sauerkraut variations :* Table II presents the mean sensory scores for the characteristics of appearance, colour, texture, aroma, taste and overall acceptability of fermented vegetable products after 7 days. The score for appearance ranged from 6.85 to 7.83, for colour ranged from 6.23 to 7.93, for texture ranged from 5.95 to 7.44, for the aroma ranged from 6.15 to 7.00, taste ranged from 6.40 to 6.73 and overall acceptability ranged from 6.25 to 7.33. As expected control (Cs) sample was highly accepted by the panel members. Control sample was standard sauerkraut with 100 Per cent cabbage and people are more used to the standard taste of sauerkraut. Sauerkraut called as 'sour cabbage' in German, is made by the fermentation of cut and salted cabbage by naturally occurring lactic acid bacteria (Johanningsmeier *et al.,* 2005). The gogu leaves sauerkraut scored the least for all the characteristics except for taste. Among other variations, sauerkraut with bitter gourd and drumstick leaves were better accepted. The difference in sensory characteristics

TABLE 1

*Standardization of fermented vegetable sauerkraut variations with 2.25 per cent salt*

| Variations | Combinations | Cabbage | Bitter gourd | Drumstick leaves | Chakramuni leaves | Gogu leaves |
|---|---|---|---|---|---|---|
| Cs | | 100 | | | | |
| BGS (1) | A | 95 | 5 | | | |
| BGS (2) | B | 75 | 25 | | | |
| BGS (3) | C | 50 | 50 | | | |
| DLS (1) | A | 95 | | 5 | | |
| DLS (2) | B | 75 | | 25 | | |
| DLS (3) | C | 50 | | 50 | | |
| CLS(1) | A | 95 | | | 5 | |
| CLS(2) | B | 75 | | | 25 | |
| CLS(3) | C | 50 | | | 50 | |
| GLS(1) | A | 95 | | | | 5 |
| GLS(2) | B | 75 | | | | 25 |
| GLS(3) | C | 50 | | | | 50 |

Cs-Cabbage sauerkraut, BGS-Bitter gourd sauerkraut, DLS- Drumstick leaves sauerkraut, CLS - Chakramuni leaves sauerkraut and GLS-Gogu leaves sauerkraut

TABLE II

*Mean sensory scores of fermented vegetable sauerkraut variations (at 25%) after 7 days*

| Variations | Appearance | Colour | Texture/ Consistency | Aroma | Taste | Over all a cceptability |
|---|---|---|---|---|---|---|
| Cs | 7.83 | 7.93 | 7.44 | 7.00 | 6.73 | 7.33 |
| BGS | 7.50 | 7.70 | 7.24 | 7.04 | 6.10 | 6.70 |
| DLS | 7.35 | 7.00 | 6.93 | 6.38 | 6.03 | 6.72 |
| CLS | 7.44 | 7.05 | 6.60 | 6.40 | 6.03 | 6.69 |
| GLS | 6.85 | 6.23 | 5.95 | 6.15 | 6.40 | 6.25 |
| F - value | * | * | * | * | * | * |
| SEm± | 0.16 | 0.15 | 0.23 | 0.26 | 0.25 | 0.26 |
| CD | 0.43 | 0.94 | 0.62 | 0.71 | 0.74 | 0.73 |

Cs-Cabbage sauerkraut, BGS-Bitter gourd sauerkraut, DLS- Drumstick leaves sauerkraut, CLS-Chakramuni leaves sauerkraut and GLS-Gogu leaves sauerkraut. * Significance at 5 per cent level

viz. appearance, colour and texture, among different variations was statistically significant ($p<0.05$). The scores were in the range of like slightly to like moderately.

The mean sensory scores of bitter gourd sauerkraut stuffed chapathi rolls are presented in Table III A. The score for appearance ranged from 8.05 to 8.25, colour ranged from 7.95 to 8.15, texture ranged from 7.71 to 8.20, aroma ranged from 7.80 to 8.25, taste ranged from 8.03 to 8.20 and overall acceptability ranged from 7.83 to 8.10. The control scored highest for all the characteristics. The difference in sensory characteristics *viz.,* appearance, colour, texture, aroma taste and overall acceptability among different combinations of BGS was found to be statistically significant ($p<0.05$).

The mean sensory scores of bitter gourd sauerkraut stuffed breads are also presented in Table III B. The control sample had the highest score for all the sensory characteristics. Among three combinations of BGS, BSB3 scored the least for all the characteristics. The difference in mean sensory scores was also found to be statistically significant ($p<0.05$) for aroma, taste and overall acceptability.

The mean sensory scores of stuffed chapathi rolls with different combination of drumstick leaves sauerkraut (DLS) are presented in Table III B. The score for appearance ranged from 7.70 to 7.87, colour ranged from 7.69 to 7.72, texture ranged from 7.81 to 8.17, aroma ranged from 7.60 to 7.85, taste ranged from 7.81 to 8.27 and overall acceptability ranged from 7.80 to 8.24. The control scored the highest for all characteristics. The overall acceptability was found to be highest for DSC3 sample. The difference in sensory characteristics of texture, aroma, taste and overall acceptability among all the different combinations of DLS found to be statistically significant ($p<0.05$).

The mean sensory scores of stuffed bread with different combination of drumstick leaves sauerkraut (DLS) are also presented in Table III B. The control sample had the highest score for all the sensory attributes. Among all three combinations of DLS, DSB3 scored least for all the characteristics. The difference in mean sensory score was also found to be statistically significant ($p<0.05$) for texture, aroma, taste and overall acceptability. However non-significant difference was observed for appearance and colour.

Thus, Stuffed chapathis were acceptable with samples of BGS and DLS sauerkrauts up to 50 per cent incorporation. In stuffed bread, it was up to 25 per cent. Stuffed products were found to be more acceptable by the panel compared to serving sauerkraut with different vegetables as such. Higher per cent incorporation of sauerkrauts stuff was not liked by the sensory panelist. This may be due to the change in natural sensory attributes of experimental products and the concept of stuffing sauerkraut is new as well.

**Physical characteristics of developed fermented vegetable products**

*Colour :* Johanningsmeier (2007) observed the colour of sauerkraut with 2 per cent NaCl Sauerkraut had 63±1.0 L value which indicated the overall lighter color, which is a desirable quality. In the present study colour of all combinations of sauerkrauts ranged with the hue of yellow according to the Munsell colour chart. The colour of experimental products might be different due to the incorporation of vegetable which can be attributed to the hue of yellow (Table IV).

*Yield / Volume :* Data given in Table IV also depicts the percent yield of sauerkraut combinations which ranged between 2.81 to 2.93 per cent. GLS samples showed the highest yield (2.93%) followed by BGS (2.90%) the lowest yield was observed in sample CLS (2.81%). Overall, there was increase in yield in the variations. According to the Holzapfel *et al.* (2008), sodium chloride (salt) causes the osmotic withdrawal of water from the cabbage cells of which the emerging liquid fills up the space between pieces of cabbage and supports the development of anaerobic conditions and it may increase yield of the product.

*Texture :* Table V presents the texture of the developed sauerkraut combinations analyzed. Toughness of sauerkraut combinations ranged from 45.60 to 44.65 on the first day of fermentation. The toughness was found to be increased among all the products during seventh day of fermentation. This may be because of osmotic forces extract more juice from the plant cells, making them firmer.

TABLE III A

*Mean sensory scores of stuffed chapathi rolls and stuffed breads with bitter gourd sauerkraut*

| Variations | Stuffed chapathi rolls | | | | | | | Stuffed bread | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cs | BGS 1 | BGS 2 | BGS 3 | F - value | S. Em ± | CD | Cs | BSB 1 | BSB 2 | BSB 3 | F - value | S. Em ± | CD |
| Appearance | 8.25 | 8.10 | 8.05 | 8.05 | NS | 0.156 | 0.435 | 8.09 | 8.08 | 8.05 | 8.05 | NS | 0.158 | 0.439 |
| Colour | 8.15 | 7.97 | 7.95 | 7.95 | NS | 0.144 | 0.400 | 7.98 | 7.98 | 7.95 | 7.95 | NS | 0.147 | 0.407 |
| Texture/Consistency | 8.20 | 7.79 | 7.71 | 8.13 | NS | 0.145 | 0.403 | 7.90 | 7.70 | 7.70 | 7.63 | NS | 0.155 | 0.432 |
| Aroma | 8.25 | 7.80 | 7.80 | 8.23 | * | 0.149 | 0.413 | 8.25 | 7.80 | 7.80 | 7.79 | * | 0.149 | 0.413 |
| Taste | 8.20 | 8.03 | 8.05 | 8.16 | * | 0.246 | 0.697 | 8.25 | 6.98 | 6.98 | 6.03 | * | 0.208 | 0.578 |
| Overall acceptability | 8.10 | 7.83 | 7.89 | 8.09 | * | 0.134 | 0.373 | 7.40 | 7.35 | 7.36 | 6.74 | * | 0.188 | 0.523 |

Cs -Control, BSC1-15% incorporation, BSC2 -25% incorporation and BSC3-50% incorporation* Significant at 5 % level, NS- Non significant

Cs-Control, BSB1-15% incorporation, BSB2-25% incorporation and BSB3-50% incorporation* Significant at 5 % level, NS- Non significant

TABLE III B

*Mean sensory scores of stuffed breads and stuffed chapatti rolls with drumstick leaves sauerkraut*

| Variations | Stuffed chapathi rolls | | | | | | | Stuffed bread | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cs | DSC 1 | DSC 2 | DSC 3 | F - value | S. Em ± | CD | Cs | DSB 1 | DSB 2 | DSB 3 | F - value | S. Em ± | CD |
| Appearance | 7.87 | 7.70 | 7.70 | 7.78 | NS | 0.194 | 0.539 | 7.15 | 7.03 | 7.15 | 7.09 | NS | 0.689 | 1.94 |
| Colour | 7.72 | 7.69 | 7.71 | 7.71 | NS | 0.193 | 0.535 | 7.20 | 6.88 | 7.12 | 7.10 | NS | 0.403 | 1.140 |
| Texture /consistency | 8.17 | 7.81 | 7.85 | 8.14 | * | 0.146 | 0.406 | 7.45 | 7.38 | 7.40 | 7.05 | * | 0.413 | 1.169 |
| Aroma | 7.85 | 7.60 | 7.60 | 7.73 | * | 0.160 | 0.445 | 7.05 | 6.83 | 7.00 | 6.75 | * | 0.455 | 1.287 |
| Taste | 8.27 | 7.81 | 7.83 | 8.22 | * | 0.127 | 0.354 | 7.20 | 6.83 | 7.19 | 6.85 | * | 0.546 | 1.537 |
| Overall acceptability | 8.24 | 7.80 | 7.88 | 8.18 | * | 0.148 | 0.294 | 7.05 | 6.78 | 7.00 | 6.73 | * | 0.561 | 1.587 |

Cs-Control, DSC1-15% incorporation, DSC2-25% incorporation and DSC3-50% incorporation* Significant at 5 % level, NS- Non significant

Cs-Control, DSB1-15% incorporation, DSB2-25% incorporation and DSB3-50% incorporation* Significant at 5 % level, NS- Non significant

TABLE IV

*Colour values and yield of developed sauerkraut combinations*

| Colour values for developed sauerkraut combinations | | | | Yield of developed sauerkraut combinations | | | |
|---|---|---|---|---|---|---|---|
| Combinations | Hue | Value / Chroma | Colour | Fermenation duration | Intial weight (g) | Final weight (g) | yield (%) |
| BGS | 5.0Y | 8/4 | 5.0Y/4 | 7 days | 200.43 | 206.25 | 2.90 |
| DLS | 5.0Y | 6/4 | 5.0Y/4 | | 199.92 | 205.68 | 2.88 |
| CLS | 5.0Y | 6/4 | 5.0Y/4 | | 200.20 | 205.82 | 2.81 |
| GLS | 5.0Y | 6/4 | 5.0Y/4 | | 200.32 | 206.19 | 2.93 |

BGS-Bitter gourd sauerkraut, DLS-Drumstick leaves sauerkraut, CLS-Chakramuni leaves sauerkraut and GLS-Gogu leaves sauerkraut.

TABLE V

*Texure, pH and Titrable acidity (%) of sauerkraut combinations during fermentations*

| Texture | | | pH | | Titrable acidity (%) | |
|---|---|---|---|---|---|---|
| Combinations | 1st Day | 7th Day | 1st Day | 7th Day | 1st Day | 7th Day |
| BGS | 45.60 | 51.91 | 5.7 | 4.7 | 0.70 | 0.92 |
| DLS | 44.90 | 50.21 | 5.6 | 4.5 | 0.69 | 0.87 |
| CLS | 44.84 | 50.10 | 5.6 | 4.6 | 0.72 | 0.90 |
| GLS | 44.65 | 50.23 | 5.4 | 4.2 | 0.75 | 0.89 |

BGS-Bitter gourd sauerkraut, DLS-Drumstick leaves sauerkraut, CLS-Chakramuni leaves sauerkraut and GLS-Gogu leaves sauerkraut.

*pH and Titrable acidity :* Table V also depicts that pH of the sauerkrauts variations was slightly acidic ranging from 5.4. to 5.7 BGS showed highest pH (5.7) and lowest was in the GLS (5.4). It was observed that pH decreased in all the products and ranged from 4.5 to 4.2 on the seventh day of fermentation. Table V also shows the titrable acidity of the sauerkraut products on first and seventh days of fermentation. On the first day the titrable acidity ranged from 0.75 to 0.69 per cent, highest being in GLS (0.75%) followed by CLS (0.72%). Titrable acidity increased after seven days and the value ranged from 0.87 to 0.92 per cent. BGS had highest titrable acidity on seventh day (0.92%) and DLS had the least (0.87%). Sweet potato roots were pickled by lactic fermentation by brining the cut and blanched roots in common salt (NaCl, 2–10%) solution and subsequently inoculated with a strain of *Lactobacillus plantarum* (MTCC 1407) for 28 days. There was a gradual but quick fall of pH during the first 7 days (5.0–5.2 on day 2, 4.2 - 4.5 on day 4 and 3.3 - 3.5 on day 6) of fermentation. After fermentation for 7 days, the pH values were reduced to 2.6 - 2.9. The decrease in pH during lactic acid fermentation was probably due to the accumulation of organic acids, mainly lactic acid. The titratable acidity values of sweet potato fermented in brine solutions increased in the range of 2.3–6.6 g / kg roots after fermentation for 7 days. A rapid increase in acidity in fermented vegetables is associated with the increase in organic acids (Panda *et al.,* 2007).

*Nutrient composition of developed fermented vegetable combinations :* Table VI revealed that moisture content ranged from 86.00 to 91.20 per cent for the developed fermented vegetable variations having the lower values for DLS and higher values for BGS samples. Per cent protein content ranged from 0.90 to 1.85 where the control sample had the lowest value and the highest value was with CLS sample. The per cent fat content ranged from 0.10 to 1.02. The lowest value was found to be in control sample and highest in CLS sample. Crude fibre ranged from 0.09 to 1.01 g /100 g. Control sample had lowest value for total ash *i.e.,* 3.40 g and DLS sample had the highest content i.e. 7.00 g / 100 g. Carbohydrate content was found to be in the range of 3.39 g / 100 g to 5.28 g / 100 g with the lowest found to be in BGS samples and the highest found to be in DLS samples. The energy content of samples ranged from 20.74 to 36.03 Kcal per 100 g higher being in CLS sample (Table VI) Table VI also depicts that calcium content ranged from 30.90 to 102.00 mg / 100 g. The lowest value was found to be in control sample (30.09 mg) and highest was in CLS (102.00 mg) sample. Iron content of sauerkraut samples ranged from 0.93 to 1.12 mg /100 g. DGS sample had lowest value of iron i.e. 0.93 mg and CLS sample had the highest content i.e. 1.12 mg / 100 g. Zinc content of samples ranged from 0.28 to 0.39 mg / 100 g. The lowest value found

TABLE VI

*Nutrient composition of sauerkraut variations*

| Combination | Cs | BGS | DLS | CLS | GLS | F - value | S. Em ± | CD |
|---|---|---|---|---|---|---|---|---|
| Moisture (%) | 90.0 | 91.20 | 86.0 | 86.50 | 87.80 | * | 0.337 | 1.062 |
| Protein (g) | 0.90 | 0.94 | 1.04 | 1.85 | 1.04 | * | 0.015 | 0.047 |
| Fat (g) | 0.10 | 0.14 | 0.68 | 1.02 | 0.14 | * | 0.054 | 0.170 |
| Crude fiber (g) | 0.91 | 0.99 | 1.0 | 1.01 | 0.09 | * | 0.037 | 0.118 |
| Total ash (g) | 3.40 | 5.00 | 7.00 | 5.70 | 5.80 | * | 0.126 | 0.397 |
| Carbohydrate (g) | 4.69 | 3.39 | 5.28 | 4.93 | 3.61 | * | 0.040 | 0.127 |
| Energy (Kcal) | 23.26 | 20.74 | 31.40 | 36.03 | 24.72 | * | 0.236 | 0.745 |
| Calcium (mg) | 30.09 | 31.00 | 100.20 | 102.00 | 80.52 | * | 0.332 | 1.048 |
| Iron (mg) | 0.96 | 0.93 | 0.97 | 1.12 | 1.05 | * | 0.020 | 0.062 |
| Zinc (mg) | 0.28 | 0.37 | 0.39 | 0.31 | 0.28 | * | 0.008 | 0.025 |
| Vitamin B12(µg) | 1.89 | 1.92 | 1.91 | 1.90 | 1.90 | NS | 0.014 | 0.044 |
| Vitamin C (mg) | 52 | 110 | 142 | 145 | 60 | * | 0.512 | 1.645 |
| Totalcarotene(mg) | 0.82 | 0.91 | 2.81 | 2.13 | 1.65 | * | 0.492 | 1.567 |
| Oxalate (mg) | 3.00 | 3.01 | 26.02 | 30.1 | 3.07 | * | 0.233 | 0.736 |

BGS-Bitter gourd sauerkraut, DLS- Drumstick leaves sauerkraut CLS – Chakramuni leaves sauerkraut and GLS- Gogu leaves suerkraut * Significant at 5 % level, NS- Non significant

to be in control (Cs) 0.28 mg / 100 g and highest was in DGS (0.39 mg /100 g) followed by CLS (0.31 mg / 100 g). Vitamin C content of sauerkraut samples ranged from 52 to 145 mg / 100 g. The highest Vitamin C found in CLS sample followed by DLS and lowest was in the control (Cs). Total carotene content of sauerkraut samples ranged from 0.82 to 2.81 mg /100 g. The sample DLS had highest content of total carotene (2.81 mg / 100 g) followed by CLS (2.13 mg) and found less in the control (Cs) 82 mg / 100 g. Oxalate content of samples ranged from 3.00 to 30.10 mg / 100 g. The lowest content of oxalate found to be in control and highest content was in GLS followed by DLS.

Kwak *et al*. (2008) studied the vitamin B12 content in some Korean fermented foods and reported that traditional type of Doenjang and Chungkookjang contained 1.85 ìg / 100 g and 0.69 ìg / 100 g of vitamin B12 respectively, while the factory-type of Doenjang and Chungkookjang contained 0.04-0.86 ìg / 100 g and 0.06-0.15 ìg / 100 g. Vitamin B12 was not detected in steamed soybeans and Tofu which is a not-fermented soybean product, indicating that vitamin B12 might be synthesized during the fermentation process. Similarly in the present study Vitamin B12 content of sauerkraut variations were analyzed which ranged between 1.89 to 1.92 ìg / 100 g. The highest was found in BGS 1.92 ìg followed by DLS 1.91 ìg and lowest was found to be in control (1.89 ìg).

*Storage studies of developed products :* Effect of storage on physico-chemical parameters of developed sauerkraut samples : pH of the product tells about the acidity or basicity of the products. Weekly evaluation of pH of products revealed that the effect of storage on pH of two sauerkraut samples *i.e.* BGS and DLS. Decreased from 5.76 to 3.82 and from 5.60 to 3.78 from first to twenty first day of storage duration respectively. The decrease in pH from first to twenty first day in both the samples was found to be statistically significant ($p<0.05$). The effect of storage on titrable acidity of sauerkrauts depicted that in both samples (BGS and DLS) the significant ($p<0.05$) increase in titrable acidity was found during the storage duration of twenty one days. The increase was from 0.70 to 1.61 in samples BGS and from 0.69 to 1.61 in sample DLS during storage period. Suganya and Kailappan (2013) conducted a study to analyze moisture content during pearl millet fermentation and reported that fermentation increased the moisture content significantly with fermentation time. Similarly in the present study, the moisture content of DLS sample increased from 85.52 to 86.62 per cent during storage (Table- VII).

*Effect of storage on microbial population :* Table VII also depicts that the increase in microbial count of developed sauerkraut samples was negligible. The increased in total bacterial count in BGS sample was from 150 x 103cfu on the first day to 153 x 103cfu on twenty first days. The same was increased from 147 x 103cfu on first day in DLS sample to 149 x103cfu on twenty first days during storage. The lactic acid bacteria counts also found to increase from 1.3 x 103cfu to 8 x 103cfu for BGS and from 1.2 x 103cfu to 7 x 103cfu for DLS on storage. The fungi count found to be reduced from 2.3 x 103cfu to1.0 x 103cfu in BGS sample during storage for twenty one days. The same trend was observed in case of DLS sample *i.e.,* a reduction of 2.0 x 103cfu of fungi count to 1.0x103cfu on twenty first days. Statistically the reduction was significant for change in lactic acid bacteria count and fungi count at 5 per cent level whereas it was non-significant for total bacterial count.

Pundir and Jain (2010) analyzed the microbial load during the storage of sauerkraut for 90 days and reported that no fungal colony was found up to 28$^{th}$ day of fermentation. Fungal growth was observed on sauerkraut after 60$^{th}$ day of storage and completely spoiled on 90$^{th}$ day. Sauerkraut spoiled by molds growing on the surface exposed to air. The authors have reported that the spoilage might be due to higher acidity. In the present study total bacterial count and lactic acid bacteria increased from first day of storage to twenty first days and fungi population was decreased in both samples.

*Effect of storage on sensory characteristics :* Effect of storage on sensory characteristics of sauerkraut samples is presented in Table-VIII. The reduction in sensory attributes for both the

TABLE VII

*Effect of storage on pH, titrable acidity, moisture content and microbial population (x103 cfu.g-1) of sauerkraut samples*

| Samples | Duration | pH | Titrable acidity (%) | Moisture (%) | Group of micro organism | | |
|---|---|---|---|---|---|---|---|
| | | | | | Total Bacterial Count | Fungi | Lactic Acid Bacteria |
| | 1st day | 5.76 | 0.70 | 90. 92 | 150 | 2.3 | 1.3 |
| | 7th day | 4.70 | 0.92 | 91.20 | 153 | 1.0 | 3.0 |
| | 14th day | 3.90 | 1.20 | 91.59 | 153 | 1.0 | 5.0 |
| BGS | 21st day | 3.82 | 1.61 | 91.98 | 153 | 1.0 | 8.0 |
| | F –value | * | * | * | * | * | * |
| | SEm± | 0.0131 | 0.0222 | 0.0092 | 0.577 | 0.064 | 0.709 |
| | CD | 0.0427 | 0.0727 | 0.0302 | 1.88 | 0.210 | 2.313 |
| | 1st day | 5.60 | 0.69 | 85.92 | 147 | 2.0 | 1.2 |
| | 7th day | 4.50 | 0.87 | 86.00 | 148 | 1.1 | 2.5 |
| DLS | 14th day | 3.92 | 1.25 | 86.38 | 149 | 1.0 | 4.0 |
| | 21st day | 3.78 | 1.57 | 86.62 | 149 | 1.0 | 7.0 |
| | F –value | * | * | * | NS | | |
| | SEm± | 0.0336 | 0.0066 | 0.0306 | - | 0.074 | 0.410 |
| | CD | 0.1097 | 0.0217 | 0.1000 | - | 0.243 | 1.338 |

BGS-Bitter gourd sauerkraut, DLS- Drumstick leaves sauerkraut * Significant at 5 % level, NS- Non significant

TABLE VIII

*Effect of storage on sensory characteristics of sauerkraut samples*

| Samples | Duration | Appearance | Colour | Texture | Aroma | Taste | Overall acceptability |
|---|---|---|---|---|---|---|---|
| | 7th day | 7.50 | 7.70 | 7.24 | 7.04 | 6.80 | 6.70 |
| | 14th day | 7.00 | 7.25 | 7.00 | 6.8 | 6.75 | 6.65 |
| | 21st day | 6.8 | 6.9 | 7.75 | 6.6 | 6.65 | 6.30 |
| BGS | F –value | * | * | * | * | * | * |
| | SEm± | 0.471 | 0.470 | 0.376 | 0.413 | 0.471 | 0.596 |
| | CD | 1.347 | 1.345 | 1.075 | 1.183 | 1.347 | 1.704 |
| | 7th day | 7.35 | 7.00 | 6.93 | 6.38 | 6.03 | 6.72 |
| | 14th day | 6.95 | 6.8 | 6.60 | 6.25 | 5.9 | 6.50 |
| DLS | 21st day | 6.75 | 6.56 | 6.45 | 6.00 | 5.74 | 6.30 |
| | F –value | NS | * | * | * | * | * |
| | SEm± | 0.50 | 0.451 | 0.374 | 0.276 | 0.259 | 0.402 |
| | CD | 1.430 | 1.289 | 1.070 | 0.790 | 0.741 | 1.150 |

BGS-Bitter gourd sauerkraut, DLS- Drumstick leaves sauerkraut * Significant at 5 % level, NS- Non significant

experimental samples was evident on weekly observation and was significant over the storage period ($p<0.05$). As the storage period increased the mean sensory scores were decreased. Only the reduction in mean sensory score of appearance of drumstick leaves sauerkraut was non-significant during storage.

The study showed that perishable vegetables can be successfully fermented to extend the shelf life, enhance nutritional value and enrich health benefits. Shelf - stable as well as acceptable value added products can be developed from vegetables by fermentation. It was suggested that several other traditional fermented products like sauerkraut juice, kimchi, khalpi *etc.* could be standardized with different vegetables/combination of vegetables.

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# An Economic Evaluation of Coorg Mandarin Cultivation in Kodagu District of Karnataka State

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Abstract

The present study was carried out in three taluks of Kodagu district of Karnataka state during 2014-15 to analyze the area and production of coorg mandarin and to compute the cost and returns of coorg mandarin. A sample of 120 coorg mandarin growers (40 small growers, 40 medium growers and 40 large growers) were randomly selected from 12 villages of Madikeri, Somwarpet and Virajpet taluks. Data was collected using a pre-tested interview schedule. The results revealed that there existed a positive growth rate of coorg mandarin both in area ( 3.13 and 2.80) and production ( 8.18 and 8.15) in Coorg district and Karnataka State, respectively. The total cost of growing coorg mandarin, average gross income and net returns was Rs. 62,065/-, Rs 1,56,447/- and Rs. 94,412/- respectively. The benefit cost ratio of producing coorg mandarin was worked out to be 1:1.96 indicating that coorg mandarin cultivation is a profitable agricultural venture.

The Mandarin (*Citrus reticulata*) originated from tropical and sub-tropical region of South East Asia, particularly from India, China and Philippines. Coorg mandarin, Nagpur santra, Khasi orange, Darjeeling orange and Kinnow are all strains of mandarin and each of them are known for their juiciness, taste and quality. Coorg mandarin is classed under mandarin group and also popularly known as Santras in India. They are also referred as loose jacket orange. Mandarins are famous for its excellent quality characteristics viz., taste, flavour and colour. They have good content of Vitamin C, Vitamin A, Calcium, Iron and Copper and can lower the risk of developing liver cancer and is good for the skin and immune system. Mandarins are also having anti-microbial properties which prevents viral, fungal and bacterial infections. A major portion of mandarin produced is marketed as a fresh fruit. It is also preserved in the form of juice, marmalade, jam, canned product, squash, syrup, candy and other products.

China ranks first in the production of mandarin contributing to more than 50 per cent of the world production followed by Spain, Brazil and Japan. Mandarin is commercially the most important citrus fruit grown in India and is second among the most widely produced fruits in the world after banana. The area under mandarin constituted 4.60 per cent of total fruit area and contributed 3.90 per cent to the total fruit production in India during 2013-14. The total citrus production in India during 2013-14 was 11,147 thousand MT with an area of 1,078 thousand hectares having a productivity of 10.3 MT/ha. Punjab, Madhya Pradesh, Maharashtra, Rajasthan, Assam and Karnataka are the major mandarin producing states in India. The country during 2013-14 achieved a production potential of 3431.4 thousand MT.

Karnataka stood sixth in the country both in terms of production (75.9 thousand MT) and area (3.4 thousand hectares) of coorg mandarin. The state stood first in the country with respect to the productivity at 22.3 MT/ha of coorg mandarin followed by Punjab (21.6 MT/ha) and Rajasthan (20.5 MT/ha) during the year 2013-14. In Karnataka, Coorg district is the highest producer with a production of 39,225 tonnes of mandarin and it was cultivated in an area of 1,569 hectares during the year 2013-14 . With this background, the present study was carried out with the following specific objectives: to analyze the area and production of Coorg mandarin and to compute the cost and returns of Coorg mandarin.

## Methodology

The present study was conducted in Kodagu district of Karnataka state during 2014-15. Coorg district was purposively selected for the study, as it is the major producer of Coorg mandarin in Karnataka. The district comprises of three taluks namely, Madikeri, Somwarpet and Virajpet. All the three taluks were selected for the study. Two village panchayats were selected from each taluk and two villages from each gram panchayat were chosen for the study. From each village, three categories of growers, viz., small growers

(possessing land of less than 2.00 ha), medium growers (2.01 to 4.00 ha) and large growers (more than 4.00 ha) based on the area under Coorg mandarin were selected. In total, 120 mandarin growers (40 small growers, 40 medium growers and 40 large growers) from 20 villages were selected for the study following simple random technique. The data for the study included both primary and secondary data. The primary data was obtained from the sample growers through personal interview method using a pre-tested structured schedule.

Compounded growth rate analysis was employed to assess the trend in area and production of coorg mandarin. It was computed using exponential function ($Y_t = ab^t u_t$). Establishment cost, annual cost and returns were worked out for arriving at the cost and returns of coorg mandarin. Benefit cost ratio, net present value and internal rate of returns were worked out to know the financial viability of coorg mandarin.

## Results and Discussion

*Compound annual growth rates in area and production of Coorg mandarin :* The details about area and production of Coorg mandarin in Coorge district and Karnataka state with respect to the compound growth rates during the period 2000-01 to 2013-14 are presented in Table I.

The area under mandarin in Coorg district increased from 980 hectares in 2000-01 to 1,540 hectares in 2013-14 and the production of mandarin increased from 1,2970 MT in 2000-01 to 39,225 MT in 2013-14. There is a positive growth rate of mandarin in Coorg district in respect of area and production from 2000-01 (3.13) to 2013-14 (8.18). The increase in area and production of mandarin in Coorg district has occurred in two different phases from 2000-01 to 2004-05 and from 2007-08 to 2013-14.

The area under mandarin in Karnataka state increased from 2,050 hectare in 2000-01 to 3410 hectares during 2013-14 and the production of mandarin increased from 25,340 MT in 2000-01 to 71,885 MT during 2013-14. The growth rate of mandarin showed a positive trend in respect of area and production between 2000-01 (2.80) and 2013-14 (8.15). The increase in area and production of mandarin has occurred in two different phases ie., from 2000-01 to 2004-05 and from 2007-08 to 2013-14.

Table I

*Compound annual growth rate in area and production of Coorg mandarin*

| Years | Coorg District | | Karnataka State | |
|---|---|---|---|---|
| | Area (ha) | Production (tons) | Area (ha) | Production (tons) |
| 2000-01 | 980 | 12970 | 2050 | 25340 |
| 2001-02 | 990 | 14200 | 2100 | 26645 |
| 2002-03 | 1120 | 15680 | 2250 | 28970 |
| 2003-04 | 1350 | 17640 | 2320 | 32674 |
| 2004-05 | 1380 | 18340 | 2330 | 33300 |
| 2005-06 | 1050 | 11260 | 1790 | 22360 |
| 2006-07 | 1120 | 10970 | 1760 | 21035 |
| 2007-08 | 1330 | 17540 | 1820 | 35580 |
| 2008-09 | 1340 | 18760 | 1860 | 36630 |
| 2009-10 | 1360 | 19110 | 1900 | 36645 |
| 2010-11 | 1400 | 22300 | 2210 | 41355 |
| 2011-12 | 1480 | 32450 | 3000 | 63640 |
| 2012-13 | 1500 | 38670 | 3210 | 71865 |
| 2013-14 | 1540 | 39225 | 3410 | 71885 |
| Cumulative Average Growth Rate | 3.13 | 8.18 | 2.80 | 8.15 |

The increased growth rate of mandarin in Coorg district and Karnataka state could be attributed due to the adoption of various area expansion and rejuvenation programmes of the Government by mandarin growers of Coorg district during the recent years. Reduced incidence of pest and disease, better availability of input services and market facilities have also contributed to the positive rate of growth. The decrease in area and production between 2005-06 and 2006-07 is due to the incidence of Citrus greening disease during the same period.

It can be inferred that there is a small positive difference in growth rates between Coorg district and Karnataka state from 2000-01 to 2013-14 indicating that Coorg district is showing better growth rates in both area and production compared to the Karnataka state.

*Age of Coorg mandarine plantations :* Table II presents the age profile of Coorg mandarin plantations of the sampled growers. It could be observed from Table I that a larger number (27.50 %) of the sampled plantations were in the age group of 16 to 20 years, followed by the age groups of 21 and above years (26.67 %), 11 to 15 years (24.16 %) and 0 to 10 years (21.67 %). It is interesting to note that more number of small growers had 0 to 10 years old plantations (10 Nos) and 11-15 years old plantations (11 Nos) revealing that small growers are late adopters in the cultivation of coorg mandarin. Similar findings were reported by Satnaamsingh (2004), Kanaujia *et al.,* (2009) and Kumar and Singh (2010).

TABLE II

*Age of coorg mandarin plantations*

| Age (Years) | Coorg mandarin growers | | | Overall |
|---|---|---|---|---|
| | Small growers (<2 ha) | Medium growers (2 to 4 ha) | Large growers (< 4 ha) | |
| 0-10 | 10 | 8 | 8 | 26 (21.67) |
| 11-15 | 11 | 8 | 10 | 29 (24.16) |
| 16-20 | 10 | 13 | 10 | 33 (27.50) |
| 21and above | 9 | 11 | 12 | 32 (26.67) |
| Total | 40 | 40 | 40 | 120 |

*Note* : Figures in parentheses indicate percentages to the column total

*Establishment cost incurred for different plantation groups :* Table III reveals that the total establishment cost for raising Coorg mandarin plantation was Rs. 1,42,780/- per hectare for small growers, Rs. 1,41,708/- per hectare for medium growers and Rs. 1,38,586/- per hectare for large growers. The difference in cost for different farm groups is due to economies of scale. The establishment cost for the pooled sample was Rs. 1,41,013/. Of the total establishment cost, the four major cost items were towards manure and fertilizers (23.43%, 24.12%, and 25.16% for small, medium and large growers, respectively), cost on irrigation (15.28 %, 15.53 % and 14.12 % for small, medium and large growers, respectively), intercultural operations (14.53 %, 13.85

TABLE III

*Establishment cost incurred for different plantation groups of coorg mandarin*

| Particultars | Farm groups (Rs. / ha for five years) | | | |
|---|---|---|---|---|
| | Small growers | Medium growers | Large growers | Pooled |
| Land preparation | 2723 (1.90) | 2678 (1.93) | 2523 (1.82) | 2641 (1.87) |
| Digging and filling of pits | 4437 (3.13) | 4193 (3.03) | 3975 (2.87) | 4202 (3.04) |
| Cost of seedlings | 9138 (6.40) | 9054 (6.53) | 9208 (6.64) | 9133 (6.48) |
| Planting and staking | 2280 (1.60) | 2155 (1.56) | 2144 (1.55) | 2193 (1.56) |
| Manures and fertilizers | 33456 (23.43) | 34223 (24.12) | 34869 (25.16) | 34183 (24.24) |
| Application of manures and fertilizers | 16657 (11.67) | 16503 (11.43) | 16468 (11.40) | 16543 (11.73) |
| Irrigation charges | 21818 (15.28) | 21924 (15.53) | 18732 (14.12) | 20825 (14.77) |
| Plant protection chemicals | 12287 (8.61) | 12359 (8.70) | 13102 (9.45) | 12583 (8.92) |
| Application of plant protection chemicals | 6944 (4.86) | 6790 (4.70) | 7083 (5.11) | 6939 (4.85) |
| Intercultural operations | 20741 (14.53) | 19548 (13.85) | 18266 (13.18) | 19518 (13.84) |
| Interest on working capital | 1043 8(7.31) | 10359 (7.25) | 10109 (7.18) | 10301 (7.30) |
| Land revenue | 150 (0.11) | 150 (0.11) | 150 (0.11) | 150 (0.11) |
| Depreciation | 1675 (1.17) | 1772 (1.34) | 1957 (1.50) | 1795 (1.27) |
| Total cost | 142780 (100.00) | 141708 (100.00) | 138586 (100.00) | 141013 (100.00) |

Note: Figure in parentheses indicate percentages to the column total

% and 13.18 % for small, medium and large growers, respectively) and application of manure and fertilizers (11.67%, 11.43% and 11.40% for small, medium and large growers, respectively) in the order of importance. The above trend of findings could be attributed to high cost of manures, fertilizers and agricultural implements and high wage rate of labours.

*Annual cost incurred and returns for different plantation groups* **:** The total annual cost for Coorg mandarin plantations was Rs. 60,832/-, Rs. 62,800/-, Rs. 62,562/- for small, medium and large growers, respectively. The difference in total annual cost among the growers is because of the number of plantations above 15 years of age is more in case of medium and large growers (Table IV) resulting in higher yield and higher harvesting cost which has subsequently increased the total cost.

The overall average of total annual cost for the pooled sample was Rs. 62,065/-. Of the total annual cost, the total variable cost accounted for 64.83 per cent (Rs. 40,239/-) and total fixed cost accounted for the remaining 35.17 per cent (Rs.21,826/-). The major share in variable cost was harvesting cost (11.00%, 10.79% and 10.89% for small, medium and large growers, respectively) followed by manure and fertilizers (10.07 %, 10.08 % and 9.95 % for small, medium and large growers, respectively) and plant protection measures (8.63%, 7.99% and 8.21% for small, medium and large growers, respectively). The above trend of findings could be attributed to high cost of manure, fertilizers and plant protection chemicals and high wage rate of labour.

The major cost item under fixed cost was rental value of land for all the growers (20.61 %, 21.78 %

TABLE IV

*Annual cost incurred and returns for different plantation groups*

| Particultars | Farm groups (Rs./ha years) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Small growers | | Medium growers | | Large growers | | Pooled | |
| Weeding and intercultural operations | 4916 | (8.07) | 5028 | (8.01) | 5042 | (8.06) | 4995 | (8.05) |
| Training and pruning | 4540 | (7.46) | 4712 | (7.50) | 4756 | (7.60) | 4669 | (7.52) |
| Manures and fertilizers | 6123 | (10.07) | 6328 | (10.08) | 6223 | (9.95) | 6225 | (10.03) |
| Plant protection chemicals | 5248 | (8.63) | 5015 | (7.99) | 5137 | (8.21) | 5133 | (8.27) |
| Irrigation charges | 4525 | (7.44) | 4487 | (7.14) | 4462 | (7.13) | 4491 | (7.24) |
| Harvesting cost | 6692 | (11.00) | 6776 | (10.79) | 6812 | (10.89) | 6760 | (10.89) |
| Transportation cost | 4837 | (7.95) | 5142 | (8.19) | 4974 | (7.95) | 4984 | (8.03) |
| Interest on working capital | 2950 | (4.85) | 2999 | (4.78) | 2992 | (4.78) | 2981 | (4.80) |
| Total variable cost | 39831 | (65.48) | 40487 | (64.47) | 40398 | (64.57) | 40239 | (64.83) |
| **Fixed Cost** | | | | | | | | |
| Depreciation | 1795 | (2.95) | 1892 | (3.01) | 2077 | (3.32) | 1921 | (3.10) |
| Land revenue | 30 | (0.05) | 30 | (0.05) | 30 | (0.05) | 30 | (0.05) |
| Rental value of land | 12540 | (20.61) | 13685 | (21.78) | 13412 | (21.43) | 13210 | (21.28) |
| Interest on fixed capital | 548 | (0.90) | 662 | (1.05) | 735 | (1.17) | 648 | (1.04) |
| Amortized cost | 6088 | (10.01) | 6044 | (9.62) | 5910 | (9.45) | 6014 | (9.69) |
| Total fixed cost | 21001 | (34.52) | 22313 | (35.53) | 22164 | (35.43) | 21826 | (35.17) |
| Total cost | 60832 | (100.00) | 62800 | (100.00) | 62562 | (100.00) | 62065 | (100.00) |
| **Returns (tons/ha)** | | | | | | | | |
| Yield | 13.13 | | 13.65 | | 14.04 | | 13.61 | |
| Gross returns | 150995 | | 156975 | | 161460 | | 156476 | |
| Net returns | 90162 | | 94174 | | 98897 | | 94411 | |

Note: Figure in parentheses indicate percentages to the column total

and 21.43 % for small, medium and large growers, respectively). The total overall average yield was 13.61 tonnes per hectare per annum. The average yield was 13.13, 13.65 and 14.04 tonnes per hectare per year for small, medium and large growers, respectively. The difference in yield is due to the number of plantation above 15 years of age is more in case of medium and large growers resulting in higher yield. The net returns were worked out to be Rs. 90,162/- Rs. 94,174/- and Rs. 98,897/- for small, medium and large growers, respectively. Whereas, the net return for the pooled sample was Rs. 94,411/-.

*Average cost and returns from Coorg mandarin plantation per year :* The establishment cost was amortized over 25 years at the rate of eight per cent that accounted to Rs. 6,014/- (Table V). The maintenance cost was calculated to be Rs. 56,051/-. Thus the total cost per hectare per year was Rs. 62,065/-. The average gross return per year was Rs. 1,56,477/- and thus the net return per year was Rs. 94,412/-. The returns realized in Coorg mandarin production are found to be profitable and beneficial to the growers in relation to the total cost incurred by them.

TABLE V

*Average cost and returns from Coorg mandarin plantation per year*

| Particulars | Amount (Rs.) |
|---|---|
| Establishment cost amortized over 25 years @ 8% per year | 6014.00 |
| Average maintenance cost per annum | 56051.00 |
| Total cost per year | 62065.00 |
| Average gross income | 156476.7 |
| Net income per year | 94411.67 |

*Financial viability of Coorg mandarin cultivation :* The Benefit-Cost ratio and the Net present value per hectare were worked out as 1.96 and Rs. 3,91,947/-, respectively. The internal rate of return was worked out to be 32.73 per cent. The research results indicates that the cultivation of Coorg mandarin is profitable to the growers (Table VI).

The total cost per year for growing coorg mandarin was worked out to Rs. 62,065/-, whereas the average gross income was Rs. 1,56,476/- and net returns was worked out to Rs. 94,411/-. The Benefit

TABLE VI

*Financial viability of Coorg mandarin cultivation*

| Measures of investment worth | Value |
|---|---|
| Benefit-Cost ratio @ 8% discount rate | 1.96 |
| Net present value @ 8% discount rate per ha (Rs.) | 3,91,947 |
| Internal rate of return (%) | 32.73 |

Cost ratio, Net present value and internal rate of return was worked out to be 1.96, Rs. 3,91,947/- and 32.73 per cent, respectively indicating that the coorg mandarin cultivation is profitable in nature.

There is an increasing demand for Coorg mandarin because of its distinctive taste and excellent blend of acid and sugar. Hence, there is a need to increase the production and productivity of the coorg mandarin. Extension educational activities (Demonstrations, farmers field school, field day etc.) needs to be organized by the Karnataka State Department of Horticulture and concerned agencies for motivating the farmers to adopt improved cultivation practices for getting higher yield and income.

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# Farmers' Characteristics Influencing the Decision Making Pattern in Sugarcane Cultivation Activities

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## Abstract

The present study was carried out in Mandya district of Karnataka state during 2014-15 to find out the association between the personal, socio-economic, psychological and communication characteristics of sugarcane farmers with their decision making pattern in sugarcane cultivation activities. One hundred and twenty sugarcane farmers from Maddur and Mandya taluks were personally interviewed using a schedule. Education, innovativeness, extension participation, age, farming experience, scientific orientation, management orientation, achievement motivation, economic motivation, mass media participation and extension agency contact of sugarcane farmers were found to be having a significant to highly significant association with their decision making pattern. The results also revealed that 72.80 per cent of the variation in the decision making pattern of sugarcane farmers was explained by all the 15 independent variables included in the study. Further, it was observed that management orientation and achievement motivation of sugarcane farmers had direct, indirect and largest indirect effects on the decision making pattern of sugarcane farmers.

Agriculture is the largest sector of our country, which provides livelihood to more than 70 per cent of the population and contributes about 40 per cent to the national production. Agriculture progress in India depends on millions of farmers, who must know, understand and act upon the new technology. In rural families too, the decisions are required to be taken in farming as well as in other family activities. The decision-making process passes through a series of "Ifs and Buts", before finally arriving at a decision. The decision to adopt a technology not only depends upon the availability of technologies, but by various other amalgam of factors. In this study, an attempt is made to unearth the factors which influences the decision making pattern of farmers in sugarcane cultivation activities. Against this background, the present study is carried out with the following specific objectives:

To find out the associations between the personal, socio-economic, psychological and communication characteristics of sugarcane farmers with their decision making pattern on sugarcane cultivation activities.

To know the extent of contribution of the personal, socio-economic, psychological and communication characteristics of sugarcane farmers to the decision making pattern

To analyze the direct, indirect and largest indirect effects of the personal, socio-economic, psychological and communication characteristics contributing to the decision making pattern of sugarcane farmers.

## Methodology

The present study was conducted in Maddur and Mandya taluks of Mandya district in Karnataka State during 2014-15. Five villages were randomly selected for the study from each of the two sampled taluks. From each village, 12 sugarcane farmers were randomly selected for the study. The total sample constituted 120 sugarcane farmers from ten villages of Mandya and Maddur taluks. Data was collected from 120 sugarcane growers using a pre-tested interview schedule. The details about the number of sugarcane growers sampled for the study are as follows:

*Number of villages and sugarcane farmers sampled for the study*

| District | Taluk | Village | Sugarcane Farmers |
|---|---|---|---|
| Mandya | Mandya | 5 | 60 |
| | Maddur | 5 | 60 |
| | Total | 10 | 120 |

Decision making pattern (dependent variable) refers to the 'extent of involvement of farm men and women in deciding the sugarcane cultivation activities that needs to be performed'. Decision making was measured using the scale developed by Puri (1972) with slight modification. A total of 15 sugarcane cultivation activities were included to know the decision making pattern of farmers. While analyzing the decision making pattern of farmers, the respondents were given a score of 2 to the respondents who were involved in decision making and a score of 1 was given to respondents who were not involved in decision making. The minimum and maximum decision making score one could get was 15 and 30, respectively. Based on the total score obtained by each respondent, they were grouped into low, medium and high using mean and half standard deviation as a measure of check.

Information regarding 15 personal, socio-economic, psychological and communication characteristics (independent variables) (Table 1) of sugarcane growers were collected using a structured schedule with suitable scales.

The collected data was analyzed using frequency, percentage, mean, chi-square test, multiple regression analysis and path analysis. Chi-square test was employed to find out the association between independent variables and dependent variable. Multiple regression analysis was used to find out the extent of contribution of independent variables on dependent variable. Path analysis was employed to find out the direct, indirect and largest indirect effects of independent variables on dependent variable.

## RESULTS AND DISCUSSION

*Personal, socio-economic, psychological and communication characteristics of sugarcane farmers :* Table I showed that a greater proportion of sugarcane farmers were of middle age (59.16%), small farmers (51.66%), living in nuclear family (91.67%), having moderate farming experience (47.50%) with high level of economic motivation (43.34%) and low levels of annual income (41.67%) and education (42.50%). It is observed from the table

TABLE I

*Personal, socio-economic, psychological and communication profile of sugarcane farmers*

(n=120)

| Characteristics | Category | Sugarcane farmers | |
|---|---|---|---|
| | | Number | Per cent |
| 1 | 2 | 3 | 4 |
| Age | Young | 17 | 14.17 |
| | Middle | 71 | 59.16 |
| | Old | 32 | 26.67 |
| Education | Low | 51 | 42.50 |
| | Medium | 38 | 31.67 |
| | High | 31 | 25.83 |
| Family type | Nuclear | 110 | 91.67 |
| | Joint | 10 | 8.33 |
| Farming experience | Less | 35 | 29.16 |
| | Moderate | 57 | 47.50 |
| | More | 28 | 23.34 |
| Land holding | Marginal | 58 | 48.34 |
| | Small | 62 | 51.66 |
| Annual family income | Low | 50 | 41.67 |
| | Medium | 42 | 35.00 |
| | High | 28 | 23.33 |
| Attitude towards farming | Less favourable | 24 | 20.00 |
| | Favourable | 52 | 43.34 |
| | More favourable | 44 | 36.66 |
| Innovativeness | Low | 37 | 30.84 |
| | Medium | 55 | 45.83 |
| | High | 28 | 23.33 |
| Scientific orientation | Low | 32 | 26.66 |
| | Medium | 56 | 46.67 |
| | High | 32 | 26.67 |
| Management orientation | Low | 32 | 26.66 |
| | Medium | 58 | 48.34 |
| | High | 30 | 25.00 |

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| Achievement motivation | Low | 34 | 28.34 |
| | Medium | 55 | 45.83 |
| | High | 31 | 25.83 |
| Economic motivation | Low | 24 | 20.00 |
| | Medium | 44 | 36.66 |
| | High | 52 | 43.34 |
| Mass media participation | Low | 39 | 32.50 |
| | Medium | 44 | 36.67 |
| | High | 37 | 30.83 |
| Extension agency contact | Low | 43 | 35.84 |
| | Medium | 53 | 44.16 |
| | High | 24 | 20.00 |
| Extension participation | Low | 38 | 31.66 |
| | Medium | 51 | 42.50 |
| | High | 31 | 25.84 |

that more number of sugarcane farmers were possessing favorable attitude towards farming (43.34%) and having medium levels of innovativeness (45.83%)., scientific orientation (46.67%), management orientation (48.34%), achievement motivation (45.83%), mass media participation (36.67%), extension agency contact (44.16%) and extension participation (42.50%). It can be inferred from the above findings that majority of the sugarcane farmers were of middle age, small farmers, living in nuclear family and having medium levels of other socio-economic, psychological and communication characteristics.

*Association of personal, socio-economic, psychological and communication characteristics of farmers with their decision making pattern in sugarcane cultivation activities :* Table II reveals that family type, land holding, annual family income and attitude towards farming of farm men and women were found to be having a positive and non-significant association with their decision making pattern. Education, innovativeness and extension participation

TABLE II

*Association of independent variables with the decision making pattern of farmers in sugarcane cultivation activities*

(n=120)

| Independent variables | Contingency co-efficient | Chi-square Value |
|---|---|---|
| Age | 0.27 | 10.01 * |
| Education | 0.31 | 13.67 ** |
| Family type | 0.12 | 1.92 NS |
| Farming experience | 0.27 | 10.08 * |
| Land holding | 0.17 | 3.67 NS |
| Annual family income | 0.18 | 4.01 NS |
| Attitude towards farming | 0.14 | 2.68 NS |
| Innovativeness | 0.32 | 13.69 ** |
| Scientific orientation | 0.27 | 9.88 * |
| Management orientation | 0.27 | 9.69 * |
| Achievement motivation | 0.28 | 10.99 * |
| Economic motivation | 0.31 | 13.11 * |
| Mass media participation | 0.29 | 11.62 * |
| Extension agency contact | 0.27 | 9.98 * |
| Extension participation | 0.31 | 13.28 ** |

NS = Non-significant
* = Significant at 5 per cent level
** = Significant at 1 per cent level

of sugarcane farmers had a positive and significant association with their decision making pattern at one per cent level of probability. Whereas, age, farming experience, scientific orientation, management orientation, achievement motivation, economic motivation, mass media participation and extension agency contact of sugarcane farmers were found to be having a positive and significant association with their decision making pattern at five per cent level of probability. The above findings are in line with the findings of Thejaswini *et al.* (2004), Vinay Kumar (2005), Bharat Kumar (2010), Ganeshprasad (2010), Satyanarayan and Jagadeeswary (2010), Yavana Priya (2010), Sunitha (2012), Gopala (2014), Madhushree (2014) and Nayak (2014).

The explanation for the independent variables having significant to highly significant association with the decision making pattern of sugarcane farmers are given in ensuing paragraphs.

As the age increases the farmer's experience and knowledge also increases which helps the farmers to understand the situation better and enhance their decision making ability to take appropriate decisions. Education exposes farmers to more communication media and methods. Better perception and comprehension could be observed among better educated than others. Acquisition of formal education may also help to interpret ideas in a rational manner resulting in pragmatic decision making. Education also widens the horizon of the individual and therefore, farmers with higher education had higher involvement in decision making.

Experience in sugarcane cultivation aids in effective management and helps in making quick decisions to perform farm activities. Innovativeness is associated with accepting change leading to decisions on adoption of innovative ideas and scientific practices. The farmers who are more innovative are highly involved in decision making about cultivation of sugarcane. Scientific orientation of farmers influences adoption of innovative ideas and practices thus, leading to active and regular participation in the decision making.

Management orientation offers a chance for working towards excellence, which could enable an individual to manifest themselves as excellent in their field of activity and the urge to move earlier than others will act as an instrument to acquire and adopt managerial components related to agriculture. Thus, the need to have better management orientation might have raised the decision making ability of the farmers. Achievement motivation influences the urge of the individual to excel in their life and it is the important determinant of excellence or perfection in what one does. It is the value associated with an individual that drives them to excel in farming and there by attain a sense of personal accomplishment. In order to achieve this distinction, the farmers would have actively involved in decision making about sugarcane cultivation. If responsibility of a farmer to earn more money for meeting his family needs increases, then such farmers try to involve in making decisions to adopt new technologies for earning higher profit.

Exposure to mass media develops modern orientation among farmers; making them more efficient in acquiring, retaining and evaluating the effectiveness factors leading to knowledge gain which influences their decision making ability. Mass media also provides enormous opportunity of repeated exposure to new technologies, motivating farmers to take positive steps relevant for decision making.

Contact with extension agents influences the decision making ability and participating in different extension activities to upgrade knowledge regarding farming. Extension professionals not only communicate latest developments in sugarcane cultivation but also about development in other farmer's fields. Collecting information on sugarcane cultivation from researchers and from farmers is possible through extension agency for making appropriate decisions regarding sugarcane cultivation.

Participation in agricultural extension activities like demonstrations, discussion, general meetings, field days, campaigns, etc., promotes the acquisition of knowledge and helps the farmers to involve in making decisions to adopt innovative farm technologies. Frequent and effective participation by farmers in extension activities might act as strong motivational factor for making decisions which aids in better management of farming.

*Extent of contribution of personal, socio-economic, psychological and communication characteristics to the decision making pattern of sugarcane farmers* **:** Table III reveals that that 72.80 per cent of the variation in the decision making pattern of sugarcane farmers was explained by all the 15 independent variables included in the study as evidenced by $R^2$ value of 0.7280. The results further revealed that education and extension participation were significantly contributing to the decision making pattern at one per cent level of probability. Whereas, innovativeness, Management orientation and extension

TABLE III

*Extent of contribution of independent variables with the decision making pattern of farmers in sugarcane cultivation activities*

(n=120)

| Independent variables | Regression co-efficient (b) | Standard error | 't' value |
|---|---|---|---|
| Age | 0.20 | 0.31 | 1.49 NS |
| Education | 0.27 | 0.88 | 3.26 ** |
| Family type | 0.30 | 0.30 | 1.01 NS |
| Farming experience | 0.08 | 0.11 | 1.38 NS |
| Land holding | 0.36 | 0.25 | 0.71 NS |
| Annual family income | 0.45 | 0.41 | 0.92 NS |
| Attitude towards farming | 0.60 | 0.29 | 0.48 NS |
| Innovativeness | 0.40 | 0.81 | 1.99 * |
| Scientific orientation | 0.27 | 0.41 | 1.52 NS |
| Management orientation | 0.28 | 0.69 | 2.49 * |
| Achievement motivation | 0.08 | 0.11 | 1.33 NS |
| Economic motivation | 0.18 | 0.26 | 1.42 NS |
| Mass media participation | 0.07 | 0.12 | 1.81 NS |
| Extension agency contact | 0.38 | 0.78 | 2.02 * |
| Extension participation | 0.33 | 0.91 | 2.68 ** |

NS = Non-significant

* = Significant at 5 per cent level

** = Significant at 1 per cent level

$R^2$ = 0.7280

agency contact and were significantly contributing to the decision making pattern of sugarcane farmers at five per cent level of probability. The remaining variables namely, age, family type, farming experience, land holding, annual family income, attitude towards farming, scientific orientation, achievement motivation, economic motivation and mass media participation had not significantly contributed to the decision making pattern of sugarcane farmers.

Education, extension participation, innovativeness, management orientation and extension agency contact of sugarcane farmers have synergic effect on one another influencing the decision making process.

*Direct, indirect and largest indirect effects of personal, socio-economic, psychological and communication characteristics of sugarcane farmers with their decision making pattern* **:** Eleven variables which were found to be having significant association with the decision making pattern of sugarcane farmers were considered for computing the path analysis. It is observed from the Table IV that all the 11 variables selected for path analysis had positive direct effect on decision making pattern of sugarcane farmers .

Ranking variables based on their direct effect on decision making pattern revealed that management orientation (X6), achievement motivation (X7), extension participation (X11), extension agency contact (X10), economic motivation (X8), scientific orientation (X5) and innovativeness (X4) occupied first seven ranks in that order, whereas education (X2), mass media participation (X9), farming experience (X3) and age (X1) obtained the last four ranks in the same order.

As regards to total indirect effects channeled through other variables for each of the independent variables, it was found quite substantial. Ranking of these effects revealed that management orientation (X6), achievement motivation (X7), extension participation (X11), economic motivation (X8), innovativeness (X4), extension agency contact (X10) and scientific orientation (X5) occupied the first seven ranks, which had the highest total indirect effect on decision making pattern in the descending order of magnitude. On the other hand, farming experience (X3), education (X2), mass media participation (X9) and age (X1) occupied the last four ranks in the same order.

The first largest indirect effect channeled through is management orientation (X6) in the case of six variables and the remaining five variables channeled through extension agency contact (X10) and extension participation (X11). The second largest indirect effect channeled through achievement motivation (X7) in case of eight variables, closely followed by mass media participation (X9), extension agency contact (X10) and

TABLE IV

*Direct, indirect and largest indirect effects of independent variables on the decision making pattern of farmers in sugarcane cultivation activities*

(n=120)

| F. No | Factor number | Direct effect | Rank | Total Indirect effect | Rank | Three largest indirect effects channeled through |
|---|---|---|---|---|---|---|
| X1 | Age | 0.0092 | 11 | 0.0091 | 11 | 0.174 X6<br>0.090 X7<br>0.012 X11 |
| X2 | Education | 0.0391 | 8 | 0.0292 | 9 | 0.081 X6<br>0.019 X7<br>0.017 X11 |
| X3 | Farming experience | 0.2912 | 10 | 0.0301 | 8 | 0.109 X11<br>0.101 X7<br>0.024 X10 |
| X4 | Innovativeness | 0.0411 | 7 | 0.0411 | 5 | 0.240 X6<br>0.050 X7<br>0.032 X11 |
| X5 | Scientific orientation | 0.0499 | 6 | 0.0311 | 7 | 0.590 X11<br>0.021 X7<br>0.021 X4 |
| X6 | Management orientation | 0.0768 | 1 | 0.0812 | 1 | 0.112 X10<br>0.500 X7<br>0.020 X11 |
| X7 | Achievement motivation | 0.0711 | 2 | 0.0712 | 2 | 0.579 X10<br>0.120 X11<br>0.042 X6 |
| X8 | Economic motivation | 0.0511 | 5 | 0.0412 | 4 | 0.120 X6<br>0.079 X7<br>0.023 X11 |
| X9 | Mass media participation | 0.0310 | 9 | 0.0196 | 10 | 0.578 X11<br>0.089 X7<br>0.051 X6 |
| X10 | Extension agency contact | 0.0522 | 4 | 0.0399 | 6 | 0.115 X6<br>0.036 X9<br>0.034 X11 |
| X11 | Extension participation | 0.0691 | 3 | 0.0661 | 3 | 0.198 X6<br>0.046 X10<br>0.036 X8 |

Residual effect : 0.272

extension participation (X11). However, the third largest indirect effect has channeled through extension participation (X11) in case of six variables, closely followed by innovativeness (X4), management orientation (X6), economic motivation (X8) and extension agency contact (X10). The total residual effect was found to be 0.272.

Management orientation and achievement motivation had direct, indirect and largest indirect effects on the decision making pattern of sugarcane farmers. Management orientation offers a chance for working towards excellence, which could enable an individual to manifest themselves as excellent in their field of activity and the desire for better management, resulting in greater efforts towards excellence. The urge to move earlier than others will act as an instrument to acquire and adopt managerial components related to agriculture. Thus, the need to have better management orientation might have raised the decision making ability of the farmers.

Achievement motivation influences the urge of an individual to excel in their life and it is the important determinant of excellence or perfection in what one does. It is the value associated with an individual that drives them to excel in farming and thereby attain a sense of personal accomplishment. In order to achieve this distinction, the sugarcane farmers would have actively involved in decision making about sugarcane cultivation.

Therefore, management orientation and achievement motivation were found to be not only having major direct effect on the decision making pattern, but also through indirect and largest indirect effects influencing the decision making. Hence, management orientation and achievement motivation were the dominant variables through which other variables can influence the decision making. Management orientation can be considered as the forerunner of the decision making pattern of farmers in sugarcane cultivation activities activities that needs to be performed in the field..

The desire for better management, resulting in greater efforts towards excellence and profitability is the main criteria for involvement of sugarcane farmers in decision making about sugarcane cultivation. Hence, management orientation of sugarcane farmers had contributed immensely for the decision making in the sugarcane cultivation activities.

The research results revealed that a strong association exist between the management orientation, extension participation, mass media participation and extension agency contact of sugarcane farmers with their decision making pattern in sugarcane cultivation activities. The decision making pattern needs to be increased by strengthening leadership and capacities of sugarcane farmers in planning and production of sugarcane. Dissemination of improved sugarcane technologies through media (newspapers, farm magazines, radio, television etc.) in local languages will increase their knowledge and thereby enhancing the decision making ability and involvement of farmers in sugarcane cultivation activities. More exposure of farmers to the extension activities and frequent contacts with the formal extension personnel will help the farmers to gain knowledge for improving self perception, self esteem and confidence to help them to contribute in decision making and increased participation in sugarcane cultivation activities.

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# Nature of Exploitation of Child Labourers in Mahabubnagar District of Andhra Pradesh

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## Abstract

The study was conducted at Mahabubnagar district of Andhra Pradesh regarding the nature of exploitation of child labourers. Majority of both girls and boys expressed frequently that their remuneration was not in correspondence with work, pay was not provided for overtime or extra work drawn while the adults are obtaining more pay for similar work. But pay was not provided for holidays and irregularity in payment by the employer was rarely expressed by both girls and boys Regarding exploitation in terms of work, both the girls and boys expressed that frequently the work was highly tiresome and laborious, work was unsuitable for children and they had heavy work load and most frequently require tiresome working posture. Most of the child labourers frequently had long working hours, but lack of leisure during work was rarely observed. The work hazards faced by the girls and boys frequently include cuts and injuries and exposure to extreme weather conditions such as to sun, rain and cold. Majority of the girls were sometimes exposed to chemicals but boys were rarely exposed.

Children of a nation are the hopes of tomorrow. The future prosperity of the society is hidden within the vast potentialities of the children. Ensuring physical, mental, moral and social development of children is therefore the duty of the state to make the country strong. However, when a sizable percentage of children population gets diverted to manual labour, it becomes naturally a source of concern. The use of child labour is wide spread in most of the developing countries of the world and one among them is India, where the concentration of child labour is the highest in the world. A more comprehensive definition, taking into account the consequences of labour on children has been provided by the International Labour Organization, according to which "Child labour includes children prematurely leading adult lives working long hours for low wages under conditions damaging to their health and to their physical and mental development, sometimes separated from their families, frequently deprived of meaningful educational and training opportunities that could open up for them a better future". Child labor is simply the single most important source of child exploitation and child abuse in the world today. Among the numerous explanations of the rise and growth of child labour, the socio-economic backwardness is considered as one of the most crucial factors. Countries like India, with massive and abysmal poverty are said to be fertile grounds for the large scale employment of children.

## Methodology

Keeping in view the objectives of the study, a Descriptive Research Design was used for conducting the study. Mahabubnagar district of Andhra Pradesh was purposively selected for the study. Out of the 64 mandals, five mandals were selected from the district through simple random sampling method. From the five selected mandals, three villages from each mandal, thus making a total of 15 villages were selected randomly. In each village ten child labourers comprising of five girl child labourers and five boy child labourers were selected randomly and therefore, a total of 150 child labourers were selected as a sample for the study. A pre-tested interview schedule was used for collecting the required data through personal interview method.

The nature of exploitation of child labourers by the employers refer to the employment of children in tasks or under conditions that jeopardize their physical and mental well being, the extraction of profits form child labour by paying low wages, and the denial to children of their right to play, to learn to enjoy a normal childhood.

The nature of exploitation of child labourers by the employer in the areas of remuneration, work, working hours and work hazards were studies separately.

## Results And Discussion

*Exploitation in terms of remuneration given to the child labourers:* The Table I depicts that a great majority of girls (74.66%) and boys (64.00%) together making 69.33 per cent of the total child labourers felt that frequently their earnings were not commensurate with work done. A sizeable number of girls (69.33%) and 40.00 per cent of boys figuring to 54.66 per cent of the total child labourers expressed that frequently pay was not provided for overtime or extra work. These results are in confirmation with those of Rajawat (2004). The child labourers were rarely exploited in terms of providing pay for holidays in most of the cases (55.33%), out of which girls and boys form 52.00 per cent and 58.66 per cent, respectively. The child labourers frequently observed that adults were obtaining more pay for similar work, in huge majority of the cases (80.00%) comprising of 84.00 per cent of girls and 76.00 per cent of boys, whereas majority of the total child labourers (62.00%) expressed that they rarely faced irregularity in payment from which girls were 70.66 per cent while 53.33 per cent were boys. Their wages are generally lower than those given to their adult counterparts who because of their maturity have greater capacity to bargain and also to claim what becomes due to them. Child workers, from the standpoint of payment that they receive in lieu of work done by them, get very low wages which, in most cases, are insufficient for their own subsistence, nevertheless their family members send them to work with a view to get rid of at least the burden of their maintenance. It is a reality that wages of children are generally fixed at much lower level than those of adults, despite the fact that child workers, in many situations, give a greater output in terms of the total work done by them by working more quickly and uninterruptedly for longer hours at one stretch under strict discipline without any grouse or complaint. However, most of the parents secured advances from the employers and had surrendered and used their children as security. The loans are returned by the children in terms of their wages

Table I

*Distribution of child labourers in terms of exploitation in remuneration given*

(Girls : n=75; Boys : n=75; Total : N = 150)

| Remuneration | Frequently | | | Sometimes | | | Rarely | | |
|---|---|---|---|---|---|---|---|---|---|
| | Girls | Boys | Total | Girls | Boys | Total | Girls | Boys | Total |
| Earnings are not commensurate with work | 56 (74.66) | 48 (64.00) | 104 (69.33) | 14 (18.66) | 20 (26.66) | 34 (22.66) | 5 (6.66) | 7 (9.36) | 12 (8.00) |
| Pay is not provided for overtimeor extra work | 52 (69.33) | 30 (40.00) | 82 (54.66) | 11 (14.66) | 22 (29.33) | 33 (22.00) | 12 (16.00) | 23 (30.66) | 35 (23.33) |
| Pay is not provided for holidays | 29 (38.66) | 15 (20.00) | 44 (29.33) | 7 (9.33) | 16 (21.33) | 16 (10.66) | 39 (52.00) | 44 (58.66) | 83 (55.33) |
| Adults obtaining more pay for similar work | 63 (84.00) | 57 (76.00) | 120 (80.00) | 9 (12.00) | 17 (22.66) | 26 (17.33) | 3 (4.00) | 1 (1.33) | 4 (2.66) |
| Irregularity in payment | 17 (22.66) | 25 (33.33) | 42 (6.66) | 5 (6.66) | 10 (18.33) | 15 (70.66) | 53 (70.66) | 40 (53.33) | 93 (62.00) |

Figures in parentheses indicate percentages

making them to some kind of 'bonded labour' to their landlords and cannot claim for more money.

*Exploitation in terms of work:* It is evident from Table II that a large majority of the total child labourers (78.00%) were frequently involved in highly tiresome and laborious work of which 72.00 per cent were girls and 84.00 per cent were boys. Out of the total child labourers, a sizeable majority (58.00%) were involved in 'unsuitable work' very frequently which include 44.00 per cent of girls and boys accounting for 72.00 per cent. The child labourers had heavy work load 'frequently' in 64.00 per cent of girls and 73.33 per cent of boys together figuring to 68.66 per cent of the total child labourers. A considerable number of child labourers (49.33%) with girls forming, 61.33 per cent and boys forming 37.33 per cent frequently had tiresome working posture.

These children were being exploited in work because of the obvious reasons that the employers know that the children could be asked to do any kind of work not only because of their young age, but more importantly because of the child's anxiety to know and do new things. They also know that these children could be put to long hours of work since they do not get exhausted soon and do not feel the job monotony. As a matter of fact, they are ordinarily interested in getting the work done by the children unmindful of the feelings and reactions (suppressed) of the young children employed by them.

*Exploitation in terms of working hours:* It is apparent from the Table III that an equal number of girls (46.66%) have frequently faced lack of leisure during work and another 46.66 per cent of them have rarely faced the same. Majority of boys (65.33%) also rarely faced 'lack of leisure during work' both together figuring to 56.00 per cent of total child labourers. Majority of the child labourers (61.33%) were rarely 'involved in additional work during night' who constituted both girls (52.66%) and boys (70.66%). Frequency of 'long working hours' were reported by a great majority of girls (74.66%) and a wast majority of boys (88.00%) together forming 81.33 per cent of total child labourers. These results were in conformity with the findings of Bhargava (2003).

Unduly long hours of work is another major form of exploitation of child labourers. In agriculture and domestic work, these children were put to excessively long hours of work varying from eight to twelve hours or more. Further, more night work is not uncommon, especially at the time of harvesting and storage. Perhaps this was because the employers feel that they could extract maximum work from the children. It is

TABLE II

*Distribution of child labourers in terms of exploitation in work*

(Girls : n=75; Boys : n=75; Total : N = 150)

| Work | Frequently | | | Sometimes | | | Rarely | | |
|---|---|---|---|---|---|---|---|---|---|
| | Girls | Boys | Total | Girls | Boys | Total | Girls | Boys | Total |
| Involvement in highly tiresome and laborious work | 54 (72.00) | 63 (84.00) | 117 (78.00) | 21 (28.00) | 11 (14.66) | 32 (21.33) | - | 1 (1.33) | 1 (0.66) |
| Involvement in unsuitable work | 33 (44.00) | 54 (72.00) | 87 (58.00) | 28 (37.33) | 13 (17.33) | 41 (27.33) | 14 (18.66) | 8 (10.66) | 22 (14.66) |
| Heavy work load | 48 (64.00) | 55 (73.33) | 103 (68.66) | 20 (26.66) | 20 (26.66) | 40 (26.66) | 7 (9.33) | - | 7 (4.66) |
| Tiresome working posture | 46 (61.33) | 28 (37.33) | 74 (49.33) | 12 (16.00) | 25 (33.33) | 37 (24.66) | 17 (22.66) | 22 (29.33) | 39 (26.00) |

Figures in parenthesis indicate percentages

TABLE III

*Distribution of child labourers in terms of exploitation in working hours*

(Girls : n=75; Boys : n=75; Total : N = 150)

| Working hours | Frequently | | | Sometimes | | | Rarely | | |
|---|---|---|---|---|---|---|---|---|---|
| | Girls | Boys | Total | Girls | Boys | Total | Girls | Boys | Total |
| Lack of leisure during work | 35 (46.66) | 13 (17.33) | 48 (32.00) | 5 (6.66) | 13 (17.33) | 18 (12.00) | 35 (46.66) | 49 (65.33) | 84 (56.00) |
| Involvement in additional work during night | 16 (21.33) | 9 (12.00) | 25 (16.66) | 20 (26.66) | 13 (17.33) | 33 (22.00) | 39 (52.66) | 53 (70.66) | 92 (61.33) |
| Long working hours | 56 (74.66) | 66 (88.00) | 122 (81.33) | 19 (25.33) | 9 (12.00) | 28 (18.66) | — | — | — |

Figures in parenthesis indicate percentage

this type of employers who do not have any consideration for the tender age of the child workers and extract work from the children as long as they could, for the sole reason of having more production and consequently high profits. Majority of them stated that they worked beyond stipulated hours because of fear of termination of their job. As it is understood that girls work to supplement their families' inadequate incomes, they may not want to go against the instructions of their employers for fear of losing their work.

*Work Hazards:* It could be inferred from Table IV that majority of girls (58.66%) had frequent cuts and injuries and same number of boys (58.66%) had sometimes faced such hazards during their work. A large majority of total child labourers (86.66%) which include both girls (84.00%) and boys (89.33%), rarely faced burns while working. A sizeable majority of girls (72.00%) were sometimes and a great majority of boys (81.33%) were rarely exposed to chemicals.

Exposure to extreme weather conditions was frequently seen in a high majority of girls (72.00%) and boys (69.33%) figuring to 70.66 per cent of total child labourers. All the girls (100.00%) and 97.33 per cent of boys together making an extremely high majority of child labourers (98.66%) have rarely come across any accidents.

Children especially the girls who were working in agricultural sector are subjected to occupational hazards such as exposure to machinery, biological and chemical agents and constant physical effort. They were found to be involved in works like mixing, loading, applying pesticides, fertilizers or herbicides, some of which are highly toxic and potentially carcinogenic. Pesticides exposure poses a considerably higher risk to children than adults and has been linked to an increased risk of cancer, neuropathy, neuro-behavioural effects and immune system abnormalities. In construction, where children are often used for fetching, carrying and similar tasks, they are vulnerable to falls, to cut, injuries from falling objects, to damage from the lifting of heavy weights and other types of accidents. Similar results were reported by Reddy (2007). Their lack of training and experience in handling tools, their span of concentration, the use of unguarded machinery that is designed for adults, the insalubrious state of work places resulting from dust, lack of hygiene, are all potential sources of accidents and injuries. Such dangers were compounded by fatigue due to excessive hours of work, under nutrition and physical weakness of children.

It is a reality that wages of children are generally fixed at much lower level than those of adults, despite the fact that child workers, in many situations, give a

TABLE IV

*Distribution of child labourers based on the work hazards faced*

(Girls : n=75; Boys : n=75; Total : N = 150)

| Category | Frequently | | | Sometimes | | | Rarely | | |
|---|---|---|---|---|---|---|---|---|---|
| | Girls | Boys | Total | Girls | Boys | Total | Girls | Boys | Total |
| Cuts and Injuries | 44 (58.66) | 29 (38.66) | 73 (48.66) | 21 (28.00) | 44 (58.66) | 65 (43.33) | 10 (13.33) | 2 (2.66) | 12 (8.00) |
| Burns | 5 (6.66) | 6 (8.00) | 11 (7.33) | 7 (9.33) | 2 (2.66) | 9 (6.00) | 63 (84.00) | 67 (89.33) | 130 (86.66) |
| Exposure to chemicals | - | - | - | 54 (72.00) | 14 (18.66) | 68 (45.33) | 21 (28.00) | 61 (81.33) | 82 (54.66) |
| Exposue to extreme weather conditions (sun,rains & cold) | 54 (72.00) | 52 (69.33) | 106 (70.66) | 13 (17.33) | 11 (14.66) | 24 (16.00) | 8 (10.66) | 12 (16.00) | 20 (13.33) |
| Accidents | - | - | - | - | 2 (2.66) | 2 (1.33) | 75 (100.0) | 73 (97.33) | 148 (98.66) |

Figures in parenthesis indicate percentage

greater output in terms of the total work done by them by working more quickly and uninterruptedly for longer hours at one stretch under strict discipline without any grouse or complaint. As a matter of fact, the employers are ordinarily interested in getting the work done by the children unmindful of the feelings and reactions (suppressed) of the young children employed by them. It is this type of employers who do not have any consideration for the tender age of the child workers and extract work from the children as long as they could, for the sole reason of having more production and consequently high profits. All this shows a cruel and inhuman attitude towards the children who start working for their survival at a very young age. Social mobilization in this area should aim at creating 'a first call' for the elimination of child labour among the community and to influence attitudes and behaviours of all members of society so that the scope and meaning of the right of children to protection from exploitation and harmful work and the right to education is understood.

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# Economic Analysis of Urbanisation Impact on Different Social Groups Located in Fringes of Bengaluru Urban

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Abstract

The study was conducted in Ramanagara District of Karnataka state. Two categories of rural fold considered were : 1) men, women and children and 2) Agricultural labour, marginal farmers, small farmers, medium farmers, large farmers. According to farmers' perception, urbanization had negative impact (about 60% and 63 % in the case of rainfed and irrigated situation, respectively) on the men community as it created shortage of agriculture labour and also loss of interest in the farming activity. Farmers felt that urbanization had both positive (better non-agricultural jobs, leisure, and reduction in the work load due to new technologies) and negative impact (imparts laziness) on the women community. Urbanization had positive impact (65 % and 70% in the case of rainfed and irrigated situations) on the children as it created better school facilities in turn helping for over all development of the children. Farmers felt that urbanization had positive impact (60 % and 68 % in the case of rainfed and irrigated situations) on labour as it creates better job opportunities for them, thereby increasing their standard of leaving. Farmers perceived that urbanization has negative impact (about 55% and 63% of rainfed and irrigated farmers, respectively) on marginal farmers as there was difficulty in investing on land for commercialized farming and also fear of losing lands. Urbanization had negative impact (60% and 68% in the case of rainfed and irrigated situations, respectively) on the small farmers. Urbanisation had both positive and negative impact on medium farmers. Urbanization had negative impact (65% and 53% of the sample farmers from rainfed and irrigated situations, respectively) on large farmers as it was difficult to get the agricultural labour for work and larger land holdings calls for larger investment, market risk and prove to theft of the produce.

Worldwide urbanization is pervading rural areas and more so in developing countries including India. In the country, rural areas around Bengaluru are experiencing rapid urbanization process and its growth has been unprecedented. In the past two decades in India, the level of urbanization has gone up by 27.80 per cent in 2001 to 31.20 per cent in 2011 and likely to increase to greater than 50 per cent by 2050. In relative terms, rural population which was 89.14 per cent in 1901,had decreased by 20.3 per cent in the last eleven decades to about 69 per cent. On the contrary, the urban population had increased almost threefold from 10.86 per cent in 1901 to 31.16 per cent in 2011. The urban–rural ratio (an index measuring the number of urban people for each rural person) for 2011 was 0.45 (in simple terms, for 100 rural people, there were 45 urban people), with an increase of 6 per cent from the previous decade (39 in 2001), again highlighting that India is catching up fast in the process of urbanization in the recent decades (Sudhira and Gururaja, 2012). In 1951, there were only five Indian cities with a population greater than one million and only 41 cities greater than one tenth of million population. Much of India effectively lived in 0.56 million villages. In 2011, there were three cities with population greater than ten million. Over 833 million Indians lived in 0.64 million villages, but 377 million lived in about 8,000 urban centres. By 2031, it is projected that there will be six cities with population greater than 10 million.

Karnataka is India's 7$^{th}$ most urbanized State in India. As per Census 2011, Karnataka had 6.10 crore population, out of which 38.60 per cent (i.e. 2.35 crore) resided in urban areas. In terms of urbanization, the state had witnessed an increase of 4.68 per cent in the proportion of urban population in the last decade. As per the Registrar General of India, for the decade 2001-2011, the absolute increase in population had been more in urban areas than in rural areas for the first time since independence. Karnataka's urban population had grown by 31.27 per cent between 2001 and 2011, compared with 28.85 per cent in the previous decade. The growth of urban population between 2001 and 2011 was also higher as compared to the growth of 7.63

per cent in the rural population. The state is expected to reach an urban population proportion of 50 per cent in the next eleven years that is in the year 2026 (Anonymous, 2011).

Bengaluru district's population ballooned 46.68 per cent over the past decade to around 9.59 million in 2011. The district today houses over 15.69 per cent of the state's population. Urbanization has bought major changes in demand for agricultural products both from increases in urban populations and from changes in their diets and demands. Thus importance of agriculture is especially marked in the nearby rural areas with respect to fresh and perishable fruits and vegetables supply to cater the need of urban Bengaluru.

## Methodology

Ramanagara district was purposively selected for the research study as it surround Bengaluru Urban District. The sample frame consists of 80 farmers, 40 farmers had assured irrigation and 40 farmers had dry lands. Data were obtained from the selected farmers using a pre-tested schedule developed for the study through personal interview. The information elicited from the respondent farmers pertained to family size, educational level, etc. Farmers' opinion about urbanization and its impact on the social groups such as men, women and children are different.

Cochran Q test for 'k' related sample provides a method for testing whether three or more matched sets of frequencies or proportions of relevant characteristics differ significantly among themselves. The matching may be based on relevant characteristics of the different subjects, or on the fact that the same subjects are used under different conditions. This test is suitable when the data are in a nominal scale or dichotomized ordinal information.

In this study Cochran Q test was used to study the impact of urbanization on society which includes across the members of the family and across the categories of the farmers.

**The test procedure is outlined briefly as follows**

Arrange the data into separate columns for each condition, with the scores for each subject in a separate row. For the computation of this statistic, the response variable scores must be coded as '0' and '1'. Compute sum of each column represented as 'G', the sum of each row is represented as 'L'. Also compute square of the sum of the rows represented as '$L^2$', number of conditions as 'K'.

Compute Q test using following formula:

$$Q = \frac{(K-1)*[(K*\Sigma G^2)-(\sum G)^2]}{(K*\sum L)-\sum L^2}$$

Compute Chi square value with degrees of freedom as 'K-1'.

If obtained 'Q' value is less than the critical Chi square value, then null hypothesis should be accepted and inferred that there is no relationship between subjects' values on one categorical variable and their values on the other categorical variable, in the population represented by the sample.

## Results and Discussion

*General profile of sample farmers :* The details about general profile of sample farmers are shown in Table I. Average age of farmers in rainfed and irrigated areas were 51 and 41 years, respectively. Average size of the family in both rainfed and irrigated areas was five members. An average year of schooling of sample farmers was eight and ten years for rainfed and irrigated areas, respectively. About 63 per cent and 95 per cent of the sample farmers were literates in the case of rainfed and irrigated situations respectively.

Table I

*General profile of sample farmers in the study areas*

| Particulars | Rainfed | Irrigated |
|---|---|---|
| Age of the farmer (Years) | 51 | 41 |
| Size of the Family (Number) | 5 | 5 |
| Years of schooling | 8 | 10 |
| Illiterates (Number) | 15(38) | 2(5) |
| Literates (Number) | 25(63) | 38 (95) |
| Primary School (Number) | 10(25) | 8(20) |
| High school (Number) | 9(23) | 14(35) |
| PUC (Number) | 3(8) | 7(18) |
| College and above (Number) | 3(8) | 9(23) |

Note: Figures in the parentheses indicate per cent to total.

*Impact of urbanisation on social groups (men, women and children) :* It is evident from the Table II, sample farmers viewed that urbanisation had a negative impact (about 53% and 60% in the case of rainfed and irrigated situation, respectively) on men. They felt that urbanisation creates fancy towards the city with in the minds of men, had made man lazy creating shortage of agriculture labour and making men lose interest in cultivation of crops. Sample farmers felt that urbanisation had positive impact on men (about 40% and 48% in the case of rainfed and irrigated situation, respectively) as it provides better income, more job opportunities in non farm sector, better and near market for agricultural produce.

As shown in the Table III, majority of the farmers (55% in the case of rainfed farmers and 50% in the case of irrigated farmers) expressed that urbanisation had created laziness and women had developed dominating nature which sample farmers felt that its negative aspects of the urbanisation. Equally urbanisation provides better non-agricultural jobs, there would be more leisure available and due to new technologies there will be reduction of household work load, thus impacting positively on the women community. Thus equally there is an impact of urbanisation on women community positive (48%) and negative (52%)

As indicated in Table IV, both rainfed and irrigated farmers viewed that urbanisation had positive impact (65% and 70% in the case of rainfed and irrigated situations) on children in terms of better exposure, better schooling, exposure to english language and exposure to competitive world. But one third (35% and 30% in the case of rainfed and irrigated

TABLE II

*Impact of urbanisation on men in the study areas*

| Particulars | Rainfed (n=40) | | Irrigated (n=40) | | Over all (N=80) | |
|---|---|---|---|---|---|---|
| | Number | Per cent | Number | Per cent | Number | Per cent |
| Better income | 5 | 13 | 6 | 15 | 11 | 14 |
| More job opportunities | 6 | 15 | 8 | 20 | 24 | 18 |
| Closer markets for produce | 5 | 13 | 5 | 13 | 22 | 13 |
| Fancy towards urban area | 10 | 25 | 9 | 23 | 39 | 24 |
| Laziness | 8 | 20 | 5 | 13 | 26 | 17 |
| Non available for crop work | 2 | 5 | 4 | 10 | 11 | 8 |
| Reduced interest in agricultural work | 4 | 10 | 3 | 8 | 14 | 9 |
| Positive impact | 16 | 40 | 19 | 48 | 71 | 44 |
| Negative impact | 24 | 60 | 21 | 53 | 89 | 57 |

TABLE III

*Impact of urbanisation on women in the study areas*

| Particulars | Rainfed (n=40) | | Irrigated (n=40) | | Over all (N=80) | |
|---|---|---|---|---|---|---|
| | Number | Per cent | Number | Per cent | Number | Per cent |
| Better non agricultural jobs | 7 | 18 | 6 | 15 | 13 | 17 |
| Leisure availability | 4 | 10 | 6 | 15 | 10 | 13 |
| Reduction of work load | 5 | 13 | 5 | 13 | 10 | 13 |
| Transfer of technology | 6 | 15 | 6 | 15 | 12 | 15 |
| Domination by women | 12 | 30 | 12 | 30 | 24 | 30 |
| Laziness | 6 | 15 | 5 | 13 | 11 | 14 |
| Positive impact | 18 | 45 | 20 | 50 | 38 | 48 |
| Negative impact | 22 | 55 | 20 | 50 | 42 | 53 |

TABLE IV

*Impact of urbanisation on children in the study areas*

| Particulars | Rainfed (n=40) | | Irrigated (n=40) | | Over all (N=80) | |
|---|---|---|---|---|---|---|
| | Number | Per cent | Number | Per cent | Number | Per cent |
| Better exposure | 7 | 18 | 7 | 18 | 14 | 18 |
| Better schools | 10 | 25 | 10 | 25 | 20 | 25 |
| English learning | 4 | 10 | 7 | 18 | 11 | 14 |
| More competitive options | 5 | 13 | 4 | 10 | 9 | 12 |
| Conservative behaviour | 5 | 13 | 3 | 8 | 8 | 11 |
| Language thought is not mother tongue | 2 | 5 | 2 | 5 | 4 | 5 |
| Junk eatables | 4 | 10 | 4 | 10 | 8 | 10 |
| More school work | 3 | 8 | 3 | 8 | 6 | 8 |
| Positive impact | 26 | 65 | 28 | 70 | 54 | 68 |
| Negative impact | 14 | 35 | 12 | 30 | 26 | 33 |

situations) of the farmers felt that urbanisation had negatively influences their children by means of making their children conservative, access to more junk foods, more work load from school and not much importance to the mother tongue was given. Over all opinion concludes that urbanisation had positive impact on children.

*Impact of urbanisation on social groups (labourers and farmers) :* As described in Table V both the categories of farmers believed that urbanisation had positive impact (60 % and 68 % in the case of rainfed and irrigated situations) on landless labourers in the form of better income opportunities and better jobs, thereby increasing their standard of living. But about 38 and 30 per cent of rainfed and irrigated farmers believed that urbanisation impacted negatively on the labour class as landless labours were unwilling to work in agricultural lands, they tend to follow demonstration effect and they would also become addicted to bad habits. Over all, there was a positive impact of urbanisation on labour class.

TABLE V

*Impact of urbanisation on labour in the study areas*

| Particulars | Rainfed (n=40) | | Irrigated (n=40) | | Over all (N=80) | |
|---|---|---|---|---|---|---|
| | Number | Per cent | Number | Per cent | Number | Per cent |
| Additional income opportunities | 4 | 10 | 5 | 13 | 9 | 12 |
| Better exposure | 6 | 15 | 7 | 18 | 13 | 17 |
| Better income jobs | 9 | 23 | 9 | 23 | 18 | 23 |
| Improved standard of leaving | 5 | 13 | 6 | 15 | 11 | 14 |
| Addiction to bad habits | 5 | 13 | 3 | 8 | 8 | 11 |
| Demonstration effect | 5 | 13 | 5 | 13 | 10 | 13 |
| Unwillingness to work in the farm | 6 | 15 | 5 | 13 | 11 | 14 |
| Positive impact | 24 | 60 | 27 | 68 | 51 | 64 |
| Negative impact | 15 | 38 | 12 | 30 | 27 | 34 |

TABLE VI

*Impact of urbanisation on marginal farmers in the study areas*

| Particulars | Rainfed (n=40) | | Irrigated (n=40) | | Over all (N=80) | |
|---|---|---|---|---|---|---|
| | Number | Per cent | Number | Per cent | Number | Per cent |
| Additional income opportunities | 4 | 10 | 5 | 13 | 9 | 12 |
| Better farming with household labour | 3 | 8 | 2 | 5 | 5 | 7 |
| Better utilization of leisure | 5 | 13 | 6 | 15 | 11 | 14 |
| House hold dependent | 2 | 5 | 3 | 8 | 5 | 7 |
| Can work in other's field also | 10 | 25 | 8 | 20 | 18 | 23 |
| Dilemma situation to cultivate | 5 | 13 | 6 | 15 | 11 | 14 |
| Investment on land is difficult | 8 | 20 | 7 | 18 | 15 | 19 |
| Loosing lands | 7 | 18 | 8 | 20 | 15 | 19 |
| Positive impact | 18 | 45 | 15 | 38 | 33 | 42 |
| Negative impact | 22 | 55 | 25 | 63 | 47 | 59 |

*Impact of urbanisation on marginal farmers in the study areas :* It is evident from Table VI urbanisation had negative impact on marginal farmers. About 55 and 63 per cent of rainfed and irrigated farmers, respectively believed that urbanisation had negative impact on marginal farmers as the land holdings was small, farmers cannot invest more on them, difficult to decide on what to cultivate and also as their lands were nearer to the urban area there was fear of losing of land. About 45 and 38 per cent of the rainfed and irrigated farmers, respectively felt that urbanisation positively impacted marginal farmers as they could do farming with available household labour, they can utilise the leisure in a better way and they could also work in the other fields at time of leisure.

*Impact of urbanisation on small farmers in the study areas :* According to Table VII, urbanisation had negative impact (60% and 68% in the case of rainfed and irrigated situations) on small farmers as it there existed fear of encroachment and there was also fear of losing land as influenced by land mafia. As the holdings were small , farmers were not able to

TABLE VII

*Impact of urbanisation on small farmers in the study areas*

| Particulars | Rainfed (n=40) | | Irrigated (n=40) | | Over all (N=80) | |
|---|---|---|---|---|---|---|
| | Number | Per cent | Number | Per cent | Number | Per cent |
| Additional income opportunities | 4 | 10 | 5 | 13 | 9 | 12 |
| Better income | 8 | 20 | 6 | 15 | 14 | 18 |
| Better non-agricultural opportunities | 5 | 13 | 4 | 10 | 9 | 12 |
| Farming with household labour | 3 | 8 | 3 | 8 | 6 | 8 |
| Encroachment | 3 | 8 | 4 | 10 | 7 | 9 |
| Fear of losing lands | 8 | 20 | 9 | 23 | 17 | 22 |
| Investment on land is difficult | 7 | 18 | 8 | 20 | 15 | 19 |
| No proper utilization of resources | 6 | 15 | 6 | 15 | 12 | 15 |
| Positive impact | 16 | 40 | 13 | 33 | 29 | 37 |
| Negative impact | 24 | 60 | 27 | 68 | 51 | 64 |

invest on their land. However about 40 and 33 per cent of the farmers in the rural and peri-urban area, respectively felt that urbanisation also had positive impact as it creates better non agricultural opportunities for the farming household. Some of the farmers felt that farming can be done effectively using the household labour only.

*Impact of urbanisation on medium farmers in the study areas :* As indicated from Table VIII, farmers from rainfed and irrigated area had mixed opinion on the impact of urbanisation on medium farmers. About 50 per cent and 53 per cent of rainfed farmers and irrigated farmers, respectively viewed that urbanisation had negative impact (such as difficulty in managing the farming, requirement of huge investments etc) on medium farmers, whereas about 50 and 48 per cent of the rainfed and irrigated farmers were of the view that urbanisation had positive impact (such as better income, better access to market and better value for the land) on the medium farmers.

*Impact of urbanisation on large farmers in the study areas :* As summarised in Table IX, both categories of the farmers believed that urbanisation had negative impact (labour problem, marketing risk and theft) on large farmers. About 65 and 53 per cent of the sample farmers from rainfed and irrigated situations,

TABLE VIII

*Impact of urbanisation on medium farmers in the study areas*

| Particulars | Rainfed (n=40) | | Irrigated (n=40) | | Over all (N=80) | |
|---|---|---|---|---|---|---|
| | Number | Per cent | Number | Per cent | Number | Per cent |
| Better income | 9 | 23 | 9 | 23 | 18 | 23 |
| Better market | 7 | 18 | 6 | 15 | 13 | 17 |
| Better value for land | 4 | 10 | 4 | 10 | 8 | 10 |
| Difficult to get the labour | 7 | 18 | 8 | 20 | 15 | 19 |
| Huge investment | 4 | 10 | 6 | 15 | 10 | 13 |
| Management difficult | 9 | 23 | 7 | 18 | 16 | 21 |
| Positive impact | 20 | 50 | 19 | 48 | 39 | 49 |
| Negative impact | 20 | 50 | 21 | 53 | 41 | 52 |

TABLE IX

*Impact of urbanisation on large farmers in the study areas*

| Particulars | Rainfed (n=40) | | Irrigated (n=40) | | Over all (N=80) | |
|---|---|---|---|---|---|---|
| | Number | Per cent | Number | Per cent | Number | Per cent |
| Commercialized farming | 4 | 10 | 5 | 13 | 9 | 12 |
| Huge value for the land | 5 | 13 | 6 | 15 | 11 | 14 |
| More income if managed properly | 5 | 13 | 6 | 15 | 11 | 14 |
| Difficult to get the paid labour | 11 | 28 | 10 | 25 | 21 | 27 |
| Huge investment | 7 | 18 | 3 | 8 | 10 | 13 |
| Market risk | 4 | 10 | 3 | 8 | 7 | 9 |
| Theft | 4 | 10 | 5 | 13 | 9 | 12 |
| Positive impact | 14 | 35 | 19 | 48 | 33 | 42 |
| Negative impact | 26 | 65 | 21 | 53 | 47 | 59 |

TABLE X

*Cochran's Q test to analyse the impact of urbanisation across the different classes*

| Particulars | Rainfed | Irrigated | Table Chi square value |
|---|---|---|---|
| Impact on men, women and children | 6* | 5.03 | 5.99 |
| Impact on labour and farmers | 5.86 | 12.39* | 9.49 |

Note: * indicates significant at 5 per cent.

respectively believed that urbanisation had negative impact on large farmers. Urbanisation had negative impact on large farmers as it was difficult to get the agricultural labour for work and larger land holdings calls for larger investment, market risk and prove to theft of the produce. About 35 and 48 per cent of the rainfed and irrigated farmers, respectively felt that as urbanisation encourages commercialization of farming reflecting in increased the value of agricultural lands and more value for the produce, thus pointing towards the positivity of urbanisation.

*Validation of positive and negative opinions regarding social categories by the respondent farmers :* The result of Cochran's Q test is furnished in Table X. The test results indicated that the impact of urbanisation on social groups (men, women and children) was statistically significant in the case of rainfed situations according to the opinion of sample farmers. But results were insignificant in the case of irrigated situations. There had been industrialization at the fringes of Bengaluru city. Men and women had better income earning opportunities than one at native village or home. Thus they had moved out of their natives in seek of better earnings.

Opinions of farmers on impact of urbanisation on different classes of farmers (landless, marginal, small, medium and large farmers) were significant in the case of irrigated farmers. But it was non-significant statistically in the case of rainfed situations as indicated by the table chi square values. Due to urbanisation farmers either go for better farming or will lose interest in the farming.

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# A Scale to Measure the Attitude of Youth Towards Farming

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Abstract

An attempt is made to develop and standardize a scale to measure the attitude of youth towards farming using summated ratings method. The attitude scale developed was found to be reliable and valid. Thus, the scale developed is useful in explicitly measuring the attitude of youth towards farming.

Youth constitute a numerically dominant potential, resourceful and also adventurous segment of the population in our country. More than 50 per cent of India's current population is below the age of 25 years and over 65 per cent is below the age of 35 years. Majority of them live in rural areas. The population in the age group of 15-34 years increased from 351 million in 2001 to 430 million in 2011. By 2020, India is set to become the world's youngest country with 64 per cent of its population in the working age group (Anonymous, 2011). To handle the standards of globalised farming situation, the need for high technological backup, knowledge base, extension networking and risk involvement among the farming community is the need of the hour. The only option to bring laurels to farming and to make it as a lucrative option in the rural areas is the involvement of youth in farming. Youth have a very strong mind set, possess high self confidence, risk taking ability and inquisitiveness to adopt innovations in farming. Their education, cosmopoliteness and group dynamics will give strong support to handle the present farming environment, but a rising number of rural youth are more interested in going to cities for acquiring necessary skills for getting jobs in companies or corporate sector. Limited access to markets, assets, finance and infrastructure in rural areas, coupled with rapid growth and opportunities in urban areas increasingly makes cities, the obvious choice for the youth in the search for a better life.

The responsibility of youth is to carry forward the tradition of farming because it has the potential of keeping the economy healthy even at times of recession by all means. There is a need to consider farming as an important industry to rely upon even in the modern era of industrialization and urbanization. In this context, a scale on attitude of youth towards farming is developed and standardized.

*Development of Scale to Measure the Attitude of Youth towards Farming :* Attitude is defined as the degree of positive or negative affect associated with some psychological object. (Thurstone, 1946). Kreth and Crutchfield (1948) defined attitude as an enduring organization of motivational, emotional, perceptual and cognitive process with respect to some aspect of the individuals world. For the present study, attitude of youth towards farming was operationalised as the psychological disposition of the rural youth about farming in varying degrees of favourableness or unfavourableness. Youth was operationalised as, a farmer who was been in farming since three years and are below 35 years of age. The method of Summated Rating scale developed by Likert (1932) was used in this study to develop an attitude scale to measure the attitude of youth towards farming.

The following steps were carried out to construct the scale to measure the attitude of youth towards farming.

*Collection and Editing of Statements :* In this step, a number of statements about attitude of youth towards farming were gathered from books, magazines, newspapers, research articles, journals, academic attainments, expertise of intellectuals in extension, research, teachers, farmers, self intuitions and own experiences. From all these sources a tentative list of 60 statements belonging to attitude of youth towards farming were prepared keeping in view of the applicability of statements suited to the area of study. The 60 statements collected were carefully edited by using 14 criteria given by Wang (1932), Bird

(1940) Edwards (1941), Thurstone (1946) and Kilpatrick (1948).

After editing the 60 statements, 14 statements were deleted, thus making a total of 46 Statements (Table I).

*Testing the Statements for Relevancy :* All the statements collected may not be relevant equally in measuring the attitude of youth towards farming. Hence, the statements were subjected to scrutiny by judges to determine the relevancy and screening for inclusion in the final scale. For this purpose, the list of all the 46 statements was prepared in the form of questionnaire and was sent to 100 judges. They were requested to give their responses on a four point continuum *viz.,* highly relevant, moderately relevant, slightly relevant and less relevant with scores 4, 3, 2 and 1 of respectively. They were also requested to feel free to add some more statements, if they feel important and also delete unrelated statements. The judges included the faculty and scientists working in Acharya N. G. Ranga Agricultural University, Extension Education Institute, Hyderabad, University of Agricultural Sciences, Bangalore, College of Agriculture, Pune, Central Agrciultural University, Meghalaya, Punjab Agricultural University, Ludhiana and also progressive farmers. The responses obtained from judges were subjected to Standard Normal Deviate test (z test). 'z' values were calculated for each statement after scoring the statements. Finally, the grand 'z' of all the 46 statements was obtained and '  ' was calculated. All the statements with 'z' values above $\bar{z}$ (-0.013) were selected as the scalable statements of attitude of youth towards farming. The statements with 'z' values below '$\bar{z}$' were eliminated. Thus, 34 statements out of 46 were selected through relevancy testing. The list of statements selected with their 'z' values are presented in Table I.

*Treating the statements with Likert's Summated Rating Technique of Scale Construction :* In this step, the 34 statements selected through relevancy test were given to 100 youth practicing farming in a non sample area and were asked to indicate their responses on a five point continuum viz., strongly agree (SA), agree (A), undecided (UD), disagree (DA) and strongly disagree (SDA) with 5,4,3,2 and 1 for positive statements and vice-versa for negative statements. After receiving the responses from the youth, the sum of the scores of all statements given by each respondent was calculated and the respondents were arranged in descending order based on the sum of the scores obtained for all the statements. The top 25 per cent of the respondents with the highest scores and the bottom 25 per cent of the respondents with the lowest scores were considered as criterion groups to evaluate individual statements. The middle 50 per cent of the respondents were deleted for further analysis. The top 25 per cent was considered as high group and bottom 25 percent was considered as low group to calculate the critical ratio i.e. 't' value for each statement. The calculated 't' value for each statement will measure the extent to which the statement differentiates between the respondents of high group and low group. The 't' values were calculated by using the formula suggested by Edwards (1969). The 't' value for each statement was calculated by using the following formula.

$$\bar{z} \quad t = \frac{\left(\bar{X}_H - \bar{X}_L\right)}{\sqrt{\Sigma\left(X_H - \bar{X}_H\right)^2 + \Sigma\left(X_L - \bar{X}_L\right)^2 / n\,(n-1)}}$$

*where,*

$X_L$ = Mean score on a given statement for the high group

$X_H$ = Mean score on a given statement for the low group

$$\Sigma\left(X_H - \bar{X}_H\right)^2 = \Sigma X_H^2 - \frac{\Sigma (X_H)^2}{n_H}$$

$$\Sigma\left(X_L - \bar{X}_L\right)^2 = \Sigma X_L^2 - \frac{\left(\Sigma X_L\right)^2}{n_L}$$

$$\bar{X}_H = \frac{\Sigma X_H}{n_H}$$

$$\bar{X}_L = \frac{\Sigma X_L}{n_H}$$

$$n = n_L = n_L$$

TABLE I

*Selection of attitude statements based on relevancy test*

| Statements | 'Z' Value |
|---|---|
| Advanced technologies encourage youth to flourish in farming | 0.19 + |
| I want to be an elite person in society through farming | 0.60 + |
| There is less opportunity for career development in farming* | 0.78 + |
| I prefer to be a farmer than as an employee | 0.84 + |
| As there is no other means of income I am forced to do farming* | 0.91 + |
| For highly educated youth it is unwise to do farming* | 0.31 + |
| I enjoy the relationship with nature through farming | 0.11 + |
| Farming is not viewed as a respectable profession in the society* | 0.08 + |
| I will not encourage my children to be in farming* | 0.38 + |
| Access to inputs and marketing is poor in farming* | 0.91 + |
| Farming is cumbersome compared to other occupations* | 0.11 + |
| I feel proud to be as part of profession feeding the nation | 0.43 + |
| Farming will give less scope for higher education accessibility to our children* | 0.83 + |
| The present environment is more hopeful for farming | 0.31 + |
| I feel farming is more profitable than any other occupation | 0.21 + |
| If you choose farming, you have to be ready to face the adverse effects* | 0.04 + |
| I am willing to seek for further knowledge and skills in farming | 0.43 + |
| I am ready to invite innovations in farming | 0.44 + |
| I work hard and smart to make farming worthy | 0.95 + |
| I can overcome any type of hardships in farming | 0.48 + |
| I do not want to continue in farming further* | 0.52 + |
| Farming leads to increasing standard of living | 0.52 + |
| Shortage of resources is major limiting factor in farming* | 0.06 + |
| Farming is more stressful* | 0.18 + |
| People who are able to take risks in farming are successful | 0.06 + |
| It is pleasure to lead a life in rural areas by farming | 0.35 + |
| I have my own vision to develop my farm | 2.36 + |
| Climate vagaries are the major threat for farming* | 2.20 + |
| For smallholders farming is not profitable * | 1.52 + |
| Farming gives us good reputation in society | 0.91 + |
| Farming is a major source of livelihood for rural people | 1.26 + |
| Low education qualification will force the youth to take up farming* | 0.38 + |
| Farming is only a type of tradition for rural people* | 2.51 + |
| I feel myself productive being involved in farming | 2.36 + |
| I perform different operations in farming with lot of interest | -1.05 |
| Intelligent people will persist in the farming with a hope of success | -0.25 |
| I will encourage others to engage in farming | -1.57 |
| As a hereditary occupation I am doing farming for livelihood* | -2.56 |
| I have freedom to work in my own way in farming | -1.44 |
| I do experiments to improve my farming | -0.99 |
| One should have passion towards farming to practice it | -0.90 |
| It is my privilege to sustain in farming | -0.46 |
| I will focus on economic gains rather than productivity in farming | -1.23 |
| I am in doldrums due to troubles in farming* | -2.31 |
| I prefer to take risks in farming at any cost | -0.68 |
| The existing farm amenities are not enough for farming* | -0.44 |

Note- * Negative Statements, + Statement with $\bar{z}$ value of -0.013 and less

TABLE II

*Selection of final attitude statements based on 't' values*

| Statements | 't' Value | |
|---|---|---|
| Advanced technologies encourage youth to flourish in farming | 4.13 | # |
| I work hard and smart to make farming worthy | 4.08 | # |
| For highly educated youth it is unwise to do farming* | 4.04 | # |
| I am willing to seek for further knowledge and skills in farming | 2.89 | # |
| Farming will give less scope for higher education accessibility to our children* | 2.44 | # |
| I prefer to be a farmer than as an employee | 2.39 | # |
| Farming leads to increasing standard of living | 2.33 | # |
| Access to inputs and marketing is poor in farming* | 2.19 | # |
| As there is no other means of income I am forced to do farming* | 2.14 | # |
| Shortage of resources is major limiting factor in farming* | 2.05 | # |
| Farming is cumbersome compared to other occupations* | 2.04 | # |
| I feel proud to be as part of profession feeding the nation | 2.04 | # |
| I do not want to continue in farming further* | 2.03 | # |
| I will not encourage my children to be in farming* | 2.02 | # |
| I am ready to invite innovations in farming | 1.94 | # |
| I want to be an elite person in society through farming | 1.91 | # |
| There is less opportunity for career development in farming* | 1.86 | # |
| If you choose farming, you have to be ready to face the adverse effects* | 1.84 | # |
| Farming is not viewed as a respectable profession in the society* | 1.82 | # |
| Farming is more stressful* | 1.81# | |
| The present environment is more hopeful for farming | 1.80 | # |
| I feel farming is more profitable than any other occupation | 1.80 | # |
| I can overcome any type of hardships in farming | 1.80 | # |
| I enjoy the relationship with nature through farming | 1.78 | # |
| Low education qualification will force the youth to take up farming* | 1.54 | |
| Farming gives us good reputation in society | 1.50 | |
| Farming is a major source of livelihood for rural people | 1.21 | |
| I feel myself productive being involved in farming | 0.99 | |
| Farming is only a type of tradition for rural people* | 0.79 | |
| It is pleasure to lead a life in rural areas by farming | 0.72 | |
| For smallholders farming is not profitable * | 0.71 | |
| Climate vagaries are the major threat for farming* | 0.66 | |
| People who are able to take risks in farming are successful | 0.56 | |
| I have my own vision to develop my farm | 0.48 | |

Note : * Negative Statements, #The statement with 't' values more than 1.75

TABLE III.

*Scale to measure the attitude of youth towards farming*

| Statements | Measurement | | | | |
|---|---|---|---|---|---|
| | SA | A | UD | DA | SDA |
| Advanced technologies encourage youth to flourish in farming | | | | | |
| I want to be an elite person in society through farming | | | | | |
| There is less opportunity for career development in farming* | | | | | |
| I prefer to be a farmer than as an employee | | | | | |
| As there is no other means of income I am forced to do farming* | | | | | |
| For highly educated youth it is unwise to do farming* | | | | | |
| I enjoy the relationship with nature through farming | | | | | |
| Farming is not viewed as a respectable profession in the society* | | | | | |
| I will not encourage my children to be in farming* | | | | | |
| Access to inputs and marketing is poor in farming | | | | | |
| Farming is cumbersome compared to other occupations* | | | | | |
| I feel proud to be as part of profession feeding the nation | | | | | |
| Farming will give less scope for higher education accessibility to our children* | | | | | |
| The present environment is more hopeful for farming* | | | | | |
| I feel farming is more profitable than any other occupation | | | | | |
| If you choose farming, you have to be ready to face the adverse effects* | | | | | |
| I am willing to seek for further knowledge and skills in farming | | | | | |
| Shortage of resources is major limiting factor in farming* | | | | | |
| I am ready to invite innovations in farming | | | | | |
| I work hard and smart to make farming worthy | | | | | |
| I can overcome any type of hardships in farming | | | | | |
| I don't want to continue in farming further* | | | | | |
| Farming leads to increase in standard of living | | | | | |
| Farming is more stressful* | | | | | |

* Negative Statement

SA = strongly agree ; A= agree; UD= undecided; D= disagree and SDA= strongly disagree

After computing 't' values for all the 34 statements, they were arranged in the order of highest 't' value to lowest 't' value. The statements with 't' values more than 1.75 were selected for the final attitude scale. Thus out of 36 statements, 24 statements with 't' value of 1.75 were selected in the attitude scale and are presented in the Table II.

The final attitude scale to measure the attitude of youth towards farming comprised of 24 statements (Table III), out of which were 12 are positive statements and the other 12 are negative statements measured on a five point continuum viz., strongly agree (SA), agree (A), undecided (UD), disagree (DA) and strongly disagree (SDA) with 5,4,3,2 and 1 for positive statements and vice-versa for negative statements as shown in the Table III.

*Reliability of the scale :* A scale is reliable when it will consistently produce the same results when

applied on the same sample (Goode and Hatt, 1952). Split half method was employed for testing the reliability. The attitude scale of 24 statements was distributed to 30 youth practicing farming in non sample area to check the reliability of the scale. After obtaining the response, the scale was divided into two halves, all odd statements into one half and all even statements into another. Then the co-efficient of reliability was calculated between the two halves. The correlation coefficient for both the sets was worked out. The correlation coefficient (r=0.84) was significant at 0.01 level indicating the attitude scale was highly suitable for administration to the youth in farming.

*Validity of the scale :* The validity of the scale on attitude of youth towards farming was obtained through content validity considering the judges opinion. The statements selected for the scale were evaluated individually and as a whole by the judges. These were again checked by experts in Acharya N.G. Ranga Agricultural University for their relevance and coverage. As the content of the attitude scale was borne out by the method of collecting statements within the universe of attitude of youth towards farming, it may reasonably be assumed that the attitude of youth towards farming scale has content validity. The final standardized scale to measure the attitude of youth towards farming was used for the main research study (Table III).

Administration of the attitude scale and method of scoring : Attitude of youth towards farming could be measured using 24 statements (Table III). Each statement of scale are provided with five point continuum viz., strongly agree (SA), agree (A), undecided (UD), disagree (DA), strongly disagree (SDA) with scores of 5,4,3,2 and 1, respectively for positive statements and 1,2,3,4 and 5 for negative statements. The total score of the respondent on the scale could be obtained by summing up the scores of all the statements in the scale. The possible minimum and maximum score was 24 and 120, respectively. The higher score indicates that respondent had more favourable attitude towards farming and vice-versa.

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# Job Performance of State Agricultural University Teachers in Karnataka

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## Abstract

The present study was conducted during 2014-2015 to analyze the job performance of teachers. Data was collected from a sample of 180 teachers comprising of 60 Assistant Professors, 60 Associate Professors and 60 Professors using a pre-tested interview questionnaire The results revealed that there was no significant difference in job performance levels of teachers of UAS (B) and UAS (D). It was found from the 't' values that there was no significant difference in the mean job performance scores between Professors and Associate Professors ('t' value =1.488) and between Associate Professors and Assistant Professors ('t' value =1.211). However, there existed a significant difference in the mean job performance score between Professors and Assistant Professors as evident from 't' value (2.100). Education, mass media participation, training undergone, perceived work load, number of publications published, achievement motivation, aspiration, competition orientation, scientific orientation, participation in seminars/conferences, award/recognition received, job experience, organizational climate and attitude towards organizations of teachers had significant to highly significant association with their job performance. Twenty two independent variables selected for the study had contributed to the tune of 69.30 per cent variation on the job performance of teachers. Majority of the teachers suggested that they must be relieved from non-academic /clerical activities (Scrutinizers, warden, members for various committees etc.) (76.11%), deputing them to pursue post-doctoral programme (69.44%) and the University should provide LCD facility in all classrooms (53.33%) for improving their job performance.

The concept of integration of teaching, research and extension has already proved its worth through remarkable progress made in the field of agricultural education, research and extension by the Agricultural Universities. There is perceptible improvement in the quality of education with more competent teachers, better equipped libraries, laboratories, etc. in the Agricultural Universities. These institutions today are serving as fountain heads of new knowledge earned through purposeful, problem-solving research and have become main centres of dissemination of useful knowledge to the farming community. There are numerous functional specialists in these Universities who have gained confidence through experience in successfully applying scientific knowledge to the solution of practical problems.

Job performance of the employee helps to know their level of performance and delineate the factors responsible for it. Job performance of the teachers is one of the criterion for evaluating the effectiveness of an organization. Employees' performance refers to an act of fulfillment of the requirement of a given job i.e., the manner in which an employee carries out his/her job efficiently (Sharma (1986). However, in many organizations especially under public sector, the performance of the staff is associated mostly to fulfill the organizational goals such as promotions, transfers and for determining the training needs. But in developmental organizations, the performance of the staff is assessed in order to achieve some targeted objectives. Unless the employees are well informed about their performance and also their strong and weak points, it is very difficult for them to improve their level of performance. This is also considered as important for reinforcing the positive points and overcoming the weakness of the employees. Thus, measurement of job performance and its feedback plays an important role in knowing the efficiency of employees. In this backdrop, the present study is undertaken with the following specific objectives:

To analyze the job performance of teachers.

To find out the association between personal, psychological, socio-economic and communication characteristics of teachers with their job performance.

To enlist the suggestions of teachers for improving their job performance.

## METHODOLOGY

The study was conducted during 2014-15 at three campuses of University of Agricultural Sciences, Bengaluru (UASB) and three campuses in University of Agricultural Sciences, Dharwad (UASD). Three campuses selected from UAS, Bengaluru were : (1) Agricultural College, GKVK, (2) Agricultural College, Hassan and (3) Sericulture College, Chintamani. Whereas the three campuses selected in UAS, Dharwad campus were: (1) Agricultural College, Dharwad, (2) Forestry College, Sirsi and (3) Agricultural College, Hanumanamatti.

The respondents for this study were the teachers working in the above mentioned six colleges. From each campus, 30 Assistant Professors, 30 Associate Professors and 30 Professors were selected for the study. Sixty Assistant Professors, 60 Associate Professors and 60 Professors from two Universities were sampled for the study. Ex-post facto research design was followed in the present study since the phenomenon has already occurred.

*Job performance (Dependent variable):* The job performance was operationalized as the degree to which the different job duties (activities) were performed by the teachers as the occupants of the post. The job performance of teachers was measured by using the scale developed by Sundaraswamy (1987) with some modifications. The scale consist of 7 items on a three-point continuum, namely, most efficient, efficient and least efficient with score of 3, 2 and 1, respectively. The minimum and maximum one could get was 7 and 21, respectively. The performance score of all the job items was summed up to get the job performance score of teachers. Then the respondents were categorized into low, medium and high levels of job performance based on mean and half standard deviation .

The information about 22 independent variables (Table V) was collected with the help of a pre-tested interview schedule. The collected data was scored, tabulated and analyzed using frequencies, percentage, chi-square test, multiple regression analysis and t-test.

## RESULTS AND DISCUSSION

*Overall job performance of UASB and UASD teachers:* Data provided in Table I presents the data on the overall job performance of teachers of UASB and UASD. The table indicates that a greater number (36.68%) of UASB teachers were belonging to high level of job performance, while 34.44 and 28.88 per cent of them were belonging to medium and low level of job performance categories, respectively. As high as 71.12 per cent of UASB teachers were found in medium to high level of job performance categories.

TABLE I

*Overall job performance of UASB and UASD teachers*

| Job Performance | Teachers | | | |
|---|---|---|---|---|
| | UAS B (n=90) | | UASD (n=90) | |
| | No. | % | No. | % |
| Low | 26 | 28.88 | 28 | 31.11 |
| Medium | 31 | 34.44 | 29 | 32.21 |
| High | 33 | 36.68 | 33 | 36.68 |
| Total | 90 | 100.00 | 90 | 100.00 |

It could also be seen from the same Table that more number of (36.68%) UASD teachers were belonging to high level of job performance, while 32.21 per cent were having medium and 31.11 per cent of them were having low level of job performance. A majority (68.89%) of the UASD teachers were found in medium to high level of job performance categories.

Better working environment, good salary coupled with promotional opportunities, job security, deputation by the University to higher education and training, availably of ICT tools for teaching etc., are the reasons for majority of teachers of UASB (71.12%) and UASD (68.89%) for performing their job better. Similar findings were reported by Narasimhagowda (1989) and Mohan (2000).

*Test of significance between the UASB and UASD teachers with respect to overall job performance:* Table II reveals that the mean job performance score of UASB teachers (16.99) was more compared to the mean job performance score

TABLE II

*Test of significance between UASB and UASD teachers with respect to overall job performance*

| Teachers | Job Performance | |
|---|---|---|
| | Mean Score | 't' Value |
| UAS(B) (n=90) | 16.99 | 0.212 NS |
| UAS(D) (n=90) | 16.01 | |

NS= Non significant

of UASD teachers (16.01). However, there was no significant difference as evident from 't' value (0.212 ) in respect of the mean job performance scores between UASB and UASD teachers. It can inferred that there is no difference in job performance of teachers of UASB and UASD.

*Overall job performance of Assistant Professors, Associate Professors and Professors:* The results in Table III presents the data on the overall job performance of Assistant Professors, Associate Professors and Professors. It could be seen from Table III that 35.00 per cent of the Assistant Professors were belonging to low level of job performance, while one-third (33.34%) and 31.66 per cent of the Assistant Professors were belonging to medium to high level of job performance categories. A majority (68.34%) of the Assistant Professors were belonging to medium to low level of job performance category.

TABLE III

*Overall job performance of Assistant Professors, Associate Professors and Professors*

| Job Performance | Teachers | | | | | |
|---|---|---|---|---|---|---|
| | Asst. Prof. (n=60) | | Assoc. Prof. (n=60) | | Professor (n=60) | |
| | No. | % | No. | % | No. | % |
| Low | 21 | 35.00 | 18 | 30.00 | 15 | 25.00 |
| Medium | 20 | 33.34 | 19 | 31.66 | 21 | 35.00 |
| High | 19 | 31.66 | 23 | 38.34 | 24 | 40.00 |
| Total | 60 | 100.00 | 60 | 100.00 | 60 | 100.00 |

More number (38.34%) of Associate Professors were belonging to high level of job performance, whereas 31.66 and 30.00 per cent of them were belonging to medium and low level of job performance categories. A majority (70.00%) of the Associate Professors were belonging to medium to high level of job performance categories.

Forty per cent of the Professors were belonging to high level of job performance category, while 35.00 and 25.00 per cent of them were belonging to medium and low level of job performance categories. A vast majority (75.00%) of the Professors were belonging to medium to high level of job performance categories.

Lack of experience, more work load and deputing them to non-academic/clerical activities (Marks-card Scrutinizers, Warden, Tour managers etc.,) are the reasons for greater number of Assistant Professors (35.00%) exhibiting low job performance compared to the high level of job performance as exhibited by Associate Professors ( 38.34%) and Professors (40.00%).

*Test of significance between Assistant Professors, Associate Professors and Professors with respect to job performance :* It is also observed from Table IV that the mean job performance scores of Professors (19.28) were more than the mean job performance scores of Associate Professors (17.01) and Assistant Professors (15.88). It can be inferred from 't' values that there was no significant difference

TABLE IV

*Test of significance between Assistant Professors, Associate Professors and Professors with respect to job performance*

| Teachers | Job Performance | |
|---|---|---|
| | Mean Score | 't' Value |
| Assistant Professors (n=60) | 15.88 | 1.211 NS |
| Associate Professors (n=60) | 17.01 | |
| Associate Professors (n=60) | 17.01 | 1.488 NS |
| Professors (n=60) | 19.28 | |
| Professors (n=60) | 19.28 | 2.100 * |
| Assistant Professors (n=60) | 15.88 | |

NS= Non-significant * Significant at 5 per cent level

in the mean job performance scores between Professors and Associate Professors ('t' value =1.488) and also between Associate Professors and Assistant Professors ('t' value =1.211). But there existed a significant difference in the mean job performance score between Professors and Assistant Professors as evident from 't' value (2.100).

*Association between the independent variables and job performance of teacher :* The analysis of the chi-square test in Table V revealed that mass media participation, training undergone, perceived work load, number of publications published, achievement motivation, aspiration, competition orientation, scientific orientation, participation in seminars/conferences and award/recognition received had significant association with the job performance of teachers at five per cent level. On the other hand, variables such as, education, job experience, organizational climate and attitude towards organizations were found to have significant association at one per cent level with the job

TABLE V

*Association and extent of contribution of independent variables with Job performance*

(n=180)

| Independent Variables | Chi Square Value | Regression Co-effieient | Standard Error | 't' Value |
|---|---|---|---|---|
| Sex | 0.692 NS | 0.944 | 0.212 | 0.225 NS |
| Age | 1.628 NS | 0.456 | 0.122 | 0.267 NS |
| Education | 14.699 ** | 0.265 | 0.828 | 3.136 ** |
| Family size | 2.312 NS | 0.824 | 0.512 | 0.621 NS |
| Annual income | 1.968 NS | 0.319 | 0.412 | 1.291 NS |
| Rural- urban background | 2.699 NS | 0.014 | 0.014 | 0.961 NS |
| Job experience | 20.699 ** | 0.320 | 0.922 | 2.888 ** |
| Rural experience | 0.928 NS | 0.148 | 0.231 | 1.560 NS |
| Mass media participation | 10.699 * | 0.211 | 0.362 | 1.712 NS |
| Training undergone | 11.621 * | 0.324 | 0.692 | 2.134 * |
| Perceived work load | 12.681 * | 0.243 | 0.412 | 1.691 NS |
| Number of publications | 1.938 * | 0.763 | 0.512 | 0.671 NS |
| Achievement motivation | 10.928 * | 0.365 | 0.012 | 2.222 * |
| Aspiration | 11.612 * | 0.324 | 0.699 | 2.156 * |
| Competition orientation | 10.062 * | 0.344 | 0.616 | 1.788 NS |
| Scientific orientation | 9.962 * | 0.335 | 0.561 | 1.671 NS |
| Organizational climate | 13.690 ** | 0.158 | 0.888 | 5.613 ** |
| Attitude towards organization | 15.699 ** | 0.235 | 0.926 | 3.916 ** |
| Participation on seminars/conferences | 11.688 * | 0.251 | 0.421 | 1.671 NS |
| Abroad exposure/countries visited | 1.699 NS | 0.392 | 0.383 | 0.976 NS |
| Awards/Recognition received | 12.666 * | 0.397 | 0.791 | 1.999 * |
| Number of post graduate students guided | 0.968 NS | 0.131 | 0.091 | 0.691 NS |

**Significant at 1 per cent level; *= Significant at 5 per cent level; NS= Non significant; $R^2$=0.693 ; F=15.69**

performance of the teachers. While, the variables such as sex, age, family size, annual income, rural-urban background, rural experience, abroad exposure/country visited and number of students guided had no significant association with the job performance of teachers.

For every unit increase in education, mass media participation, training undergone, perceived work load, number of publications published, achievement motivation, aspiration, competition orientation, scientific orientation, participation in seminars/conferences and award/recognition job experience, organizational climate and attitude towards organizations there will be increase in the job performance level of the teachers. The present findings are in line with the results of Salunkhen *et al.* (2012), Pounraj (2013), Gopika (2015), Manjunath (2015) and Tanweer (2015).

*Extent of contribution of independent variables on the job performance of teachers:* The examination of Table V also reveals that the 22 independent variables had contributed to the tune of 69.30 per cent ($R^2$=0.693) variation on the job performance of teachers. The results further revealed that the independent variables, such as, education, job experience, training undergone, achievement motivation, aspiration, organizational climate, attitude towards organization and awards/recognition received were significant in multiple regression analysis in explaining the variation on the job performance of teachers. The said eight independent variables have immensely contributed to the job performance of teachers. These variables are considered to be the crucial variables in explaining the job performance.

*Suggestions of teachers for increasing their job performance :* It is observed from Table VI that majority of the teachers suggested that they must be relieved from non-academic /clerical activities (Scrutinizers, warden, members for various committees etc.) (76.11%), depute them to pursue post-doctoral programme (69.44%) and the University should provide LCD facility in all classrooms (53.33%) for improving their job performance. Whereas, less than half of the teachers suggested that there should be transparency in transfer policy (once in 5 years ) (45.55%), the University to provide adequate number of computers with speed internet facility (39.44%), depute teachers for pre-service/in-service trainings (38.33%), depute teachers to participate in seminars/ conference/training programme etc. (36.11%), provide good working atmosphere needed for performing good work (28.33%), recruit more teachers for reducing work load of present faculty (28.33%), provide recognition for teachers for good work (23.33%), provide adequate funds for conducting research

TABLE VI

*Suggestions of teachers for increasing their job performance*

(n=180)

| Suggestions* | Teachers | |
|---|---|---|
| | No. | % |
| Deputing teachers to pursue post-doctoral programme. | 125 | 69.44 |
| Good working atmosphere needed for performing good work. | 51 | 28.33 |
| Recruitment of teachers for reducing work load of present faculty | 51 | 28.33 |
| Providing adequate number of computers with speed internet facility | 71 | 39.44 |
| Providing recognition for teachers for good work | 42 | 23.33 |
| Providing adequate funds for conducting research | 39 | 21.66 |
| Establishing adequate laboratory facilities | 26 | 14.44 |
| Transparency in transfer policy (once in 5 years ) | 82 | 45.55 |
| Adequate number of staff quarters | 24 | 13.33 |
| Teachers must to be relieved from non-academic /clerical activities (Scrutinizers, warden, members for various committees etc) | 137 | 76.11 |
| Providing LCD facility in all classrooms | 96 | 53.33 |
| Deputing teachers for pre-service/ in-service trainings | 69 | 38.33 |
| Deputing teachers to participate in seminars/ conference/training programme etc. | 65 | 36.11 |
| Adequate transport facilities for taking students to field work/visits to organizations | 30 | 16.66 |

*Multiples responses is possible

(21.66%), provide adequate transport facilities for taking students to field work/visits to organizations (16.66%), establish adequate laboratory facilities (14.44%) and provide adequate number of staff quarters (13.33%) for improving their performance.

Majority of UASB and UASD teachers belong to medium to high level of job performance categories and there was no significant difference observed between the Teachers of two farm universities in terms of their job performance. When teachers perceive job as more enjoyable, certainly their performance is going to enhance. It is necessary to improve the job performance of the teachers by the State Agricultural Universities by providing : (a) essential infrastructure facilities, (b) depute them for post-doctoral studies, higher training and seminars. workshops, conference etc., (c) appropriate promotion opportunities and suitable reward for work, and (d) relieve the Assistant Professors from non-academic / clerical activities.

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*Mysore J. Agric. Sci.*, 50 (4) : 768-769, 2016 **Research Note**

# Constraints of Bt Cotton Growers

COTTON (*Gossypium* sp.) the white gold and king of fibers is cultivated in tropical and subtropical regions of more than 70 countries across the world. India is the second largest cotton producer and consumer in the world. In India, Bt cotton occupies an area of 11.73 million ha with a production of 39.00 million bales and productivity of 565 kg/ha in 2014-15. In Karnataka, Bt cotton occupies an area of 7.60 lakh ha with a production of 26.90 lakh bales and a productivity of 626 kg/ha. The increase in productivity from 247 kg/ha in 2005-06 to 626 kg/ha in 2014-15 is mainly due increased cultivation of Bt cotton (Anon., 2014). Though the farmers are adopting the Bt cotton, they are facing various constraints. Therefore, the present study was carried out to elicit the constraints faced by the Bt cotton growers.

The present study was conducted purposively in two taluks of Belagavi district. Three villages from each taluk were selected based on the criterion of maximum area under Bt cotton. From each village, a list of Bt cotton growers was prepared with the help of Agricultural Assistants and 20 respondents from each village were selected by using simple random technique thus making a total sample of 120. Data were collected by using structured pre-tested interview schedule. Constraints faced by the Bt cotton growers were classified into three categories namely production, financial and marketing. The responses were documented as 'severe', 'moderate' and 'not at all', assigning score of 3, 2 and 1, respectively. Score obtained for each constraint was ranked.

The data in Table I revealed that high cost of plant protection chemicals (I rank), high cost of seed material (II rank) and non-availability of technical guidance (III rank) were the major production constraints by Bt cotton growers in order of priority. Other constraints faced by the Bt cotton growers was the non–availability of technical guidance. These findings are in agreement with the findings of Varadaraju *et al.*(2009), Basavaraj Gundappagol (2014) and Vinayak Narayan Nayak (2014).

With regard to the financial constraints, Bt cotton growers faced were inadequate credit (I rank) and inadequate subsidy (II rank). Most of the respondents felt that the quantum of loan was not sufficient to take up Bt cotton cultivation. Inadequate subsidy was an other major financial constraints faced by the Bt cotton growers. As the subsidies were limited in number and most of the respondents were not able to get the subsidies. With respect to high interest rate on loan, the respondents felt that interest rate on loan should be minimized. These findings are in agreement with the findings of Madhu (2010).

TABLE I

*Constraints experienced and suggestions offered by Bt cotton growers* (n=120)

| Constraints and suggestions | Score | Rank |
|---|---|---|
| **I. Constraints** | | |
| A. *Production constraints* | | |
| High cost of plant protection chemicals | 333 | I |
| High cost of seed material | 304 | II |
| Non availability of technical guidance | 296 | III |
| High cost of fertilizers | 291 | IV |
| High diseases incidence | 246 | V |
| Increased pest incidence | 242 | VI |
| Non availability of irrigation water | 238 | VII |
| Non availability of Bio fertilizers | 218 | VIII |
| Scarcity of labour | 208 | IX |
| Non availability of loan | 202 | X |
| Non availability of seed in time | 200 | XI |
| Non availability of agricultural implement | 194 | XII |
| Non availability of sowing implement on time | 185 | XIII |
| Non availability of FYM/Compost | 179 | XIV |
| B. *Financial constraints* | | |
| Inadequate credit | 272 | I |
| Inadequate subsidy | 246 | II |
| High interest rate on loan | 214 | III |
| Non availability of credit in time and insufficient | 211 | IV |
| Insufficient repayment time | 206 | V |

| Constraints and Suggestions | Score | Rank |
|---|---|---|
| C. *Marketing constraints* | | |
| Lack of market information | 331 | I |
| Delayed cash payment | 236 | II |
| Poor transport facilities | 229 | III |
| Lack of storage facilities | 221 | IV |
| Improper weighment | 217 | V |
| High transportation charges | 216 | VI |
| Exploitation by middlemen | 215 | VII |
| High commission rates | 208 | VIII |
| Distant location of market | 203 | IX |
| Non-availability of regulated market | 202 | X |
| Complexity of payment | 182 | XI |
| **II. Suggestions to overcome constraints** | | |
| Providing timely market information | 323 | I |
| Inputs should be made available at cheaper rate | 309 | II |
| Supply of power/electricity continuously | 307 | III |
| Quality seeds should be made available at affordable price | 294 | IV |
| Fixing of minimum support price | 285 | V |
| Establish demonstration plots in the locality | 278 | VI |
| Promote contract farming | 241 | VII |
| Assured irrigation facility | 238 | VIII |
| Extension personnel should visit farm once in fortnight during crop season | 224 | IX |
| Encourage the cultivation of pigmented cotton | 209 | X |
| Credit should be made available at cheaper interest rate | 199 | XI |
| Expansion of storage facility | 192 | XII |
| Create awareness on cotton picking machine | 181 | XIII |

The lack of market information (I rank), delayed cash payment (II rank) and poor transport facilities (III rank) were the major marketing constraints faced by Bt cotton growers. These findings are in consonance with the findings of Varadaraju *et al.* (2009).

Further, it is evident from the Table I that the major suggestions given by the Bt cotton growers were provide timely market information (I rank), inputs be made available at cheaper rate (II rank) and continous supply of power / electricity (III rank).

The findings of the study revealed that majority of Bt cotton growers have faced the constraints of high cost of inputs, inadequate credit and lack of market information. Major suggestions were to provide timely market information, inputs be made available at cheaper rate and continuous supply of power/ electricity. Hence, the developmental departments and concerned organizations should minimize the inputs cost, provide adequate credit and market information to the Bt cotton growers for enhancing the cotton production.

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# Profile and Constraints of Dairy Farm Women

DAIRY sector plays a prominent role in strengthening India's rural economy. It has the potential to act as an instrument to bring about socio-economic transformation. Small and marginal farmers and landless labours who derive a substantial part of their livelihood from sale of milk, own about 70 per cent of cattle in rural areas. Therefore, dairy development in India has been an effective and important instrument of rural development as it generates self-employment opportunities, increases the income of landless, marginal and small farmers, besides, providing the much needed nutrition to people (Singh, 2009).

In India, 86 per cent of rural women are engaged in agriculture and allied activities, predominantly in animal husbandry and dairying, besides performing household work. Women actively participate in the management of dairy animals, production and other aspects of dairying. Caring of animals includes activities like bringing fodder from field, chaffing the fodder, preparing feed for animals, offering water to animals, protection of animals from ectoparasites, cleaning of animals and sheds, preparation of dung cakes, milking, preparing and marketing of milk products.

The process of dairy development would be incomplete and lop sided, unless farm women are fully involved in it. Unless the profile of farm women and constraints faced by them in dairy are studied and identified, the developmental programs cannot be implemented successfully. With this background, the present study has been formulated to know the profile of women dairy farmers and to elicit the constraints faced by them in dairy farming.

The study was conducted in two taluks of Chikkamagalur district based on maximum number of Women Milk Producing Co-operative Societies (MPCSs). A list of villages in each taluk was prepared and listed in descending order by using the same criteria. Top six villages from each taluk were purposively selected. From each village, ten dairy farm women were selected by using simple random technique thus making a total sample of 120. The data were collected by using structured interview schedule.

It is evident from Table I, a larger number of respondents belong to middle aged group (48.30%), had high school education (35.00%), medium family size (51.67%), small land holding (46.67 %) , medium

TABLE I

*Personal and socio-economic characteristics of dairy farm women*

(n=120)

| Characteristics | No. | % |
|---|---|---|
| *Age* | | |
| Young (< 31 years) | 46 | 38.33 |
| Middle (31 to 50 years) | 58 | 48.30 |
| Old (> 50 years) | 16 | 13.33 |
| *Formal education* | | |
| Illiterate | 7 | 5.83 |
| Primary school | 18 | 15.00 |
| Middle school | 36 | 30.00 |
| High school | 42 | 35.00 |
| College and above | 17 | 14.17 |
| *Family size* | | |
| Small (Up to 4 members) | 40 | 33.33 |
| Medium (5 to 8 members) | 62 | 51.67 |
| Big (Above 8 members) | 18 | 15.00 |
| *Land holding (acres)* | | |
| Marginal (0.1 to 2.5) | 46 | 38.33 |
| Small (2.6 to 5.0) | 56 | 46.67 |
| Medium (5.1 to 10.0) | 12 | 10.00 |
| Big (> 10) | 6 | 5.00 |
| *Annual income* | | |
| Low (Up to Rs. 50,000) | 32 | 26.67 |
| Medium (Rs. 50,000 to Rs. 1,00,000) | 40 | 33.33 |
| High (>Rs.1,00,000.) | 48 | 40.00 |
| *Dairy experience* | | |
| Low (Below 10 years) | 63 | 52.50 |
| Medium (10 to 20 years) | 42 | 35.00 |
| High (Above 20 years) | 15 | 12.50 |

| Characteristics | No. | % |
|---|---|---|
| *Decision making* | | |
| Low (< 9.20) | 25 | 20.83 |
| Medium (9.20 to 11.78) | 58 | 48.33 |
| High (> 11.78) | 37 | 30.83 |
| *Risk orientation* | | |
| Low (<9.21) | 30 | 25.00 |
| Medium (9.21 to 12.76) | 67 | 55.83 |
| High (> 12.76) | 23 | 19.17 |
| *Economic motivation* | | |
| Low (< 8.44) | 20 | 16.67 |
| Medium (8.44 to 11.31) | 71 | 59.17 |
| High (> 11.31) | 29 | 24.17 |
| *Livestock possession* | | |
| Low (<8.46) | 32 | 26.66 |
| Medium (8.46- 10.82) | 62 | 51.66 |
| High (> 10.82) | 26 | 21.66 |
| *Social participation* | | |
| Low (<7.10) | 41 | 34.16 |
| Medium (7.10 – 11.87) | 52 | 43.33 |
| High (> 11.87) | 27 | 22.50 |
| *Mass Media participation* | | |
| Low (<5.17) | 26 | 21.66 |
| Medium (5.17 – 10.48) | 40 | 33.33 |
| High (> 10.48) | 54 | 45.00 |
| *Extension participation* | | |
| Low (< 5.04) | 30 | 25.00 |
| Medium (5.04 – 10.09) | 51 | 42.50 |
| High (>10.09) | 39 | 32.50 |

decision making (48.33%) medium risk orientation (55.83%), medium economic motivation (59.17%), medium livestock possession (51.66%), medium social participation (43.33%) and medium extension participation (42.50%). Further, more number of respondents belong to high annual income (40.00%) and high mass media participation (45.00%). Whereas, 52.50 per cent of respondents had less experience in dairy. The above results are in line with the findings of Arora *et al.* (2006) , Mande and Thombre (2009), Satyanarayan and Jagadeeshwary (2010) and Upayana Singh *et al.* (2010)

The constraints faced by farm women in relation to management, technical and economic aspects of dairy presented in Table II. With regard to management aspects, majority of dairy farm women expressed lack of knowledge on preparation of concentrates locally (89.17%) followed by non-availability required of

TABLE II

*Constraints of dairy farm women in dairy farming*

(n=120)

| Constraints | No. | % |
|---|---|---|
| A. *Management constraints* | | |
| Unable to identify the right time of the oestrus symptoms for artificial insemination | 41 | 34.17 |
| Non availability required fodder seeds | 76 | 63.33 |
| Non availability of required concentrate | 99 | 82.50 |
| Lack of training on clean milk production and dairy management | 97 | 80.83 |
| Lack of knowledge on preparation of concentrates locally | 107 | 89.17 |
| No specialised training on value addition | 70 | 75.83 |
| B. *Technical constraints* | | |
| Lack of veterinary services in the village | 66 | 55.00 |
| Expensive consultancy service by private practitioners | 70 | 58.33 |
| Lack of technical knowledge on calfrearing & disease management | 62 | 51.67 |
| Lack of knowledge regarding recordkeeping | 70 | 58.33 |
| *C. Economic constraints* | | |
| High cost of concentrates | 120 | 100.0 |
| High cost of cross breed cow/ improved Buffaloes | 115 | 95.83 |
| High cost of veterinary medicines | 53 | 44.17 |
| Difficult loan procedure | 69 | 57.50 |
| Inadequate finance support by banks for purchasing milch animals | 66 | 55.00 |
| High cost of milk production (feed cost) | 110 | 91.67 |

concentrates (82.50%) and lack of training on clean milk production and dairy management (80.83%) as major constraints. The technical constraints faced by the respondents include expensive consultancy service of private practioners (58.33%) and lack of knowledge regarding record keeping (58.33%) followed by lack of veterinary services in the village (55.00%) and lack of technical knowledge on calf rearing and disease management in dairy animals (51.67%). In case of economic constraints, cent per cent of dairy farm women expressed that the high cost of concentrates followed by high cost of crossbreed cows or improved buffalo (95.83 %) and high cost of milk production (91.67 %) are the other constraints. Similar constraints were reported by Anil Chauhan (2006) and Agarwal *et al.* (2007).

There is a need by the Milk Unions and Dept. of Animal Husbandry to educate the farm women about preparation of concentrates locally, cleaned milk production and dairy management. Further, strategic manipulation of variables such as education, decision making, risk orientation, livestock possession, economic motivation, social participation, extension participation and mass media participation can motivate the dairy farm women to enhance their participation.

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# Empowerment of Women through Self Help Groups in Karnataka

THE study was conducted in Karnataka state during 2014-15. Eight districts from all the four geographical divisions *viz.*, Chitraduraga, Ramanagara, Chickballapur, Bagalkot, Belagavi, Dharwad, Koppal and Mandya were selected for the study. From each district 50 SHGs formed between 2005-10 were selected and from each SHG, one office bearer and two members were selected to assess the empowerment. Thus, the total sample consisted of 400 SHGs and 1200 respondents (400 office bearers and 800 members). Empowerment was measured with the help of scale developed for the study. The scale consisted of separate statements to measure all the three types of empowerment *viz.,* socio-psychological, economic, legal and political empowerment.

The empowerment through SHG's was measured based on the perception of the respondents, on a three point continuum for each statement as 'no change', 'some change' or 'change to a large extent' after joining SHG's.

The level of empowerment of overall SHGs was highest in case of socio-psychological (4.14) followed by economic (3.38) and legal and political (2.72) (Table I). The overall empowerment was 3.65, which clearly indicate that SHG members are empowered to a large extent. Socio-psychological empowerment is greater than economic empowerment because all the members are almost regular in attending meetings and have started interacting with others. But cent per cent of the members have not undertaken income generating activities, hence the economic empowerment is less compared to socio-psychological empowerment. There are no specific activities undertaken by the groups which results in legal and political empowerment, hence it is low compared to other types of empowerment.

The perceived change in socio-psychological empowerment of SHG members is given in Table II. With regard to socio-psychological empowerment, economic and, legal and political, 88.75 per cent of office bearers perceived that the change was to a 'larger extent' and only 11.25 per cent of office bearers said that there was 'some change'. Whereas, in case of members, 98.50 per cent perceived change to a 'large extent' and only 1.50 per cent of office bearers perceived 'some change'. Overall percentage shows that 95.22 per cent perceived the change to a 'large extent' and only 4.78 said that there was 'some change'. There is no much difference between office bearers and members in the extent of empowerment. The SHGs have facilitated the members to mingle and interact with other women thereby empowering them socio-psychologically. Hence, majority of SHG members have perceived that they are empowered socio-psychologically to a 'large extent'.

TABLE I

*Level of empowerment of members*

(N =1200)

| Levels of empowerment | Mean (Range 1.00 -5.00) |
|---|---|
| Socio- psychological | 4.14 |
| Economic | 3.38 |
| Legal and political | 2.72 |
| Over all | 3.65 |

In respect of economic empowerment, 87.75 per cent of office bearers and 93.62 per cent of members perceived the change to a 'large extent', whereas, 2.25 per cent of office bearers and 1.25 per cent members perceived that there was 'some change' and ten per cent office bearers and five of per cent of members felt that there was 'no change' in their economic empowerment after joining SHGs. The overall percentage shows that 91.67 per cent perceived the change to a 'large extent', 1.58 said that there was 'some change' and the remaining 6.66 per cent perceived as there was 'no change' due to joining SHGs.

One of the important objective of SHGs is to increase the income level of rural women by taking up income generating activities along with easy access to credit. Around 50 per cent of the women have taken up income generating activities and are earning regularly income. But, the rest of them have gained access to credit due to the savings made in the group,

TABLE II

*Distribution of SHG members according to perceived change in socio-psychological, economic and legal and political empowerment*

| Extent of change | Office bearers ($n_1$=400) | | Members ($n_2$=800) | | Overall change (N=1200) | |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % |
| *Socio-psychological empowerment* | | | | | | |
| No change | - | - | - | - | - | - |
| Some change | 45 | 11.25 | 12 | 1.50 | 58 | 4.78 |
| To a large extent | 355 | 88.75 | 788 | 98.50 | 1148 | 95.22 |
| *Economic empowerment* | | | | | | |
| No change | 40 | 10.00 | 40 | 5.00 | 80 | 6.66 |
| Some change | 09 | 2.25 | 10 | 1.25 | 19 | 1.58 |
| To a large extent | 351 | 87.75 | 749 | 93.62 | 1100 | 91.67 |
| *Legal and political empowerment* | | | | | | |
| No change | 303 | 75.75 | 600 | 75.00 | 903 | 75.25 |
| Some change | 10 | 2.50 | 55 | 6.87 | 65 | 5.4 |
| To a large extent | 87 | 21.75 | 90 | 11.25 | 177 | 14.75 |

hence they are able to help the family during financial crisis. Due to this they are feeling economically empowered. Hence, 91.67 per cent of the members have perceived economic empowerment to a large extent.

In respect of legal and political empowerment, the results reveals that 75.75 per cent of office bearers and 75.00 per cent of members perceived that there was 'no change', 2.5 per cent of office bearers and 6.87 per cent of members felt that there was 'some change', and 21.75 per cent of office bearers and 11.25 per cent of members perceived that there was change to a 'large extent' with regard to legal and political empowerment after joining SHGs. The overall percentage show that 75.25 per cent perceived 'no change', 5.4 per cent perceived 'some change' and 14.75 per cent perceived change to a 'large extent' with regard to legal and political empowerment.

Thus, the results shows that majority had 'no change' in legal and political empowerment. Economic empowerment is a base for all other types of empowerment, hence economic empowerment is given more importance in self help groups. As majority who felt that they are economically empowered. In case of legal and political empowerment the percentage is low. Groups as such are not taking up any activities related to legal and political empowerment. Hence, the legal and political empowerment is low compared to socio-psychological and economic empowerment. Higher percentage of office bearers (21.75%) have gained legal and political empowerment to larger extent as compared to members (11.25%).The reason behind this may be the office bearers are more active in solving group problems and attending all outside activities on behalf of members.

Comparison of mean score of change in empowerment of office bearers and members in Table III shows that there was significant difference between the socio-psychological empowerment of office bearers (2.89) and members (2.86). The change was grater in case of office bearers than members because the office bearers were involved in organizing

TABLE III

*Comparison of change in empowerment of office bearers and members after joining Self Help Groups*

(N=1200)

| Type of empowerment | Mean Score (Range 1.00 -5.00) | | 't' test |
|---|---|---|---|
| | Office bearers | Members | |
| Socio-psychological | 2.89 | 2.86 | 7.32 ** |
| Economic | 2.31 | 2.49 | 2.32 * |
| Legal and political | 1.36 | 1.19 | 5.34 ** |
| Overall | 2.40 | 2.37 | 4.58 ** |

*Significant at 5% level, **Significant at 1% level

more meetings and activities of the Self Help Groups. Due to greater involvement their empowerment is also high. In case of economic empowerment also, there was significant difference between office bearers (2.31) and members (2.49), but the members extent of change in economic empowerment of members was higher than the office bearers. The reason behind this may be more of members have taken up income generating activities than the office bearers. Similarly in case of legal and political empowerment also, there is significant difference between the extent of empowerment of office bearers (1.36) and members (1.19), which indicates that the office members were empowered more in case of legal and political than the members. Office bearers represent actives of groups, hence they also participate in other village activities as well as go out of the groups in solving problems faced by the groups, hence they are more empowered than members.

The findings of the study clearly shows that the extent of empowerment in case of socio -psychological and economic is to a 'large extent' as perceived by the members due to joining SHG's. This shows that the SHG's have really worked in empowering rural women to a 'large extent'. But the level of change in case of legal and political empowerment is low compared to socio-psychological and economic empowerment. Hence, the activities of SHGs should focus towards increasing the legal and political empowerment. So that it can bring out all round development in rural women. As the SHGs have helped to empower rural women to a large extent, efforts could be increased towards making all the rural women joining SHGs compulsorily so that they get empowered and in turn help in rural development.

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# *Abstracts of Ph. D. Theses submitted to the University of Agricultural Sciences, Bengaluru*

## AGRICULTURAL ECONOMICS

### Socio-economic Impact Analysis of New Co-operatives for Promotion of Horticulture in Mekong Delta, Vietnam

DOAN HUU TIEN

THIS study is a comparative institutional analysis of the new co-operatives in horticultural crops and their socio-economic impact in Mekong Delta, Vietnam in comparison with horticulture co-operative in India. Primary data were obtained from 15 horticultural co-operatives (HCs), 330 farmers and 100 private traders for 2013-14 through personal interview. The production function, data envelopment analysis, partial budgeting technique, Garrett's ranking and discriminant function analysis are used. The results showed that, HCs provided higher price for fruits and vegetables (3-17 %) at lower cost of services (5-21 %) than private traders. Comparing members of co-operative with non-members, productivity of fruits and vegetables was higher (6-14 %), farm business income was higher (19 %); and the net returns in Pineapple and Okra, were higher by 68 and 56 per cent, respectively. The net gain measured through partial budgeting due to membership were VND. 8,355,000 in Pineapple and VND.14,263,000 in Okra per hectare. The elasticity of gross returns with respect to labor cost in Pineapple (organic manure cost in Okra) was 0.81 per cent (0.207) for members while it was 0.56 per cent (0.098) for non-members. The economic efficiency in the Pineapple and Okra cultivation of members was higher than non-members. The farmers' realized price and producer share in wholesale consumer's price offered by cooperative were crucial factors in discriminating members of co-operative from non-members. The top ranking advantage enriching the bargaining power of members of HCs was 'Fruits and vegetables with trademark'. The average bargaining cost incurred by HCs was 22.6 per cent lower than that by wholesalers. Lack of capital was the major constraint faced by HCs. Given the significant contribution of HCs, it is recommended that the horticultural cooperatives should be further expanded in Vietnam by enriching the capital base, service provision and handling capacity of horticulture crops.

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### Economic Impact of Urbanisation on Production Systems and Agro Ecosystem Services in Peri Urban and Rural Areas

ROOPA, H. S.

THE present study was carried out with an overall objective of economic impact of urbanisation on rural and peri-urban farming household across irrigated and rainfed situations. Primary data were collected from 160 farmers, 80 each from rural (Ramanagara taluk) and peri-urban (Hoskote taluk) region. Among 80 farmers, 40 farmers each under rainfed and irrigated situation were considered. Time series data on area under all crop categories were considered for 26 years (1986 to 2012). Over the years, area under crop categories like cereals, pulses and oilseeds had shown negative growth rate, whereas perennials like coconut, mango and eucalyptus had shown positive growth rate. Agro ecosystem services such as fertility status and pollution factors influence agricultural land values to an extent of 20 to 25 per cent. Farmers in the peri-urban areas used urban and industrial waste contaminated water as source of irrigation and were able to realize additional net income of about Rs 28,425 per acre. Sample farmers viewed that the urbanisation had negative impact on men, women as they were losing interest in farm and allied activities and inculcated fancy towards the nearby urban areas, whereas they felt there was positive impact on children because of exposure to better education system. Urbanisation had negative impact on farming community as there was fear of encroachment of agricultural lands, non availability of labour for agricultural activities etc. Urbanisation had positive impact on landless labourers as there was ample job opportunities on farm and also on non-farm sectors. Sale proceedings of agricultural land revealed that investments on the real estate (0.27) had fetched better returns, followed by investment on agricultural lands (0.20).

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## AGRICULTURAL ENTOMOLOGY

### Determination of Insecticidal Resistance and Management of Fruit Borer, *Earias vittella* (Fabricius) on Okra

NARASA REDDY, G.

THE fruit and shoot borer, *Earias vittella*(Fabricius) is one of the major pest of okra throughout India. Susceptibility to insecticides was investigated by collecting field populations of *E. vittella* from different locations of Karnataka (Bengaluru, Doddaballapur, Mandya, Shivamogga and Raichur). The resistance ratios varied greatly among the populations*viz.*, cypermethrin (3.00 to 19.16 fold), fenvelerate (1.22 to 8.11 fold), chlorantraniliprole (2.00 to 8.5 fold), emamectin benzoate (2.00 to 7.25 fold) and quinalphos (1.28 to 31.71 fold). The Raichur and Shivamogga population exhibited higher resistance to the older insecticides and low resistance to newer insecticides. The activity of the esterases and GST enzymes was positively correlated to the observed levels of resistance to insecticides in different *E. vittella* populations. Eight different *Trichogramma*, an important egg parasitoid of lepidopterans were screened against *E. vittella*, the highest per cent parasitism was observed *in T. chilonis* (94.20 %), which was on par with *T. achaeae* (88.60 %) in the laboratory screening test. In a field cage studies, highest parasitism was recorded in *T. chilonis* (43.86 %) compared to *T. achaeae* (36.14 %) when parasitoids were released @ 1,50,000/ha. In the field experiment, significantly lowest fruit infestation was recorded in *T. chilonis* + chlorantraniliprole (8.08 %) followed by chlorantraniliprole (11.32 %), *T. chilonis* (15.29 %) and untreated control (22.74 %). Significantly highest marketable yield of fruits recorded in *T. chilonis* + chlorantraniliprole treatment (98.34 q/ha in *Kharif*and 92.58 q/ha in *Rabi*). In host plant resistance studies, Kashi Satadhari and Kashi Leelawere found as better accessions by registering least number of per cent fruit damage on number basis (9.18 and 9.68 %, respectively) by *E. vittella*under field condition.

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### Systematic Studies on Pentatomidae (Hemiptera : Pentatomoidea) of South India

SALINI, S.

FOUR subfamilies of the Pentatomidae, Asopinae, Pentatominae, Phyllocephalinae and Podopinae are reported from south India. Examination of 4037 specimens of Pentatominae revealed the presence of 96 species belonging to 63 genera grouped in 29 tribes from south India. All taxa of Pentatominae dealt with are described and illustrated. Keys to families of Pentatomoidea, subfamilies of Pentatomidae, genera of Asopinae, Phyllocephalinae and Podopinae and tribes, genera and species of Pentatominae are given. A checklist of south IndianPentatomidae comprising 186 species is also provided. Thirteen putative new species belonging to 11 genera are recognised. New records include 21 species belonging to 18 genera for Karnataka and 11 species belonging to 9 genera for south India. Genus *Brachycoris*Stål with *Glauciasnigromarginatus*(Stål)and *Brachycoris*sp. 1were recorded for the first time from India. Study of external scent efferent system of Pentatomidae showed the presence of seven peritremal types with spout and rugatypes forming the common types.Apreliminary phylogenetic analysis of 96 taxa using 64 morphological characters revealed the paraphyletic nature of several tribes in Pentatominae. Species diversity of Pentatominaeanalyzedacross ecosystems such as rice, cereals, pulses, vegetables, forest trees, medicinal plants and fruit orchardsusing Shannon-Weiner Index showed that the cereals ecosystem was the most diverse (S-W Index = 2.69) followed by forest tree ecosystem (S-W Index = 2.14).Twenty two and 11 species of Pentatomidae were associated with plant families Poaceae and Lamiaceae, respectively.

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## AGRICULTURAL EXTENSION

### A Comparative Analysis of Livelihood Status in Irrigated and Rainfed Farming Situations in Central Dry Zone of Karnataka

YASHODHARA, B

THE present study was carried out in two districts of central dry zone in Karnataka state during 2014-15 to compare the livelihood status of irrigated and rainfed farmers. Data was collected from a sample of 90 farmers from irrigated area (Davanagere and Hariharataluks form Davanagere district) and other 90 farmers from rainfed area (Challakere and Molkalmurutaluks from Chitradurgadisrtict) using pre-tested interview schedule through personal interview method. Standardized scales to measure livelihood status was developed and used in the study. The study indicated that 44.4 per cent of farmers had high level of livelihood status, followed by medium (37.8 %) and low level of livelihood status (17.8 %) in irrigated situation. In rainfed situation, 43.3 per cent of farmers had low level of livelihood status followed by 38.9 per cent had medium and 17.8 per cent had high level of livelihood status. The findings revealed that 40.0 per cent of the farmers took crop production, 20.0 per cent crop production with diary in irrigated situation and in rainfed situation 33.3 per cent of respondents practiced crop production with dairy & sheep rearing, 18.9 per cent crop production with sheep, 15.6 per cent crop production alone. High cost of inputs, lack of remunerative prices and high labour cost are major constraints faced by irrigated farmers and uncertainty of rainfall, lack of remunerative prices and inadequate irrigation facility are major constraints faced by rainfed farmers. Reducing the input cost and increase the support price are the major suggestions suggested by irrigated farmers. Ground water recharge programmes and linkage of different water bodies are the major suggestions suggested by rainfed farmers.

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### Economic Contribution of Agricultural Extension Services Provided by Karnataka Watershed Development Project to Beneficiaries of Bijapur District

GANGAPPAGOUDA BIRADAR

THE present study is conducted to measure the Economic contribution of Agricultural Extension Services provided by Karnataka Watershed Development Project to the beneficiaries of Bijapur district' during the year 2014-15. Ex-post facto research design, specifically before and after method was adopted to know the changes in the important indicators such as annual income, crop yields, employment generation and materials status among beneficiaries due to KAWAD project and also developed a scale on Economic contribution of AESs to capture the contribution of each services to the economic status of the beneficiaries. Hence, 90 beneficiary farmers and 90 non-beneficiary farmers were selected, thus 180 respondents constitute the sample for the research study. Then, structured interview schedule was used to collect data. Important findings of the study reveals that majority (42.22 %) of the beneficiary farmers were belonged to 'medium' and 'high' (37.78 %) category with respect to overall access to the services of KAWAD project. Over a half (55.56 %) of the beneficiary farmers had 'better' accessed to the credit services followed by training services (54.45 %) and advisory services (51.11 %), about 67.78 and 46.67 per cent of them had 'best' accessed to input services and land based & crop management services respectively. About 40.00 per cent of them poorly accessed to the market services. Overall contribution of AESs towards economic status of beneficiary farmers was found to be 24.37 per cent, among major contribution from credit services (5.06%), land based and crop management services (4.45%) and least contribution was from advisory services (3.09 %). Cent per cent of them adopted the services like land leveling, land shaping &bunding followed by construction of check dams &nala bunds (86.66 %), new tanks and farm ponds (83.33 %), contour bunding (76.66 %) *etc,*. Study also reveals that the positive impact of KAWAD project on crop yield, annual income, employment generation, cropping intensity and on material status. Increase in annual income by more than fourfold, employment generation from 95 to 182 man-day's per annum, cropping intensity (98.66 to 186.99 %). Whereas, among the suggestion the major was to supportive prices for standing crops (88.88 %) followed by training on IGAs (81.11 %). The KAWAD project has significantly contributed towards socio-political, economical and overall development of KAWAD beneficiaries.

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## AGRICULTURAL MICROBIOLOGY

### Effect of Microbial Seed Priming on Biochemical Parameters Associated with Plant Growth Promotion and Disease Resistance in Selected Leguminous Vegetables

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THE present study was undertakento evaluate the impact of microbial seed priming in legumes consumed as green vegetables (French bean and Cluster bean) with selected strains of plant growth promoting rhizobacteria (PGPR) and biocontrol agents. They were tested separately or in combinations on seeds, for their ability to induce proteins like peroxidase (PO), phenyl alanine ammonialyase (PAL), polyphenol oxidase (PPO), â-1, 3- glucanase and chitinase against *Fusarium* sp. French bean (ArkaAnoop) and cluster bean (Guar *var.*Tulsi) seeds primed with -4 bar of PEG 6000 at 25 °C and 28 °C for 32 and 16 h respectively recorded highest germination percentage, root and shoot length, total biomass and vigour index. Similarly, cluster bean seeds (*var.* Pusa-Sadabahar) primed with –6 bar PEG 6000 at 28 °C for 12 h showed improved plant growth parameters. Plants that were raised using microbial primed seeds (combination of PGPR and biocontrol agents) showed improved plant growth parameters with increased concentration of IAA, GA and cytokinin and an effective reduction in disease incidence. The bean-plants probably developed local and systemic resistance mechanism, with significant increase in activity of PAL, PPO, PO, â-1, 3- glucanase and chitinase against *Fusarium* sp compared to untreated control plants. The consortia treatments provided greater protection to plants than single inoculation. The activity of PAL, PPO, PO, Chitinase, â-1,3 glucanases and total phenol content were found to be higher in microbial primed seeds with P. f + B.m + Rhi + T. h and with P. f + B.m + Rhi. The green house and field experiments of selected leguminous plants also revealed that the microbial primed seeds performed better in terms of enhanced yield and disease suppression.

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### Functional Diversity of Yeasts in Plantation and Fruit Crops of Hassan District

YALLAPPA, M.

LEAVES and fruits samples of plantation (Coffee, Cardamom and Cocoa) and fruit (Sapota, Guava, Carambola and Ficus) crops were collected from Hassan district along with their geographical coordinated points. Totally 84 yeast isolates were isolated from leaves and fruits. All 84 yeast isolates morphological characteristics were studied and screened for wine production, biocontrol activity and plant growth promotional activities. Greenhouse evaluation of selected efficient yeast isolates for plant growth promotion in tomato crop was studied. Among 84 yeast isolates maximum alcohol content (6.25 %) was recorded by MZF- 1 in wine production, higher IAA was produced by TCL -1 (0.387 µg/ml) and maximum $GA_3$ was produced by the MZL -1 (0.642 µg/25ml). The yeast isolate TCL -1 recorded maximum plant growth parameters in spraying and root dip method of inoculation in the greenhouse experiment. Yeast isolate ACL – 1 showed higher per cent inhibition of *Pythium* sp. (29.41 %), *Fusarium* sp. (23.52 %) and *Rhizoctonia solani* (18.18 %). Based on the partial sequence of 18S rRNA gene of the yeast isolates MZF-1 isolate is identified as *Candida boidini*, TCL-1 as *Meyerozyma caribbica,* MZL-1 as *Candida dosseyi* and ACL-1 as *Candida intermedia* from the sequence analysis and compared with other 18S rRNA gene sequences of yeasts from database (NCBI).

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## AGRONOMY

### Standardization of Precision Irrigation Management Techniques for Baby Corn-capsicum Sequence under Polyhouse condition

BABAR SADHANA RAMCHANDRA

A field experiment entitled precision irrigation management techniques for baby corn-capsicum sequence under polyhouse condition was conducted at Zonal Agricultural Research Station, University of Agricultural Sciences, Bengaluru in *kharif* and *rabi* seasons during 2013-14 and 2014-15 in polyhouse and open field conditions. The experiment was laid out in split-plot design and replicated thrice with irrigation methods of surface and subsurface drip irrigation under polyhouse and open field condition as main plots and scheduling of irrigation based on Epan ratios at 0.6, 0.8 and 1.0 as sub plots. Climatic parameters recorded at the experimental site indicated that temperature (38-42$^{o}$C) and relative humidity (61-75 %) regimes were higher inside the polyhouse as compared to open field (28-32 $^{o}$C and 58-65 per cent, respectively). Among the main treatments, subsurface drip fertigation in open field condition recorded higher cob yield in baby corn (12.28 t ha$^{-1}$) and water use efficiency (WUE) (47.03 kg ha-mm$^{-1}$). Whereas, quality parameters were slightly higher under polyhouse condition. In capsicum, the fruit yield (124.03 t ha$^{-1}$) and WUE (144.90 kg ha-mm$^{-1}$) were significantly higher in subsurface drip fertigation under polyhouse condition than in other treatments. In polyhouse with congenial environmental condition, growth of capsicum ($C_3$ plant) was better than under open field. But in baby corn ($C_4$ plant) lanky growth was observed due to reduction in light. Among irrigation levels, gravimetric soil moisture and relative water contents were significantly higher at 1.0 Epan. Canopy temperature recorded was lower at 1.0 Epan that resulted in significantly higher green cob (11.25 t ha$^{-1}$), fodder yield (57.18 t ha$^{-1}$) and capsicum fruit yield (100.24 t ha$^{-1}$). The WUE was higher at 0.6 Epan in baby corn (46.20 kg ha-mm$^{-1}$) and capsicum (139.30 kg ha-mm$^{-1}$). Higher B:C ratio for baby corn-capsicum sequence was recorded in subsurface drip at 1.0 Epan under polyhouse (13.29).

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### Studies onVarietal Performance, Planting Geometry and Intercrops in Aerobic Rice (*Oryza sativa* L.)

JADEYEGOWDA, M.

FIELD experiments were conducted during the *kharif* season of 2004 and 2005 at Mian Research Station, Hebbal, University Agricultural Sciences,Bengaluru, to study the Performance of varieties and planting geometry and intercrops in Aerobic rice cultivation. The varietal and spacing study was laid out in randomized complete block design with two factors replicated thrice. There are three varieties (Jaya, Rasi and MTU -1010) and six planting geometry cm (30x10,30x15, 30x20 , 30x30 cm,40 x 10 and 40x15). The results of the study reveal that, significantly higher grain yield (55.95q ha$^{-1}$) was obtained withRasi, which was significantly superior over MTU-1010 (53.76 q ha$^{-1}$) and Jaya (50.58q ha$^{-1}$) varieties. Among the different planting geometry, (30 cm x30 cm) showed significantly higher grain yield (57.02 q ha$^{-1}$) compared to 30 cm x 15 cm (52.94 q ha$^{-1}$) and 30 cm x10 cm (50.31q ha$^{-1}$).Experiment on intercropping in aerobic ricewas laid out in a randomized complete block design with three replication having two factors. *viz.*two row patterns (normal row 45 cm x20 cm, and paired row 30/60 cm x 20 cm) and seven intercrops (rice + bhendi, rice+cluster bean, rice+french bean, rice+ragi, rice+radish, rice+soybean, and rice+sunhemp) consistedof 14 treatments. Significantly higher grain yield (23.7q ha$^{-1}$) was obtained in paired row intercrops than in normal row (19.7q ha$^{-1}$) intercropping. Significantly higher grain yield (27.7 q ha$^{-1}$) was recorded with rice + bhendi intercropping system and rice+ cluster bean (26q ha$^{-1}$) intercropping systems. Significantly, lower grain yield (6.8 q ha$^{-1}$) was obtained in rice+ ragi intercropping system. In conclusion, Rasi variety grown with 30cmx30cm under aerobic condition resulted better yield.Rice + bhendi intercropping system provided high Rice yield as well as rice equivalent yield (8167 kg ha$^{-1}$).

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## Response of Rice to Distillery Spent Wash under Different Systems of Cultivation in Cauvery Command Area of Karnataka

ATHEEKUR REHAMAN, H. M.

THE three field experiments (one each in *kharif* 2007 & 2008 and two each in summer 2008 & 2011) were conducted at Zonal Agricultural Research Station, V.C. Farm, Mandya to study the effect of spent wash on rice under different methods of cultivation. The first experiment had two methods of cultivation, three levels of nitrogen and three split applications laid out in split-split plot design and replicated thrice. Results revealed that SRI method recorded significantly higher grain and straw yield (51.66 & 58.35 q $ha^{-1}$, respectively) was better than conventional method (42.77 & 50.24 q $ha^{-1}$, respectively). Among levels of nitrogen, N through chemical fertilizer recorded significantly higher grain and straw yield of 50.12 and 57.86 q $ha^{-1}$ compared to 60 % N basal application through spent wash. The difference between split applications of nitrogen was not significant. The second experiment on aerobic rice had four sources (Chemical fertilizers, Farm yard manure, bio compost and spent wash) and 2 levels (Rec. N & 1.5 Rec. N) of N laid out in factorial RCBD design with 3 replications. Application of 1.5 Rec. N through spent wash recorded significantly higher grain and straw yield (56.2 and 64.5 q $ha^{-1}$, respectively). However, it was on par with Recommended N through spent wash and Recommended N and 1.5 Recommended N through chemical fertilizers. The third experiment on aerobic rice had 3 levels of basal application of N through spent wash (40, 50 & 60 %) and 3 irrigation schedules (1.25, 1.50 and 1.75 IW/CPE ratio). The results revealed that irrigation at IW/CPE ratio 1.75 and 60 per cent N as basal recorded significantly higher seed (50.15 q $ha^{-1}$) and straw yield (56.89 q $ha^{-1}$). Nutrient uptake, soil nutrient status, enzyme activity and economics followed the same trend

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# CROP PHYSIOLOGY

## Enhancing Oxidative Stress Tolerance in Aerobic Rice (*Oryza Sativa* L.); Validation of ROS Scavenging Enzymes by Transgenic Approach and Identification of Oxidative Stress Specific Upstream Genes

JALENDRA KUMAR, H. G.

RICE crop grown under aerobic conditions experience moisture stress between irrigations resulting in oxidative stress, which is a major constraint to realize potential yields. One of the most common strategy to improve tolerance to oxidative stress is by overexpressing either single or multiple antioxidant genes by transgenic approach. The second strategy is to overexpress the upstream regulatory genes, mainly transcription factors (TFs) specific to oxidative stress. A novel T7 polymerase based multigene construct consisting of 5 antioxidant genes of the Asada Halliwell pathway *viz.,* SOD, APX, DHAR, MDHAR and GR was developed and transformed into two selected aerobic rice genotypes-AC39020 and KMP175 by *in planta* transformation technique. Promising lines were identified based on stable integration of transgenes and response to oxidative stress. In T4 generation 13 lines of each genotype were assessed for tolerance to oxidative stress, moisture stress and high temperature stress along with grain yield under moisture stress conditions. The other objective of the study was to identify TFs associated with oxidative stress. The transcriptomic profile was assessed by microarray analysis in two contrasting rice genotypes (AC39020-tolerant & BPT5204-susceptible) subjected to oxidative stress. Among the 918 differentially expressed genes, 38 were TFs and 2 were kinases. About 20 TFs were shortlisted by extensive *in silico* analysis which included spatial expression profile, presence of ROS- elements, meta-analysis and co-expression matrix. To accurately characterize the stress response of transgenics and germplasm accessions a novel minilysimeter based phenomics facility was developed. The facility could monitor and maintain a desired soil moisture status and precisely control dry down rates. The facility successfully brought out the differences in growth between the contrasting rice genotypes by maintaining both at 70 per cent FC±5 per cent Based on the results of the pilot project, a new high through put phenomics facility was developed with 450 minilysimeters.

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## Genetic Modification of Tomato (*Solanum Lycopersicum*) to Increase the Uptake and Translocation of Zinc

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ZINC (Zn) is one of the essential micronutrient with major biological roles both in plants and humans. Deficiency of Zn is by far the most ubiquitous problem in the world affecting the plant and human nutrition. Zn deficiency in humans can be addressed through dietary diversification, mineral supplementation, food fortification and biofortification. Among these, biofortification of food crops either through genetic engineering or molecular breeding approaches is considered to be promising and sustainable. To achieve this better understanding of molecular mechanisms regulating the Zn uptake and transport in plant is most crucial. In the present investigation an attempt was made to identify the candidate Zn transporter gene in tomato responsible for high fruit Zn content. Initially 41 tomato genotypes were screened for Zn content. The contrast lines identified based on the fruit Zn content were subjected for Zn deficient and sufficient conditions and analysed for Zn transporter expression through RT- PCR. The candidate Zn transporter genes up-regulated in the high Zn type germplasm lines, *SlZIPL* and *SlZIP4* were identified and cloned. Further the genes were sub-cloned to pBINPLUS binary vector driven by constitutive promoter (CaMV35S) and the two independent gene constructs $P_{CaMV35S}$: *SlZIPL*: $T_{polyA}$ and $P_{CaMV35S}$: *SlZIP4*: $T_{polyA}$ were used for plant transformation. To develop transgenic tobacco and tomato plants, *Agrobacterium* mediated tissue culture technique was followed. Few tobacco transgenic lines over expressing *SlZIPL* and *SlZIP4* showed high leaf Zn and chlorophyll content. Similarly, tomato *SlZIPL* and *SlZIP4* transgenics also showed high fruit, leaf and petiole Zn content compared to wild type. Further the RT-PCR expression analysis of tomato transgenics showed the higher expression of *SlZIPL* and *SlZIP4*. These results imply that, *SlZIPL* and *SlZIP4* are candidate Zn transporters in tomato involved in better Zn transport and hence high fruit Zn content.

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## Stacking of Upstream Regulatory Genes to Confer Abiotic Stress Tolerance in Rice (*Oryza sativa* L.)

PATIL MAHESH

RICE cultivation under aerobic condition has phenomenal relevance in terms of saving water. But reduced water availability and high VPD affecting crop growth and productivity. Thus it is important to improve adaptation of rice under aerobic condition by improving water relations and cellular level tolerance (CLT) mechanisms. Improving CLT to sustain cell metabolic activities has relevance under stress and among several CLT mechanisms, protein synthesis and stability are crucial. From this context, an attempt has been made to validate three regulatory genes *i.e. Pg47 (Pennisetum glaucum* 47, a RNA helicase), *OseIF4E* (*Oryza sativa* translational initiation factor 4E) and *PgHSF4* (*Pennisetum glaucum* heat shock factor 4) involved in protein synthesis and protection in a model system tobacco. Transgenics expressing single and multigene cassette showed higher tolerance to diverse stresses *viz.* salinity, ER, heavy metal, drought and osmotic stress, besides showing enhanced expression of few stress responsive genes compared to wild type under stress. However, lines expressing multigene cassette showed superior phenotype and tolerance over lines expressing single genes with significantly higher protein content and lesser malondialdehyde level. This demonstrated the significance of co-expressing more than one stress specific genes / TFs over single gene. To improve adaptation of rice under semi-irrigated aerobic conditions rice transgenics co-expressing multigene cassette were developed in the background of AC39020 genotype having superior water relations. True transformants were identified based on glyphosate to lerance. The transgenics showed improved to lerance to salinity, ER and heavy metal stress apart from drought stress. Under drought stress, many promising transgenic lines showed reduced spikelet sterility and higher yield compared to wild type. The study provides proof of concept that maintaining efficient translation and protein protection improves CLT and transgenic is apotential option to combine or pyramid the relevant traits to improve field level to lerance.

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## Transcriptional regulation to enhance drought tolerance in plants : Co-expression of *AhBTF3*, *AhNF-YA7* and *EcSAP-ZF* in rice and characterization of novel regulator, *EcTAF6* in model system

PARVATHI M. SREEKUMAR

DROUGHT adversely affects crop productivity in tropical countries. To improve crop drought tolerance, modern approaches like molecular breeding and / or transgenesis are used to pyramid traits. In this study, an attempt was made to manipulate transcriptional regulation by co-expressing three stress responsive transcriptional regulators (TRs), *AhBTF3*, *AhNF-YA7* and *EcSAP-ZF* to enhance cellular tolerance under drought in rice. The putative transgenic plants tolerant to glyphosate were confirmed for transgene integration and expression. The $T_2$ plants exhibited better growth performance under non-stress conditions compared to wild type. The superior stress response of transgenic lines was evidenced in excised leaf disc and seedling level assays under multiple abiotic stresses. The selected lines had better pollen viability and grain yield than wild type, post drought at reproductive stage. Superior $T_3$ lines displayed enhanced tolerance to transcription and translation inhibition, and organellar stresses. Six promising lines have been forwarded to $T_4$ generation for productivity analysis. Additionally, efforts were made to prospect novel TRs from dry-land crop, finger millet, by analysing a drought stressed leaf transcriptome data. This led to the identification and cloning of *EcTAF6*, a subunit of transcription pre-initiation complex. Expression analysis of *TAF6* in finger millet and *Brassica rapa* revealed responsiveness to multiple stresses. Two splice variants of *EcTAF6*, probably resulting from alternative splicing, were discovered in stressed leaf cDNA. The functional characterisation of *TAF6* by down regulation using Virus Induced Gene Silencing approach in *Nicotiana benthamiana,* and *Arabidopsis attaf6* mutants demonstrated its relevance under stress. Transgenic *Arabidopsis* have been developed to over-express *EcTAF6* which are to be evaluated further. This study, for the first time, indicated that *TAF6* could be a key regulator in multiple stress response networks. In conclusion, the study has demonstrated that basal transcriptional regulators can be the novel candidates for enhancing cellular tolerance of crops under drought conditions.

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# FOOD SCIENCE AND NUTRITION

## Women in Food Enterprise : A Study in Tumkur and Bangalore Urban Districts

MAMATHA, H. S.

THE most common and vital enterprising activity for women entrepreneurship development in rural and urban area is food processing. A study was undertaken on 120 women entrepreneurs of Tumkur and Bangalore urban districts to elicit background information of women in food enterprise, popular products produced, processing method adopted, assessment of nutritional composition of selected labelled products, awareness and adoption of food safety measures. The results revealed that, in both the districts majority of entrepreneurs belonged to an age group of 36-50 years, with an investment of less than Rs 50,000 and 5 to 10 years of experience in small size food enterprises. In Tumkur and Bangalore entrepreneurs had setup their production unit (61.7 and 73.3%) at residence and possessed FSSAI certification (31.7 and73.3%) respectively. Consumption of all the selected foods by entrepreneurs was less than recommended levels. In Tumkur and Bangalore majority of entrepreneurs were producing condiments (43.3 and 13.3%), papad (36.7 and 11.7%), fingermillet products (20 and 8.3%) respectively. In Bangalore 11.7 per cent were producing instant mixes. Tumkur entrepreneurs adopted traditional method of processing with indigenous technology while in Bangalore entrepreneur aimed at products concept of health and diversification due to influence of technology. Tumkur and Bangalore entrepreneurs used local and wholesale outlets for product marketing. Fifty per cent of Tumkur and 36.7 per cent of Bangalore entrepreneurs had not labelled the products. Nutrient composition of labelled food products showed lower and higher content of nutrients compared to estimated values. Majority of the entrepreneurs expressed lack of structured market facilities as a severe problem. All the categories of Bangalore district entrepreneurs had better awareness and adoption. Even though adoption of food safety measures ranked high, but adoption was less compared to awareness.

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## GENETICS AND PLANT BREEDING

### Inheritance and Characterization of Candidate Genes Controlling Photoperiod-Induced Sensitivity to Flowering and Growth Habit in Dolichos Bean (*Lablab purpureus* L.)

KEERTHI, C. M.

AN understanding of the effect of environmental cues, especially photoperiod and temperature on time to flowering, and the genetics of photoperiod-induced sensitivity to flowering time (PSFT), growth habit (GH), floral and pod traits help enhance the pace and efficiency of breeding dolichos bean, a photoperiod sensitive (PS) short-day grain legume species. A series of experiments carried out at the experimental plots of the Department of Genetics and Plant Breeding, University of Agricultural Sciences, Bengaluru during 2012-2015 revealed the greater role of temperature than photoperiod in regulating time to flowering of PS genotypes. Dolichos bean requires critical minimum and maximum photoperiod of 11.11hrs and 12.28hrs, respectively for time to flowering. While, PSFT and flower color (FC) are each controlled by bi-allelic monogenic locus, GH, pod curvature (PC) and raceme emergence (RE) are each controlled by two genes with classical complementary and inhibitory epistasis, respectively. The genes controlling GH, PSFT and RE are linked with recombination fractions and map distances of 0.24 and 33.61cM between PSFT and GH, 0.35 and 61.40cM between PSFT and RE and 0.31 and 49.43cM between GH and RE. Higher amino acid sequence homology of dolichos bean homologues (*LpLFY*, *LpFKF1*, *LpLHY*and *LpTFL1*) of *Arabidopsis* PSFT candidate genes (*LFY*, *FKF1* and *LHY*) and GH candidate gene (*TFL1*) with those of soybean, common bean and *Medicago* andcleaved amplified polymorphic sequences assay indicated possible similar genetic and physiological mechanisms controlling PSFT and GH. The results did not favour ignoring epistasis in studies designed for determining the relative magnitude of additive and dominance genetic variancescontrolling the target traits. The study also revealed preferential use of parents contrasting for general combining ability and/or with intermediate genetic divergence to maximise the frequency of heterotic hybrids, the use of which is likely to result in greater chances of recovering high yielding purelines.

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### Genomic Selection for Resistance to Northern Leaf Blight [*Exserohilum turcicum* (Pass.) Leonard and Suggs] in maize (*Zea mays* L.)

BALASUNDARA, D. C.

NORTHERN corn leaf blight (NCLB) in maize caused by *Exserohilum turcicum* is a serious foliar disease. Resistance to NCLB is complexly inherited and controlled by several quantitative trait loci (QTL) distributed across the genome. Phenotype as well as linked DNA marker-based selection for resistance to NCLB is expected to be effective. Hence, an investigation was carried out to predict the genetic value of selection candidates for resistance to NCLB and comparing the accuracies of genomic prediction in two $F_{2:3}$ populations of crosses (CM212 × MAI172 and CM202 × SKV50) derived from contrasting parents. Linkage analysis using 297 polymorphic SNPs in population-1 and 290 polymorphic SNPs in population-2 revealed 10 linkage groups spanning 3623.88cM and 4261.92cM with an average distance of 12.40cM and 14.9cMfor the population-1 and population-2, respectively. Location-wise and pooled data across locations indicated that QTLs expression is population and environment specific. The prediction accuracy of the QTL mapping (9.92 and 9.10 for population-1 and population-2, respectively) is based on only a few markers which explain higher *per cent* phenotypic variation. The prediction accuracy of genomic selection (GS) which potentially makes use of all the genetic variation present in an analysed population by summing the effects of all individual markers and thus can include small effects gene loci that cannot be detected by QTL analysis. The prediction accuracies of the genomic estimated breeding values in the present investigation were relatively low in population-1 (0.24 to 0.26) and population-2 (0.29-0.32) compared to the expected accuracies. This could be due to use of fewer polymorphic markers and small training/population size. Though, the GS prediction accuracies were low relatively low in general, they were significantly higher compared to QTL mapping which promises better genetic gain *per* cycle.

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## Genetic Improvement of Bambara Groundnut (*Vigna subterranea* (L.) Verdc) through Mutation Breeding

CHITTI BHARATKUMAR

BAMBARA groundnut (*Vigna subterrnea* L. (Verdc.)termed as a potential crop of future is said to have its origin in Africa. It is considered to be a completely balanced food rich in protein (25-28%)and quantitatively superior to other pulses due to essential amino acids methionine and lysine. The present investigation was undertaken to utilize mutation breeding to genetically improve the selfpollinated underexploited protein rich crop. The objectives of the study include determination of $LD_{50}$ value, genotypic sensitivity, effectiveness and efficiency of EMS and isolation of economically important lines in two varieties of Bambara groundnut SB-42 andS-165A.The seeds were treated with EMS concentrations ranging from 0.1 to 0.5per cent. EMS concentration of 0.3 per cent was determined to be $LD_{50}$ value for both the varieties. Comparing the mutagenic effect on various biological parameters S-165A was more sensitive than SB-42.At 0.3per cent EMS concentration a higher number of chlorophyll mutations were recorded compared to other treatments. Morphological mutations in SB-42were identified to be more than in the variety S-165A.In $M_1$ generation a negative shift in plant height was observed per cent mean over control in all concentrations of EMS. In $M_2$ generation, days to flowering, number of pods per plant, pod yield per plant,seed yield per plant and shelling percentage exhibited a higher per cent increase over control.Based on Chi-square test for yellow mosaic virus disease resistance, the resistance was governed by single recessive gene and mutant families F-91, F-94, F-35,F-92,F-105 in SB-42 and F-9,F-86,F-1, F-7 and F-19 in S-165A families exhibited tolerance to yellow mosaic virus disease under natural conditions. Variability for characters like number of plants per plant, pod yield per plant and seed yield per plant in $M_3$ generation was higher and mutant families F-62,F-82,F-105,F-35 in SB-42 and F-7,F-14,F-9, F-1 in S-165A recorded high yield, high protein and high methionine content.

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# HORTCULTURE

## Weed Management in Tomato (*Solanum Lycopersicum* L.) - Radish (*Raphanus sativus* L.) Cropping System

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A field experiment was conducted during *Kharif* and *rabi*seasons of 2007-08 and 2008-09 to study the weed management in tomato-radish cropping system under irrigation with fifteen treatments replicated thrice in RCBD. Pre-emergence herbicides namelyalachlor at 0.75, 1.0 and 1.25kg a.i. $ha^{-1}$, pendimethalin at 0.75, 0.97 and 1.20kg a.i. $ha^{-1}$,oxyfluorfen at 0.094, 0.10 and 0.106kg a.i $ha^{-1}$, metribuzin at 0.25, 0.35 and 0.45kg a.i. $ha^{-1}$ were used. Hand weeding was taken up at 20 and 40DAT, paddy straw was used as mulch and an unweeded control. Same treatments were imposed for radish crop except hand weeding which was taken up at 10 and 20 DAS. Among the herbicides, metribuzin at 0.45kg a.i. $ha^{-1}$ and pendimethalin at 1.20kg a.i. $ha^{-1}$ reduced the weed density and dry weight significantly in tomato and radish, respectively. Metribuzin at 0.45kg a.i. $ha^{-1}$ recorded highest plant height, number of leaves, number of branches, number of fruits, fresh and dry weight of fruits, fruit yield (71.5t $ha^{-1}$) and B:C ratio (4.23). In radish,pendimethalin at 1.20kg a.i. $ha^{-1}$ recorded highest plant height, number of leaves, leaf dry weight, root yield(25.23t $ha^{-1}$), B:C ratio(3.50), fresh weight of leaf and root. The maximum net returns was obtained with the application of metribuzinin tomato and pendimethalinin radish. Hand weeding at 20 and 40DAT in tomato and 10 and 20DAS in radish recorded higher net returns in respect of mechanical operations. Germination per cent in french bean taken up after the application of herbicides to tomato and radish crops indicated that there was no inhibition of germination of French bean in any of the herbicide applied plot. The results indicated that metribuzin and pendimathalin used in tomato and radish respectively, helped in obtaining effective weed control and economical yield with no residual effect on succeeding French bean crop.

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## PLANT BIOTECNOLOGY

### Genetic Studies and Validation of Transporter Specific Markers for Zinc Fortification in Hybrids of rice (*Oryza Sativa* L.)

ASHLESHA C. PATIL

BIOFORTIFICATION is a genetic approach and one of the most cost effective apporaches to alleviate micronutrient malnutrition. Compared to varieties hybrids offer an added advantage of biofortification as for mineral heterosis be explored. Seven hybrids, sixty one rice genotypes and three hundred $F_2$ progenies of *Gopal Doddiga* x BI 33 were grown in University of Agricultural Sciences, GKVK, Bengaluru. The objectives of study were to estimate grain Zn content and productivity, design Zn transporters specific primers and validation of markers associated for grain Zn content. Significant genotypic differences were observed for all the quantitative traits in hybrids, $F_2$ population and rice genotypes, indicating considerable amount of variation exists in these genetic materials. All hybrids manifested significant positive standard heterosis for most of the traits except for days to first flowering, plant height and panicle length. All hybrids except KRH 2 showed significant positive standard heterosis for grain Zn content. Only two hybrids exhibited significant positive standard heterosis for leaf and root Zn content. To understand variations in Zn content at sequence level, twenty primers were designed for eight genes. Amplified primer products of five primers *viz*. OsZIP2-1, OsZIP3-2, OsZIP4-3, OsZIP5-3, OsZIP6-1 were sequenced. Amplicon of primers exhibited nucleotide variation and manifested significant association with grain, leaf and root Zn content except OsZIP5-3. Four candidate gene primers found associated with grain Zn content in $F_2$ population and only two primers manifested significant positive association with grain Zn content in rice genotypes. Highest Zn content and productivity was manifested for segregant (GB 224) from $F_2$ population followed by hybrids KCMS 48A / PBK 09-3-1-9-4-2-1 and (IR 62829A/ MSN 43) A / MSN 15-16. These hybrids could be further use to produce segregating materials.

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### Molecular Genetics of Sterility Mosaic Disease (SMD) Resistance in Pigeonpea (*Cajanus cajan* (L.) Millsp.)

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THE present investigation was carried to understand the genetics of resistance to SMD in pigeonpea. Genetic variability was studied among 70 pigeonpea genotypes for twelve leaf morpho-anatomical traits. Analysis of variance and descriptive statistics revealed presence of higher variability for these traits. The traits such as trichome numbers, length on both surfaces of leaf and leaf chlorophyll content showed highest GCV, PCV, broad sense heritability, genetic advance for direct selection. Screening of 70 genotypes against Bengaluru isolate of SMD revealed, only two cultivars (ICPL 7035 and BRG 3) and 11 wild genotypes were resistant. Correlations study on extreme 23 resistant and susceptible genotypes revealed significant negative association of trichome numbers on both leaf surfaces with other leaf traits. While, significant positive correlation was observed for trichome lengthson both surfaces of leaf with leaf thickness. The specific leaf area, weight, trichome numbers and length on lower surface of leaf showed higher discrimination function in relation to per cent disease incidence. Biochemical analysis revealed all susceptible genotypes with higher mean protein content (15.96) compared to resistant genotypes (9.06). SSAP and TRAP markers were developed based on active retroelement*CcRT8* and two R genes. SSR markers revealed BRG 3 and ICP 7035 werethe best resistant donors. The frequency distribution graph of $F_6$ 84RIL population against SMD revealed platykurtic (Kurtosis= -0.019) and negatively skewed (Skewness=-1.124) suggesting involvement of two or more genes for resistance. Parental polymorphism revealed, out of 55 SSR primers 40 were polymorphicbetween ICP 8863 (S) × BRG 3(R). Through bulk segregant and single-marker analysis three markers *viz.*,AHSSR $50_{150}$, AHSSR $34_{130}$ and AHSSR $20_{125}$ were found closely associated with SMD resistance and explaining 21, 8 and 6 per cent of phenotypic variations. The information generated will be very useful for resistance breeding in pigeonpea.

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## PLANT PATHOLOGY

### Genetics of Disease Resistance and Yield Loss Assessment due to Sorghum Downy Mildew in Maize Caused by *Peronosclerospora sorghi (Weston and Uppal)* Shaw

MANJUNATHA, S. V.

MAIZE *(Zea mays* L) holds an unique position in world agriculture as a food, feed and industrial crop par its excellence. Among the several *diseases,Peronosclerospora sorghi* which causes sorghum downy mildew (SDM) in maize and sorghum was the most predominant one and resulted in substantial economic losses. The present investigation was to evaluate the germplasm against SDM resistance, inheritance to SDM resistance, yield loss assessment and validation of SSR markers linked SDM resistance. Total of 321 genotypes from different maturity groups were screened and found two genotypes as resistant, Bio 451 and JH 3160 L five genotypes found moderately resistant and among 56 station inbred lines, 10 lines resistant reaction while 11 lines recorded moderately resistant reaction to SDM. The genetic analysis of resistance to SDM of maize was assessed through line X tester design using six inbreds and three testers. The magnitude of gca effects varied from -20.32 to 12.17 in lines and -17.68 to 21.15 in testers. Among testers N AI 177 registered significant gca effects in positive direction and SKV 50 and NAI 137 in negative direction. Non- additive effects appeared to play a major role in imparting resistance to SDM. The maximum (94.42%) and minimum (6.5%)loss in grain yield was noticed in unprotected plots of CM 500 and Hema with 98.0% and 10.0 % SDM incidence respectively. Validation of SSR markers linked to SDM on a set of susceptible and resistant cultivars indicated that three of the SSR markers bnlg1893, mmc0241 and phi078 produced distinct pattern particular to resistant and susceptible genotypes and these can well be utilized in marker assisted selection programme for the development

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### Investigation on Wilt Complex in Pomegranate and its Management

SHREESHAIL SONYAL

WILT incidence in major pomegranate growing districts of Karnataka ranged from 0 to 59.37 per cent. The overall wilt complex incidence was maximum in Tumkur district with 38.43 per cent, among the different pomegranate varities, Arakta (36.04 %), whereas Red sandy soils (31.30 %) and with respect to soil pH, it was found in 7.7 – 7.8 pH (41.74 %) had maximum incidence of wilt complex. The community analysis of the plant parasitic nematodes associated with pomegranate revealed that *M. incognita* was a predominant nematode with a highest prominence value. In the interaction studies, the combined or sequential inoculation of *M. incognita, C. fimbriata*and *F. oxysporum*increased the wilt incidence and fastened the appearance of wilt symptoms. Difenconazole, propiconazole, carbendazim and tricyclazole were recorded cent per cent inhibition of *F. oxysporum*and *C. fimbriata*mycelial growth. Among all the tested *P. fluorescens* strains, Pf1, Pf2 and Pf3 and BS1 strain in *Bacillus subtilis* and Th2, Th3, Th6 strain of *T.harzianum* recorded cent per cent inhibition of mycelial growth of *C. fimbriata* and *F. oxysporum*.The $J_2$ mortality of *M. incognita* were tested by different bioagents strains *in vitro,Psuedomonasfluorescens*, Pf3 (78.00 %), Th2 (68.00 %) and Th5 (68.00 %) of *Trichodermaharzianum* at 100 per cent concentration at 120 hours of exposure. Cultural variability of *C. fimbriata*and *F. oxysporum*isolates were studied, Thogargunte isolate (8.97 cm) Hosadurga town isolate (8.83 cm) had recorded maximum radial growth. Among the sixty three germplasm, two were found resistant to *C. fimbriata, F. oxysporum*and *M. incognitaviz*., IC – 318759 (SHC2) and IC – 318708 (SHC).*P. fluorescens* + *T. harzianum* + *P. lilacinus* + difenconazole was superior over all the treatments in reducing the wilting of branches, plants and managing the *M. incognita* population in soil and root.

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## Molecular Characterization, Host Plant Resistance and Epidemiology of Bean Common Mosaic Virus (BCMV) Infecting Cowpea (*Vigna unguiculata*l. Walp)

MANJUNATHA, N.

THE etiological agent causing cowpea mosaic was identified as BCMV on the basis of RT-PCR and electron microscopy. An approximately 750bp PCR product corresponding to CP region of virus and the presence of long flexuous filamentous particles measuring about 952 nm in size typical to genus potyvirus were observed under electron microscope. The characterized virus isolate genome had 10054 nucleotides, excluding the 3'terminal poly (A) tail. Comparison of polyprotein of virus with other potyvirusesshowed similar genome organization with 9 cleavage sites resulted 10 functional proteins. The pairwise sequence comparison of individual genes, P1 showed most divergent, but CP gene was less divergent at nucleotide and amino acid level. A phylogenetic tree constructed based on multiple sequence alignments of the polyprotein nucleotide and amino acid sequences of cowpea BCMV and potyviruses, showed virus is closely related to BCMV-HB. Whereas, Soybean variant of china (KJ807806) and NL1 isolate (AY112735) showed 93.8% (5'UTR) and 94.9% (3'UTR) homology respectively with other BCMV isolates. This virus transmitted to different leguminous plant species and produced systemic symptoms under greenhouse conditions. Out of 100 cowpea genotypes screened, three genotypes *viz*., IC 8966, V 5 and IC 202806 showed immune reaction in both field and greenhouse conditions. Single marker analysis (SMA) was revealed out of 4 SSR markers linked to BCMV resistance, M135 marker explains 28.2 % of phenotypic variation ($R^2$) and PIC value of these markers was ranged from 0.23 to 0.37. The correlation and regression analysis showed rainfall and minimum temperature had significant negative impact and strong relationship with aphid population, whereas weak correlation was observed with disease incidence. The aphid population had non-significant impact and weak association with disease incidence. Path coefficient analysis revealed most of the weather parameters exerted their indirect contributions to the aphid population and disease incidence except minimum temperature.

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# SEED SCIENCE AND TECHNOLOGY

## Investigation on Seed Production Technology for Single Cross Maize Hybrids (*Zea Mays* L.) (NAH-2049 and NAH-1137)

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TO standardize seed production technology *viz.,* planting ratios, synchronization of parental lines, optimum screen size, storage potential and identify suitable morphological and DNA marker for hybrid purity testing experiments were carried out for newly released two single cross maize hybrids NAH-2049 (Nithyashree) and NAH-1137 (Hema) at NSP, GKVK and ZARS, VC Farm Mandya during 2010 to 2013. Between the hybrids, Hema (52.84 and 54.42q/ha) recorded the highest seed yield compared to Nithyashree (32.59 and 33.71q/ha) at GKVK and Mandya, respectively. However between the locations, GKVK (41.64 and 39.08q/ha) was found to be more suitable place for seed production than Mandya (39.08 and 38.55q/ha) during *kharif* and *rabi*, respectively. Hema seed production in 4:1 ratio with combined application of $ZnSO_4$ and $FeSO_4$ 10kg each recorded highest seed yield at GKVK (61.40 and 58.02q/ha) and Mandya (67.66 and 59.56q/ha), similarly in Nithyashree at GKVK (31.20 and 30.39q/ha) and Mandya (30.66 and 28.19q/ha) during *kharif* and *rabi*, respectively. Sowing of male parent by two days late than female parent in Nithyashree (34.20 and 36.30q/ha) and 2 days early sowing of male parent in Hema (59.97 and 59.6q/ha) showed significantly higher seed yields as well as quality during GKVK and Mandya, respectively. The grading of SKV-50 (98.58%), MAI-105 (98.14%), NAH-2049 (98.59%) and NAH-1137 (99.79%) by using sieve size 4.00mm(S) recorded highest seed recovery while NAI-137 (96.37%) by using 6.40mm(R). The seed treatment with Spinosad @ 0.04ml/kg of seed maintained minimum germination (80%) in SKV-50, NAI-137 and NAH-2049 for ten months and MAI-105 for eight months of storage period. Polymorphic specific SSR markers *viz*., bnlg1178 for NAH-2049 and phi001, phi435417 and umc2362 of NAH-1137 could be used for purity assessment of single cross maize hybrids.

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## SERICULTURE

### Isolation and Molecular Characterization of Bacteria Associated with Flacherie Disease of Silkworm *Bombyxmori* L.

SWATHI, H. C.

SILKWORM is being a poikilothermic and sensitive to varied climatic conditions affected by viruses, fungi, protozoans and bacteria. Further, the growth and healthyness of larvae altered due to rearing structures were surveyed in Ramanagara, Chikkaballapur and Kolar district to asses the status of flacherie disease. The well ventilated stone house (6 windows, 6 ventillators and 3 airouts) were recorded higher cocoon yield of 85 kg/ 100dfls. The average flacherie disease incidence during rainy and winter recorded less in Ramanagara (8.33 and 9.00 %), kolar (6.22 and 5.00 %) and Chickballapur (6.00 and 8.33 %) districts as compare to 15.00, 16.00 and 17.33 per cent during summer months, and it was found more in RCC and less in stone house. The diseased samples were subjected for isolation and characterization based on colony character (Shape, colour, margin, configuration and elevation) biochemical and molecular tests. Among 121 isolates the identified organisms are *Viz., Pseudomonas fluorescens, Streptococcus pnumoniae, Providencia rettigeri, Staphylococcus aureus, Bacillus subtilis, Bacillus cereus, Klebsiella cloacae, Enterobacter aerogenes, Eschericia coli and Providencia vermicola.* The *Providencia rettigeri* shared 97 per cent similarity with *Providencia rettigeri*strain ALK422 and it was confirmed fromthe sequence analysis of 16S rRNA. The study revealed that, *Pseudomonas fluroscens* is a dominating bacterial isolate in surface, midgut and haemolymph of flacherie diseased worm from Ramangara district but, it has not been noticed in midgut and surface of flacherie diseased worm from Kolar and Chickballapur district.

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### Discovery of QTLs for Drought Tolerance Traits using a Biparental Mapping Population of Mulberry Segregating for Root and Water Use Efficiency (WUE)

MADHURI THINNALURI

SOIL moisture stress is one of the main factors limiting the mulberry productivity in India. Maintaining leaf water relations by better root system and maintenance of superior metabolism for positive carbon gain can enhance drought adaptability. These traits are quantitatively inherited and therefore requires a forward molecular breeding approach to pyramid them. Towards identifying QTL for these complex traits, mapping population segregating for WUE and root traits was extensively characterized for phenotypic and molecular diversity. Significant genetic variability was noticed in various physiological and biometric traits among the progeny. Root weight varied between 23.66 and 250.50 g $p^{-1}$ while Ä$^{13}$C, a surrogate for WUE varied between 15.65 and 21.28‰. The traits segregated in a 1:1 pattern conforming to the pseudo test cross in out beeding perennials. The $F_1$ progeny MPR-89, MPR-120, MPR-53, MPR-68 and MPR-123 which segregated into low Ä$^{13}$C category also had high TDM, LA and R/S ratio and appeared to be the most suitable genotypes for water limited conditions. A total of 751 SSR markers were screened which revealed 453 markers polymorphic between parents. A linkage map with 14 linkage groups (LGs) with 134 linked markers had a map length of 4263.5 cM. The distance between two linked markers varied from 5.0 to 49.8 cM with an average distance of 31.80 cM.QTL analysis was performed using composite interval mapping (CIM) using QTL CARTOGRAPHER (version 2.5). The CIM identified 23, 11 and 9 QTLs controlling various traits respectively on first, second and pooled data. Further, validation of these QTLs and saturation of these regions would help the breeder to exploit root traits, WUE and associated traits for genetic improvement of mulberry varieties and also to evolve new varieties adapted to water limited conditions.

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## SOIL SCIENCE AND AGRICULTURAL CHMISTRY

### Soil Resource Inventory and Evaluation of Mass-Volume Approach for Fertilizer Recommendation in Physically Degraded Lands

VASANTHI, B. G.

DETAILED soil survey of Hadonahallypanchayath comprising of six villages with a total area of 1586.52 ha in Doddaballapur taluk Bangalore rural district was conducted. Soil profiles were studied from all the major physiographic divisions. The soils have been described for their site characteristics, morphology, physical and chemical characteristics. Eight soil series were identified and mapped into 35 phases. The soils were shallow to very deep, sandy loam to sandy clay loam in texture, slightly acidic to moderately alkaline, low in salts, CEC and organic carbon content. The major taxa identified at great group level were Kandiustalfs, Paleustalfs and Haplustepts. The study area was found suitable for cultivation of finger millet, redgram and maize. Plot wise soil samples analyzed for fertility status indicated that 61.3, 30.12 and 45.6 per cent of the soils were low in available nitrogen, phosphorus and potassium content respectively. The micronutrients content varied from deficient to sufficient range. Soil crusting, gravelliness and severe erosion were the major constraints in the area for crop production. Field experiment to evaluate soil mass-volume relationship as an approach for fertilizer application and to study the response of finger millet to graded levels of fertilizers was carried out for two years using RCBD design with six treatments replicated four times at farmer's fields having gravelly and non gravelly soils. Finger millet grain yield was higher in non gravelly soil (24.39 q ha$^{-1}$) and was lower (17.80 q ha$^{-1}$)in gravelly soil. Similar trend was observed with straw yield. Higher concentration and uptake of nutrients was observed in non gravelly soil. Among fertilizer treatments addition of NK ± 50% and P ± 25% ($T_6$) and STCR based fertilizer application taking gravel per cent in to account ($T_3$) was found to be better both in non gravelly and physically degraded gravely lands.

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### Mulberry and Silkworm Cocoon Quality Parameters as Influenced by Soil Application of Micronutrients

SHILPA SHREE, K. G.

A field experiment was conducted in a well established mulberry garden at KVK, Chamarajanagara to study the effect of soil application of borax @ 2.5 kg ha$^{-1}$ along with 100 per cent RDF + FYM, zinc sulphate, iron sulphate, manganese sulphate @ 10 and 20 kg ha$^{-1}$, copper sulphate @ 5 and 10 kg ha$^{-1}$ in lower and higher doses, individually and in combination on growth, yield and quality of mulberry and silk. Mulberry leaves were harvested three times and three silk worm cocoon crops were harvested during 2013-14. Significantly higher shoot height (1.62 m), number of shoots (15.49), leaf area (86.95 dm$^2$ plant$^{-1}$) and leaf yield (14.53 t ha$^{-1}$ harvest$^{-1}$) were recorded with combined application of micronutrients at higher level in all the three harvests as compared to control. Among different micronutrients applied individually, application of $ZnSO_4$ @ 20 kg ha$^{-1}$ recorded significantly higher shoot height (1.57 m), number of shoots (15.28), leaf area (77.32 dm$^2$ plant$^{-1}$) and leaf yield (13.69 t ha$^{-1}$ harvest$^{-1}$) as compared to control. Similarly, combined application of micronutrients at higher level recorded significantly higher weight of cocoon (17.45 g 10 cocoons$^{-1}$), pupa (13.64 g 10 pupae$^{-1}$), shell (3.85 g 10 shells$^{-1}$) and longer silk filament (921.31 m) with less number of breaks (0.72) as compared to control. Among different micronutrients, borax @ 2.5 kg ha$^{-1}$ recorded higher weight of cocoon (16.92 g 10 cocoons$^{-1}$), pupa (13.45 g 10 pupae$^{-1}$), shell (3.47 g 10 shells$^{-1}$) and longer silk filament (875.99 m) with lesser number of breaks (1.01). Application of micronutrients to soil either individually or in combination has not significantly influenced the silk quality parameters such as denier, fibroin and sericin contents. In all the treatments, the residual available micronutrients content in soil increased over initial content.

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## Evaluation of Different Diatomite Compounds on Soil Properties, Growth and Yield of Aerobic Rice

ANITHA, M. S.

AN incubation, green house and field experiments were conducted to know the effect of different grades (DE-1, DE-2, DE-3, DE-4 and DE-5) and levels (250, 500, 750, 1000 and 1500 kg $ha^{-1}$-) of diatomite (DE) on soil properties, growth and yield of aerobic rice in acidic (Hassan) and alkaline (Mandya) soil. The study revealed that, there was a significant increase in pH of acidic and decrease in pH of alkaline soil compared to control irrespective of application rates of DE under field capacity was recorded over the incubation period. Among the different grades, DE-3 and DE-4 recorded significantly higher acetic acid-Si and $CaCl_2$-Si content at 30days after incubation in both the soils. Irrespective of different grades of DE, increased rate of application increased the N, $P_2O_5$, K, Ca, Mg and S in both the soils. In a pot culture experiment, significantly better performance of rice, increase in the availability and uptake of Si by rice was noticed with the application of DE-4 @ 750kg $ha^{-1}$ and DE-4 @ 1000kg $ha^{-1}$ in acidic and alkaline soil, respectively. The results of field experiment revealed that, application of DE-4 @ 750kg $ha^{-1}$ and DE-3 @ 500kg $ha^{-1}$ recorded higher yield of aerobic rice at Hassan and Mandya, respectively. Application of DE-3 @ 500kg $ha^{-1}$ and DE-4 @ 750kg $ha^{-1}$ recorded higher content and uptake of Si and all other nutrients by rice straw at both the locations. Lower BD and high percentage of maximum water holding capacity and water stable aggregate were recorded with the application of DE-3 @ 500kg $ha^{-1}$at Hassan and DE-4 @ 500kg $ha^{-1}$ at Mandya. In a greenhouse with moisture stress experiment, application of DE-4 @ 300kg $ha^{-1}$ at 100per cent FC recorded significantly higher straw weight and leaf relative water content, decreased proline content and electrolyte leakage in both acidic and alkaline soil. Treatment receiving DE-4 @ 300kg $ha^{-1}$ at 100per cent FC recorded higher content and uptake of Si and other nutrients by rice straw in both the soils compared to 100 and 50percent FC alone.

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## Soil Resource Inventory using Remote Sensing and GIS for Kengaki Mini-watershed of Chamarajanagar District, Karnataka

SHIVANNA, B.

CHARACTERIZATION and evaluation of soils for capability, irrigability and crop suitability was carried out in Kengaki mini-watershed of Chamarajanagar district, Karnataka using remote sensing and GIS techniques. The study area has semi-arid climate with average annual rainfall of 799.3 mm. Nine pedons representing the entire study area were studied for morphological and physicochemical properties. The soils were loamy sand to clay in texture, shallow to very deep in depth, dark yellowish brown to red in colour, slightly acidic to strongly alkaline in reaction, low to medium in organic carbon status. Based on the characters, soils were classified as Typic Rhodustalfs, Ultic Haplustalfs, Typic Haplustepts, Vertic Haplustepts. Soils of Thammadihalli, Kumachahalli-2 and Kengaki-2 series were classified under land capability class IIes, Shyanandrahalli-1, Kumuchahalli-1, Kumuchahalli-3 Kengaki-1, Shyanandrahalli-2 soils were under IIIes and Lakkuru soils were classified under IVes. Soils of Thammadihalli, Kengaki-2, and Kumachahalli-2 series were classified under soil irrigability class 2 with the moderate limitations, Shyanandrahalli-1, Kumuchahalli-1, Kumuchahalli-3 and Shyanandrahalli-2 series were classified under class 3 with severe soil and topography limitations. Soils of Kumuchahalli-2 series were highly suitable for the cultivation of sorghum, tomato, cotton and coconut whereas soils of Kumuchahalli-3 series were highly suitable for the cultivation of sorghum and tomato without any limitations. Based on the information obtained from the thematic maps and soil data, the soils were divided into four groups and for which alternate land use options were suggested.

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# *Abstracts of M. Sc. Theses submitted to the University of Agricultural Sciences, Bengaluru*

## AGRICULTURAL ECONOMICS

### Optimum Crop Planning using Resource use Efficiency and Sustainability for Northern Dry Zone of Karnataka

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THIS study is aimed at designing regional crop plan using sustainability and resource use efficiency for Northern Dry Zone (NDZ) of Karnataka. For this study, primary data were collected from 30 random sampled farmers each under rainfed, borewell irrigated and canal irrigated conditions in Bagalkot and Mudholtaluks of Northern Dry Zone. The cost of cultivation and net returns at market prices, economic prices and natural resource valuation with and without water were calculated for different crops which reflects the distortion of input subsidies (fertilizers and energy). Results indicated that the cost of cultivation for borewell irrigated sugarcane was Rs 86,669 and net returns at market price, economic, natural resource with water valuation was Rs 90,021, Rs 72,840 and Rs 27,642 respectively. Thus, due to input subsidies, distortion of net returns was Rs 17,181 and by adding natural resource cost (GHG and groundwater), the net returns decreased by Rs 45,198. The resource use efficiency of crops were estimated using Cobb- Douglas production function, indicated that the ratio of MVP to MFC was more than one in most of the crops highlighting the inefficiency in resource use. Sustainable optimal crop plan was developed for the study area using linear programming indicated that, 78,428 ha has to be allocated in canal, 2,45,336 ha for rainfed and 1,00,952 ha for borewell irrigated condition. Total optimum area allocated was 4,25,678 ha which maximize the net return at sustainability was Rs 64,747 lakhs for Bagalkot District in the NDZ of Karnataka.

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### Economics of Production and Marketing of Litchi in Dehradun District of Uttarakhand

RAVINDRA SINGH NEGI

THE present study was undertaken in Dehradun district of Uttarakhand state. The study conducted to examine growth in area, production and productivity, resource use efficiency, costs and returns in litchi, different marketing channels, marketing costs and price spread in litchi cultivation.The present study was based on the primary data collected from 120 randomly selected litchi growers from four villages in Dehradun district of Uttarakhand state. The tools used were compound annual growth rates to find growth in area, production, and productivity, tabular analysis for cost and returns, Cobb-Douglas production function for determining resource use efficiency and price spread analysis for different marketing channels. The study revealed the area under litchi in India and Uttarakhand during the period of 2000-2014 increased but productivity decreased. The production of litchi in India increased but decreased in Uttarakhand. The per hectare establishment cost and average annual cost at overall level was found to be Rs.75,236 and Rs.39,666 which was highest for small farmers followed by medium and large farmers. The study shows that resources are not optimally used by all the categories of farmers. The price spread was found to be 72.0, 48.4 and 35.0 per cent in channel-I, II and III, respectively. The major problems faced by growers in production were lack of technical know-how, financial difficulties while in marketing, the problems were short life and lack of cold storage facilities. The growers should be encouraged to form associations and take up litchi cultivation.

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## AGRICULTURAL ENGINEERING

### Development of a Watermelon (*Citrullus lanatus*) Seed Extractor

SHRINIVAS DESHPANDE

ENGINEERING properties such as physical and textural properties of the matured watermelon (*Citrulluslanatus*) fruit and its seeds were measured in order to design, develop and evaluate the watermelon seed extractor. The developed seed extractor consisted of following systems for (i) watermelon cutting, (ii) watermelon seed extraction, (iii) seed separation and (iv) power transmission. The extractor was evaluated with three types of scrapers namely stainless steel, wooden and nylon; two cutting planes *viz.,* transverse and longitudinal planes and three rotational speeds *viz.,* 50, 100 and 150 rpm. The best combination was observed to be for transverse cutting with nylon scraper at a speed of 100 rpm. The best performance for capacity, extraction efficiency, seed loss, seed damage, germination percentage and vigour index were found to be 1.98 kg of seeds/h, 99.49 %, 0.19 %, 0.26 %, 97.04 % and 3284, respectively. The total cost of developed seed extractor was Rs. 52,371. The cost of operation of the developed extractor was Rs. 57.31/h. The cost for extraction of 1 kg of watermelon seeds by manual method was Rs. 600, whereas Rs. 28.65 by the developed seed extractor. The cost-benefit ratio of developed watermelon seed extractor was 1:1.40.

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### Economics of Production and Marketing of Litchi in Dehradun District of Uttarakhand

PRIYANKA, U.

SOLAR TUNNEL dryer of 6x3x2.7 m (LxWxH) with galvanized frame structure was constructed and covered with 200 micron UV-stabilized LDPE sheet. Two fresh air inlets of 0.6 x 0.3 m size and two exhaust fans each of 9 inches dia and 50 watt capacity were installed at the rear side and front side of the dryer, respectively. The amla pretreated with 2 per cent sodium chloride and 0.1 per cent potassium meta-bi-sulphite and onion pretreated with 0.25 per cent potassium meta-bi-sulphite were subjected for drying. In solar tunnel dryer, the drying required 12-15 h and 13-14 h for various pre-treated amla segments and onion slices to reduce from moisture content of 422.32- 521.46 per cent (d.b.) to a safe moisture content of 17.01-17.39 per cent (d.b) and from moisture content of 572.92 -797.29 per cent (d.b.) to attain a safe moisture content of 6.08-6.24 per cent (d.b), for amla and onion, respectively. Chemical analysis indicates that the quality of solar tunnel dried products are superior to open sun dried products .The vitamin-C retention was found to be highest (125.68 mg/100g) in untreated amla samples dried in solar tunnel dryer. The highest total phenolics, FRAP was found to be 325.09 (µg/g) and 1617.09 (µg/g), respectively in 0.25 per cent KMS pre-treated onion dried in solar tunnel dryer. The payback period for amla is 6 months and for onion it is 9 months. The results showed that the rehydrated products could be well utilized for substituting the fresh product in off season.

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## Dehulling Studies of Kodo Millet and Storage of Milled Kodo Millet Rice

CHANDAN KUMAR, V. B.

ENGINEERING properties like longitudinal and lateral diameters, shape, 1000 grain weight, bulk and true densities, porosity, angle of repose, coefficient of friction on different surfaces (glass, mild steel, wood) and terminal velocity of kodo millet, its rice and husk were measured. Four different dehullingequipments namely, burr mill, Victor millet mill model-I, Victor millet mill model-II and rubber roll sheller were tested for dehulling raw kodo millet by varying initial moisture levels of millet (9.0-10.1%). Among the four tested equipments, Victor millet mill model-II was found to be best for dehullingkodo millet with better dehusking efficiency (82.46-85.60%), milling recovery (57.05-57.71%), head yield (87.62-89.46%) and lower rice breakage (10.52-12.37%). For polishing dehulledkodo rice, AVM Abrasive polisher was found to be suitable. Among various hydrothermal pretreatments attempted on kodo millet, soaking either in room temperature water for 24h or in hot water (75°C for 3½h) followed by steaming @1kg/cm2 pressure for 15min resulted in higher dehulling efficiency, head rice yield and milling recovery with least rice breakage. Storage study of unpolished and polished (@4 and 8% levels) kodo rice samples was done at ambient conditions for 60days using different packaging materials such as polypropylene (300 gauge), stainless steel container, spun bound nonwoven bag and HDPE woven bag. Nutritional and cooking quality analyses of stored millet rice indicated that with storage, swelling index and cooking time increased but solid loss decreased. The cost of processing kodo millet into polished rice was Rs.1.65/kg and the Cost: Benefit Ratio of processing was 1:1.88.

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## Development of Millet Separator-Grader for Effective Separation of Unhulled Grains from Dehulled small Millet Rice Grains

SHRUTHI, P. A.

PHYSICAL and engineering properties like moisture content, size, weight of thousand grains, bulk and true densities, porosity, specific gravity and frictional properties like angle of repose and static coefficient of friction were determined for unhulled and dehulled grains of four small millets namely, proso, kodo, foxtail and little millets. Separation-cum-grading performance of three existing cleaning equipments namely, destoner, air screen cleaner and specific gravity separator was evaluated to find their suitability for the selected small millets. A Small millet separator-grader was developed and tested for its separation-cum-grading performance for the above four small millet rice grains. The effects of four screen set combinations ($S_1$, $S_2$, $S_3$ and $S_4$) and five feed mixes ($M_1$, $M_2$, $M_3$, $M_4$ and $M_5$) on cleaning efficiency, screen effectiveness, cleaning index and performance index of the developed equipment was studied. The cleaning efficiency was in the range of 97.05-98.20 per cent, screen effectiveness was 0.795-0.882, cleaning index was 0.817-0.895 and performance index was 0.77-0.867. For tested small millet rice grains, the performance of separator-grader was optimum when screen set combination $S_1$ (Rd Ö2.0-Rd Ö1.5-Rd Ö1.0) and feed mix upto (90:10) were used. The cost of separation-cum-grading was in the range of ‘ 47.20-61.37 per quintal and the Cost : Benefit ratio was worked to be in the range of 1:1.62 – 1:2.11. The developed prototype was found to be suitable for effective separation of unhulled millet grains from dehulled small millet rice.

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## Development of Extruded Product Using Jackfruit Bulbs and Seed Flours

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JACKFRUIT *(Artocarpusheterophylus* L) is an important underutilized fruit crop of the tropics. A study was conducted to develop jackfruit based pasta products. Thenutritionalcompositionofdevelopedpasta productswas analyzed. The resultsofmoisture content,protein,fat,fibre,ashandcarbohydrates werefoundtobeintherangeof 6.51-8.24%, 10.06-16.95%, 2.39-2.86%, 1.61-1.89%, 3.54-4.50%, respectively.Themicronutrients present in variousPasta products were estimated as Fe 341.5-2314.6ppm,Cu 242.6-280.6ppm,Na 6.6-8.98%,Zn 664.8-946.0ppm, Mg 502.0-703.2ppm,Ca 3.08-8.09% and K 6.46-8.84%. The sensory scoresofPastaproductswere recorded between 7 and 8indicatinggoodacceptability of the developed products. Thecookingcharacteristics,namely,cookingtime,swellingpower andsolidloss of jackfruit pasta products variedfrom 6.03-10.90min., 2.06-5.33(g/g) and 5.20-9.40%,respectively. ThemeansensoryscoresofthePasta products progressively declined marginally during storage in both the packages. There was no-significant microbial growth observed in pasta products during two months of storage. The developed jackfruit pasta products were found safe for storage up to two months at ambient conditions. Among the packages,PE package was found to be the best. Thecost economicswas workedouttaking into accountthefixedandvariable costs. The processing costs and cost benefit ratios of pasta products were Rs. 41.68/kg and 2.21:1.00 (Jackfruit seed flour); Rs. 41.33/kg and 2.41:1.00 (Jackfruit bulb flour); Rs. 39.68/kg and 2.52:1.00 (Jackfruit seed + bulb flour); and Rs. 34.18/kg and 2.92:1.00 (Jackfruit seed + bulb + cassava).

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## Design and Developent of Kitchen Waste Shredder for Compost Production

GURUDATTA KHANDKE

KITCHEN waste is the food which is discarded or lost uneaten. Wastage occurs in all stages of food supply chain. House hold wastes are organic in nature and are mostly composted. The process of shredding includes reducing the particle sizeof kitchen waste which is done manuallyand used in waste management. To address this, manually operated kitchen waste shredder was developed and its performance was evaluated. The developed shredder was tested using different parameters suchas rotational speed and feeding rate. Among the different cylinder liners used, the small iron bar with specified dimension was selected for the final fabrication of the shredder.Resulting in maximum shredding efficiency (96.24 %), capacity (46.8 kg/h)&size reduction efficiency (96.86 %) for vegetable waste. For fruit waste it was observed to be 94.70 %, 40.8 kg/h and 97.47 %, respectively and for mixed waste it was 92.86 %, 44.4 kg/h and 96.34 %,respectively.Shredded kitchen waste was composted. N, P, K values were estimated for 1$^{st}$, 15$^{th,}$ 30$^{th}$ and 45$^{th}$day. Nitrogen (N) content (percent) was found to be 0.227 (1$^{st}$day), 0.306 (15$^{th}$ day), 0.340 (30$^{th}$ day) and 0.770 (45$^{th}$ day).Phosphorus (P) content (percent) was found to be on0.116 (1$^{st}$ day), 0.119(15$^{th}$ day), 0.159(30$^{th}$ day) and 0.175 (45$^{th}$day). For Potassium (P) it was, 0.09 (1$^{st}$day), 0.132 (15$^{th}$ day), 0.188 (30$^{th}$ day) and 0.378(45$^{th}$ day). The estimated cost of the shredder was¹ 5190/– and the cost ratio was found to be 1:1.69.

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## AGRICULTURAL ENTOMOLOGY

### Pest Complex of Bitter Gourd (*Momordica charantia* L.) with Special Reference to the Management of Melon Fruit Fly, *Bactrocera cucurbitae* (Coquillett) (Diptera: Tephritidae)

SUNIL

As many as 24 species of insect pests were recorded on bitter gourd, of which twelve species were defoliators, eight species were sucking pests, one was a gall former and three species were fruit borers. Among the pests, *Bactroceracucurbitae* caused serious damage during *kharif* season, where fruit infestation ranged from 30 to 52 per cent, which was significantly and positively correlated with rainfall (r = 0.71*) and positively correlated with maximum relative humidity (r = 0.59). During *rabi,* fruit fly infestation ranged from 26 to 33 per cent which was significantly and positively correlated with maximum temperature (r = 0.76*). Studies on monitoring of fruit fly with para-pheromone trap revealed that maximum trap catches, (on an average 129 to 162 flies/trap/week) were recorded between September – October 2014 and minimum trap catches (on an average 6 flies/trap/week) were recorded in January 2015. The trap catches were significantly and positively correlated with rainfall (r = 0.73*) and minimum temperature (r = 0.65*) and positively correlated with maximum temperature (r = 0.13), maximum relative humidity (r = 0.30), minimum relative humidity (r = 0.17) and wind speed (r = 0.28). Efficacy of selected insecticides against melon fruit fly revealed that the combination of jaggery @ 0.015 per cent with deltamethrin @ 0.0028 per cent showed significantly lowest fruit infestation and maggot population per infested fruit as compared to other treatments. The fruit yield was significantly also higher in this when compared to the remaining treatments.

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### Growth of *Trichogramma* Temperature Tolerant Strain VIS-A-VIS Non-Tolerant Population at High Temperature Conditions

ANJALI, A. S.

THE present study was conducted on the growth of *Trichogramma chilonis* temperature tolerant strain and non-temperature tolerant population at ambient (27±2$^0$C) and various high temperature conditions (32$^0$ - 40$^0$C) in order to assess their population growth pattern in normal laboratory temperature condition at high temperature conditions, life table studies at ambient and high temperature conditions and the growth at deficient and abundant host ability. The temperature tolerant strain is adapted to both the temperature conditions. For non-temperature tolerant strain per cent parasitism (65.44 %) and per cent adult emergence (69.7 %) decreased with increase in temperature. Mean development period of both strains decreased with increase in temperature but female ratio of the strains increased with increase in temperature. The life table studies shows that both strains at high temperature conditions had the highest $R_0$ $r_m$ and λ followed by the same strains at ambient temperature condition. The studies on biological parameters at different host density shows that number of parasitized eggs increased with egg density but per cent parasitism.decreased. The per cent parasitism of temperature tolerant strainwas found to the maximum {93.3 %) at lowest density (10 eggs) and minimum (86.9 %) at density of 150 eggs. For non-tolerant strain the highest per cent parasitism was observed at 90 eggs (91.44%). The Per cent-adult emergence and per cent females of both strains increased with egg density. The adult emergence was found to be maximum at 90 eggs and minimum at 10 egg density.

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## Influence of Urbanization on Pollinator Populations

ZAMEERODDIN

HABITAT degradation, destruction and fragmentation are considered main causes for pollinator decline and a cause of considerable concern for pollination ecosystem service. The present study was intended to investigate influence of urbanization on pollinator diversity and abundance along the urbanization gradient of North Bangalore during 2014-15. Using two methods of sampling (sweep net and bee bowl methods) over a period of six months, a total of 9,934 specimens were collected from three locations which represented 107 species of pollinators. belonging to 44 genera of six families. Highest number of species were collected in rural area (82) followed by peri-urban (74 species) and urban area (65 species). Interestingly, there was no significant difference in the pollinator diversity along the urbanization gradient. However, there was difference in species composition and temporal diversity and abundance of pollinators. The highest diversity. was recorded in the month of November in all three areas. The least number of species were found in February and March. The highest number of flowering plant species were observed in rural area followed by peri-urban and urban area. In urban area, highest number of pollinators were collected on *Leucas aspera.* This result suggests that availability of wild and garden plants in urban area support the diversity of pollinators and help in conservation of pollinators in urban habitats.

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# AGRICULTURAL EXTENSION

## Management Efficiency and Economic Performance of Bt Cotton Growers in Belagavi District

RAHUL PAWAR

The study was conducted in two taluks of Belagavi district selected based on maximum area under Bt cotton. A total of 120 Bt cotton growers were selected by using simple random technique from three villages from each taluk. The results revealed that majority of Bt cotton growers belonged to medium level of management efficiency (40.83%) and economic performance (63.33%). The characteristics such as education, land holding, extension contact, extension participation and scientific orientation had positive and significant relationship with management efficiency. Whereas experience in Bt cotton cultivation, land holding, annual income, extension participation, mass media exposure, economic motivation and innovative proneness had positive and significant relationship with economic performance. Major constraints faced by the Bt cotton growers were high cost of plant protection chemicals, inadequate credit and lack of market information. Hence, the Department of Agriculture should plan to educate the Bt cotton growers on functions of management and recommended Bt cotton cultivation practices. Further, motivate the farmers to adopt these practices in their fields. The positive and significantly related characteristics of farmers needs to be considered while selecting the farmers for the extension educational programmes. Also it should plan the strategies to minimize the inputs cost, provide adequate credit and market information to the Bt cotton growers to enhance their management efficiency and economic performance.

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## Critical Analysis of Adoption Pattern and Production Constraints of Pomegranate Growers

MEHABOOB PASHA

THE study was conducted in Koppal district of Karnataka during 2011-12 to know the adoption pattern and production constraints of pomegranate growers about recommended cultivation practices. The data was collected through personal interview method and analyzed by using suitable statistical measures.The findings of the study revealed that 38.33 per cent the respondents were found in high level of overall adoption category, followed by low (31.67%) and medium (30.00%) categories. The independent variables studied viz.,cosmoploliteness, extension participation, risk orientation, management orientation, achievement motivation and information seeking ability were positive and significant relationship with adoption. Production constraints were the major problems faced by the pomegranate growers followed byLabour, Technical,Marketing, Input and Financial problems.Further, existing marketing pattern of revealed that majority of pomegranate growers (85.00%) sold their produce through middlemen or retailer at the farm. Further, Source of market information followed by pomegranate growers were, visited to market intermediaries (58.33%), personally visiting the market (66.67%), television (50.00%), internet (37.50%), radio and newspaper (26.17%). A new market strategy (model) was suggested based on the results of the study which includes formation of growers' organization, producers companies, direct sale, grading, branding, packing etc., to enhance the profit margin of the produce.

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## An Analysis of Trainings organized by Staff Training Unit, UAS, Bangalore and its Impact

MIARKA R D'SOUZA

WITH a view to developing a comprehensive methodology to organize and assess the impact of training, a study was conducted during 2014-15 by obtaining judges opinion. A comprehensive methodology constitutes three phases and 20 steps. In the first phase (pre-training), the steps considered were training need assessment, setting objectives, development of content, preparation of session plan, method of instruction, requirement of training support material, requirement of needed resources; Training phase (second phase) comprise pre-test, use of suitable resource persons, appropriate logistics, organizing training as per plan, training approach, supply of reference material, monitoring, and preparation of training completion report; and the third one, Post training phase comprise post-test, post training contacts with trainees, feedback on utility of training at the field level, feedback on extent of application of lessons learnt, consequential effect on intended clients, and impact assessment strategies. Using the developed training methodology, a study was conducted in Staff Training Unit of University of Agricultural Sciences, Bangalore considering 25 trainings organized for the extension staff of Dept. of Agriculture. The findings of the study revealed that, the mean training efficiency score was found to be 76.40 indicating a better quality of imparting training. However, there was no emphasis on post training phase. The second level of assessment of trainings regarding application of technologies learnt in training was done considering 250 trainee respondents. The findings revealed that about 25 technologies were applied by the trainees in varying degrees indicating fair level of adoption of technologies learnt.

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## A Study on Agricultural Risk Management Strategies Adopted by the Farmers of Eastern Dry Zone of Karnataka

VIDYADHARA, B.

THE present study was conducted in the year 2013-14 in Bengaluru, Chickballapura and Tumkur districts of eastern dry zone of Karnataka to study the knowledge and adoption levels of the farmers to manage the risks in agriculture. Ex-post facto research design was employed to elicit the data from 120 respondents.Major findings were; more than half (53.33 %) of the farmers had medium level of knowledge and less than half (44.17 %) of the farmers had medium level of adoption on risk management strategies in agriculture. Land holding, annual income, scientific orientation and innovativeness by the respondents had significant association with the knowledge and adoption of risk management strategies at 1 per cent level whereas, social participation, cosmopoliteness, training undergone, extension contact and extension participation had significant association at 5 per cent level with both knowledge and adoption. Private agency representatives were found to be most preferred information source by the farmers.Production risk is the major risk faced by the farmers. Wrong methods of plant protection measures followed by increased cost of cultivation and inputs, pest and disease attacks and uneven rainfall distribution, insufficient market knowledge were the factors responsible for different risks in agriculture. To overcome the different types of risks farmers suggested use of pest and disease resistant varieties, advance crop loans from the agencies, adoption of crop insurance and contract farming, use of market information. Hence, the department of agriculture, developmental agencies and other private agencies need to encourage the adoption of above suggested risk mitigating techniques.

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## An Analysis of Entrepreneurial Behaviour of Maize Seed Producing Farmers of Haveri District

BANGARAPPA S. MATTIHALLI

THE present study was conducted during 2014-15 in Haveri district of Karnataka. Total sample of 120 Maize seed producing farmers were selected from 8 villages of Hirekerur and Ranebennur taluks. Majority of the respondents were found to be middle age, having primary school, small farmers, agriculture as main occupation, small sized family, low income category, high farm implements possesing group, medium cosmopoliteness, low extension participation, low economic motivation, low mass media exposure, low social participation. Majority of maize seed producing farmers were having high innovativeness, high decision making ability, medium information seeking ability, low risk orientation, high management orientation, medium level leadership ability, medium achievement motivation, high level scientific orientation, overall 40 per cent of maize seed producing farmers were of high entrepreneurial category. It was found that positive significant relationship between occupation, annual income, social participation and extension participation with entrepreneurial behaviour. Kaiser-Mayer-Olkin measure of sampling adequacy of 0.582 indicated that all the variables were necessarily measuring different components. More number of respondents expressed lack of electricity for irrigation supply and high labour cost as main constraint and suggested for proper and timely supply of electricity and to develop labour saving technologies.

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## AGRICULTURAL MARKETING, CO-OPERATION AND BUSINESS MANGEMENT

### Analysis of Contract Farming in Selected Seed Production Crops in Haveri District, Karnataka

SHRIKANTHA TIRAKAPPA MULIMANI

CONTRACT farming is a contractual agreement between farmer and a company for seed production. The main objectives of the study are to documentsocio-economic profileof the farmers,cost and returns in seed production,resource use efficiency, modus operandi of seed firms in hybrid vegetable seed production.The study was conducted in Byadagi, Ranebennur and Hirekerurtaluks in Haveri district of Karnataka. The primary data was collected (during 2014-15) from 120 farmersgrowing bitter gourd, ridge gourd, chilli and tomato. The data was subjected to Cobb-Douglas production function analysis and tabular presentation. The results revealedthat the average family size of farmers was 7 members,cent percent of farmers were educated with average age of 40 years.The cost of seed production per acre was estimated to be Rs. 93,502, Rs. 91,296, Rs. 2,66,708, and 2,53,008 for bitter gourd, ridge gourd, chilli and tomato, respectively.The ratio of marginal value of the product to marginal factor cost reveals the use of resources like FYM, bullock and tractor by the farmers are not optimal. Hence there is a scope for efficient use of these resources to increase returns on investment. The contract agreement prevailing between farmers and companies is a written document indicating the role and responsibilities of each. Lack of skilled labourers, high wages, lack of capital and non- existence of crop insurance are the problems faced by the farmers. To overcome these constraints the seed companies need to make payments to the farmers immediately after the purchase of seeds.

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### A Study on Marketing Management of Non-Timber Forest Products in Sirsi Division of North Canara District

PUNEETH, J.

THE study was conducted in ten villages of sirsi division in North Canara district of Karnataka state during 2014-15 to identify the marketing channels of NTFPs and document the problems encountered by NTFP collectors. A sample of 60 village Forest Committee (VFC) members and 30 non-VFC members were personally interviewed using a pre-tested schedule. Agriculture, collection and marketing of NTFPs and wage employment were the first, second and third major income generation activities of the respondents, respectively. *Garcinia gummigutte, Emblica officinalis, Terminalia chebula, Mimosa surgi, Sapindus indica, Acacia concinna* and *Mangifers indica* are the major NTFPs collected and marketed by the respondents in the study area. Three marketing channels were followed by the respondents in marketing of NTFPs. In Channel-I, collectors directly sell their NTFPs to VFCs to end user/industry. In Channel-II, the collectors sell their produce to village merchants from village merchants to end user/industry via wholesaler in channel-III, the collectors sell their produce to wholesaler/retailer from wholesaler/retailer the NTFPs are sold to end user/industry. Seasonal availability and scattered distribution of NTFPs, long distance to collect NTFPs, lack of training to extract NTFPs, low collection charge/wage rate, attack by wild animals and restriction from forest authorities to collect NTFPs were the major problems encountered by the respondents during collection of NTFPs. Lack of training on processing of NTFPs and lack of storage facilities were the processing problems. Whereas, perishable nature of NTFPs, exploitation from middleman and lack of transportation facilities were the marketing problems faced by the respondents.

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## Business Performance Analysis of KFDC (Karnataka Fisheries Development Corporation)

MANJUNATH, V.

THE Karnataka Fisheries Development Corporation was established in 1970 in Manglore. The study aimed at measuring the business performance of KFDC. Its analysis of Business performance helps in understanding financial strength of the corporation.The objectives of the study were to analyze the business performance of KFDC, to study the consumer preference for fish varieties and fish products of KFDC and to analyze the seasonal price spread for fish sold in KFDC. The data pertaining to the period from 2008-2014 were analysed using financial ratios and Best-Worst scaling technique pertaining to consumer preference. The findings of the study indicated that, KFDC has a good managerial and financial structure. Liquidity ratios were greater than unity in all the years, Measures of solvency were found to be favourable, efficiency were constantly on the increasing path. Further, the average net profit ratio was 0.01 and has been on the decreasing trend which denotes poor profitability. It was found that primary attribute that influenced consumers to purchase fish was 'Quality', with maximum difference count 184 and standard score 0.681, followed by 'Availability of required variety of fish' with maximum difference count 127 and standard score 0.470. Consumer's highest preference was given to 'Mackerel' with maximum difference count109 and standard score 0.404, followed by 'Pomfret' with maximum difference count80 and standard score 0.296.Seasonal indices of both purchase and sale prices from 2012-2014 of selected marine fishes moved in synchrony, indirectly reflecting the supply-demand gap during certain months of the year.

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## Production, Marketing and Export Performance of Jaggery in Karnataka

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KARNATAKA is one of the major sugarcane growing States, with an area of 4.31 lakh hectares producing 394.70 lakh tones of sugarcane. During the last few years farmers growing sugarcane are facing problems due to oversupply of sugar cane. Keeping these issues in mind the present study was undertaken to explore opportunities in processing sugarcane into jaggery. The study was undertaken in Shimoga and Chamarajnagar district of Karnataka. Data was collected from 60 processors in Bhadravathi and Chamarajnagar market. The total cost of jaggery production per processing unit in Bhadravathi was Rs.3652512. The return from jaggery production per processing unit was Rs.4430160 with a net margin of Rs.777647. Similarly, the total cost of jaggery production per processing unit in Chamarajnagar was Rs. 5131924.00. The return from jaggery production per processing unit was Rs.6621975 with a net margin of Rs.1490050. In all the cases, the B: C ratio is found to be more than one which implies it is profitable to the investment in jaggery processing activities. The trends in the arrivals of jaggery over the years in both Bhadravathi and Chamarajnagar area were found to be positive. The correlation coefficient between arrivals and prices of seasonal indices were found out to be 0.2635 and 0.3975 in Bhadravathi and Chamarajnagar Markets respectively.Majority of processor sold bulk of their produce through channel- I in Bhadravathi and Chamarajnagar market area respectively. Jaggery is being exported to Nearly 165 countries. Hence there is a potential to increase the export of jaggery to other countries.

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## Farmers' Preference for Private and Public Vegetable Markets - A Comparative Study of MG-6 and Mulbagal APMC Markets

MANJUNATH, V.

THE present study was conducted in Mulbagal taluk of Kolar district. The study analysed and compared the structure and conduct of private vegetable market [Mahatma Gandhi – 6 Fruits and Vegetables Wholesale Market (India) Private Limited] and public vegetable market (Mulbagal APMC) and the factors influencing farmers' preference for such markets and the constraints faced by farmers in marketing their produce.The primary data was collected from 50 farmer respondents each, participating in MG-6 and Mulbagal AMPC markets, resulting in a total sample size of 100 farmers.MG-6 market was oligopolistic in nature while Mulbagal APMC market was monopolistic in nature. Infrastructural facilities such as market yard, auction platform, storage / godown, weighing machine, shops, public address system, audio visual aids and electrification were available in both the markets. The method of price determination followed in both MG-6 and APMC markets was open auction method. Tomato was the major vegetable traded in both the markets. The market fee collected in MG-6 market was two per cent while in the case of Mulbagal APMC market; it was only one per cent. In both the markets, the major marketing cost was transportation.In the case of both markets, realization of remunerative price by the farmers was the major factor which influenced their preference for a particular market.Poor management was the main constraint faced by the MG-6 farmers while in the case of Mulbagal APMC farmers, lack of infrastructural facilities and poor maintenance was the main constraint faced by them.

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## A Study on Impact of Metro Wholesaling on Retailing in Karnataka

VARSHAA, H. G.

FOREIGN direct investment (FDI) in India was allowed with different degrees of investment permitting up to 100%. 100% FDI in wholesaling was permitted in India in 1997 which was opposed by trading community in the country. Metro a German based wholesale company started first unit in India in Bengaluru city. The present study's objectives were to document the food products range handled by Metro, to examine the impact of Metro wholesaling on retailing and to document the constraints faced by the retailers. The Metro, Yeshwanthpur was purposefully selected for the study because it was the first store to be opened in India. Thirty retailers who have purchased from Metro Yeshwanthpur spread across 10 km radius were selected for the study. Wide range of products and brands were available in Metro ranging up to 11 companies and 22 in Biscuits category. In addition unbranded products were also available. After shifting of the purchase by retailers from traditional wholesaler to Metro, the monthly turnover was raised by 26 per cent, transport cost raised by Rs 1020 per month, the time spent on purchasing was reduced by 5hrs/month and 50 per cent increase in the monthly profit was recorded. The major constrains faced by the retailers in purchasing from Metro were, non-availability of credit, high transportation cost, restricted number of entry into Metro, non-availability of few brands of choice. Traditional retail stores without its own supply chain as the modern retail format enjoys, can source from Metro to compete with modern retail format.

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## An Analysis of Marketing of Cotton in Bellary District

KARIBASAPPA, H. G.

COTTON referred as white gold is an important commercial crop in the world. China is the largest producer of cotton (32.8 million bales in 2014) in the world. Next to China, India is the largest producer of cotton 31 million bales in 2014). Karnataka stands fifth in cotton produce with 22 lack bales. The objectives of the present study were to examine the factors influencing the varietal preference, market preference for varieties and to analyse the impact of government policies in production and marketing of cotton. The study was conducted in Bellary district by collecting primary data from 60 farmers and 30 traders. The data was analysed by using garret's ranking and compound growth rate. The results of the study indicate that farmer preference for a variety is based on high yield, promotional activities and early maturity with a garret's ranking of 58.10, 57.10 and 55.26, respectively. The physical parameters considered by traders while purchasing cotton are colour, percentage of foreign matter and uniformity in lot. The quality parameters considered by traders were staple length, brightness and moisture content with a garret's ranking score of 61.13, 55.23 and 51.06, respectively. The policy of the Government allowing Bt cotton has resulted in increase in the area, production and productivity by 6.25 per cent, 10.27 per cent and 4.86 per cent, respectively. The major constraints faced by cotton growers are non-availability of quality seeds,availability of fertilizers in time,fluctuation in pricesand late payment by traders in market

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## Supply Chain Management of Pomegranate in Chitradurga District of Karnataka

KARANTH, B.

POMEGRANATE (*Punica granatum* L.) belongs to family Punicaceae and is a favourite table fruit of the tropical and sub-tropical regions of the world. It grows in a wide range of climatic conditions and can grow up to 1800 meters above mean sea level. The main objectives of the study are to analyze forward linkages, backward linkages and constraints in the supply chain. The sample size of the study was 90 farmers and 8 traders. The data was subjected to tabular analysis, percentages and Garrets ranking technique. The study indicated that the main source of credit to the pomegranate growers was from Government banks, followed by PACS, Private Banks and traders. Majority (98%) used Private consultant for varietal information and majority (80%) consulted departmental officers for INM and IPM information. For market information, all the respondents consulted traders and TV. Majority of the farmers (60.0 %) sold the produce through Producer – distant market wholesaler channel followed by Producer - Exporter channel (23.3 %). Attack of bacterial blight disease was the main constraint faced by farmers (76.7), followed by water scarcity in summer (75.2). Lack of storage facility was the main constraint faced by traders (68.94) followed by lack of processing facilities (60.13). The study indicated that the crop has good commercial potential and the area under this crop is significantly increasing in the study area. Hence, Government should plan for establishing new processing units, provide scientific storage facilities and forward linkage in the region to safeguard the interest of pomegranate growers.

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## A Study on Buying Behaviour of Fungicide Brands used by Farmers in Management of Late Blight Disease of Tomato in Kolar District

RAMESHA, B. S.

THE application of fungicides in tomato cultivation has been increasing alarmingly in the recent past. In the light of changing consumer's behavior, the present study was initiated with specific objectives to study the awareness level of farmers about fungicides brands, analyze the factors influencing buying behavior and to estimate the market share of different brands. The data collected from 90 tomato growers and 30 retailers of Agri inputs were analyzed using different statistical tools. The study revealed that about 2/3 of the farmers were aware of more than six fungicide brands. The information about fungicide was sourced from the retailers, outdoor advertisement and fellow farmers. Around 3/4 of the farmers sprayed fungicide as a precautionary measure for late blight. Cent percent of the farmers were aware of the brands of Syngenta, Bayer Crop Science, DuPont and BASF companies. Factors influencing farmers buying behavior of fungicide brands are retailer recommendation, immediate control of disease, brand popularity, price and timely availability of fungicides. Different brands of Syngenta company commands around 40 per cent of market share in fungicides. Kolar district being the major tomato growing area and farmers have well informed. All companies should target this geographical segment particularly when launching the new brands.

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## An Analysis of Processing and Marketing of Coffee in Chikamagalur District of Karnataka

CHETHAN, A. J

COFFEE is one of the most important non-alcoholic beverages of the world. Coffee is the world's second largest traded commodity after petroleum and its products. The main objectives of the study are to analyze the procurement management, processing methods and processing cost and marketing management followed by coffee processing units. The study was conducted in Chikamagalur, Moodigere, Tarikere, Koppa, Sringeri and NR pura taluks of Chikamagulur district of Karnataka. The primary data was collected from 32 coffee processing units from three categories of small, medium and large processing units based on their installed capacities. The data was subjected to tabular analysis, descriptive statistics and profitability analysis. The coffee processing units procured coffee through two channels viz., directly from planters and from the commission agents. The processing units procured more than 60 per cent of the coffee through commission agents. The procurement of coffee was maximum in the months of November to March as it coincided with the peak harvesting season of coffee. The average cost of carrying inventory per tonne was found to be Rs. 3570. The average variable cost incurred in processing of one tonne of coffee was found to be Rs. 1, 22,154, out of which the cost of raw material was found to be the highest. The coffee processing units followed two channels for marketing of the processed coffee beans viz., Channel I: Processor – Wholesaler – Consumer and Channel II: Processor – Agent – Distributor – Exporter. On an average 60.25 per cent of coffee was marketed through Channel II.

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## A Study on Participation of Women in Retailing of Traditional Flowers in Chickballapura and Bengaluru City

AVINASH

KARNATAKA ranks second in the production of loose/traditional flowers comprising of flower types like roses, crossandra, chrysanthemum, marigold, jasmine, tuberose bachelor's button and aster which are harvested with short stalk. Women play an important role in retailing of traditional flowers in the form of garlands or flower strings. The specific objectives of the study were to analyze factors influencing women to take up retail marketing of flowers and livelihood dependence of women on flower retailing. A total of 100 women flower retailers were selected from Chikkaballapura and Bengaluru city. Majority of respondents (51.11 %) spent 10-13 hours in Chikkaballapura, while in Bengaluru city (45.45 %), 8-10 hours were spent daily. A total of 17 variables were bunched on four factors, namely Suitability, Income, Family need and Livelihood with a total Eigen value of 11.56. The sources of household income from flower retailing comprised 76 per cent in Chikkaballapura and 61 per cent in Bengaluru. Fluctuations in flower Prices was the major constraint faced by retailers in both markets, lack of regular customers was the second most important constraint in Chikkaballapura, while, too much time in flower dispensing was the second most important constraint in Bengaluru city. The study has indicated that price fluctuation is the major constraint faced by retailers which supports the need for price analysis and forecasting of prices on a regular basis for streamlining flower supply.

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## A Study of Production and Marketing of Coorg Mandarins in Coorg district of Karnataka

LIKIN BOPANNA, K.

MANDARINS are one of the most important commercially grown fruits and are second among the most widely produced fruits in the world after banana. The main objectives of the study are to analyze the area and production, cost and returns, marketing channels and constraints of Coorg mandarin production. The study was conducted in Madikeri, Somwarpet and Virajpettaluks in Coorg district of Karnataka. The primary data was collected from 40 growers each from three categories of growers, viz., small growers, medium growers and large growers totalling to 120 growers.The data was subjected to tabular analysis, compound growth rate analysis,estimation of cost and returnsandGarrett's ranking. Growth rate of Coorg mandarins was 3.13 per cent and 2.8 per cent in areaand 8.18 per cent and8.15 per cent for productionbetween 2000-01 and 2013-14 in Coorg district and Karnataka, respectively. The overall establishment cost and overall annual cost was ¹ .1,41,013/- and ¹ . 62,065/-, respectively. The average gross income and net returns was ¹ . 1,56,476/- and ¹ . 94,411/-, respectively.Producer – Processing industry – Wholesaler - Retailer – Consumerchannel was the most preferred channel with the highest quantity being marketed through it. The major marketing cost was packaging material among the different marketing channels.The study indicated that high incidence of pest and disease and fluctuation of market prices were the major constraints which supports the need for price analysis and forecasting of prices by the Government on a regular basis to safeguard the interests of the growers.

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## Collection and Marketing of Soapnut – A Study in Tumkur District of Karnataka

PARAMESH, S.

*Acacia concinna* has been used traditionally for hair care in the Indian sub-continent since ancient times. It is one of the ayurvedic medicinal plants. The fruit is known in India as shikakai. The *shikakai* fruits are having good market, which fetch good prices. The specific objectives of the study were to *analyze the source-wise income of soapnut farmers, marketing channels of soapnut and constraints faced by farmers in collection and marketing of soapnut.* The data / information for the study regarding soapnut collection and marketing were collected from 80 farmers from Koratagere taluk; and 20 traders operating in Tumkur APMC. Majority (64 %) of the soapnut farmers were found to be marginal farmers. The average annual household income of soapnut farmers was found to be Rs. 20,891/- and the main source of income to the soapnut farmers was from agriculture which accounted for 37.38 per cent of the total income followed by soapnut collection (33.18 %). Majority (50 %) of the soapnut farmers marketed soapnut through channel II (Farmer – Commission agent – Trader – Processing unit) followed by channel III (Farmer – Trader – Processing unit) which was used by 35 per cent of the farmers. The price fluctuation was the major constraint faced by farmers while scarcity of labour was the major constraint faced by soapnut traders. The study recommends that instead of selling the soapnut as such, the farmers may process it into powder and sell so that they can realize better prices.

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## Consumer Preference for Braned Edible oil: A Study in Bengaluru Urban and Rural Districts

DIVYA, M.

EDIBLE oils constitute an important component of food expenditureand the major source of energy for human beings. The changing consumer behaviour, entry of corporate companies and government regulations facilitated popularity of branded edible oil in the recent past. In this context, the study made an attempt to analyze the consumer preference and purchase behaviour for various types of branded edible oil, factors influencing the consumer's decision making process and consumer brand loyalty towards branded edible oil. A sample of 45 respondents each from Bengaluru urban and rural districts were selected for the study. The study revealed that sunflower oil is the most preferred oil in urban and rural areas with 88.89 per cent and 64.44 per cent respectively. Groundnut oil is the second most preferred edible oil in both urban and rural areas. However, more number of consumers (28.89 %) preferred groundnut oil in rural areas compared to urban areas (13.33 %). Cent per cent of the consumers in urban area and 93 per cent in rural area preferred branded edible oil. Quality, cholesterol content and price were the major factors considered by the urban consumers while price, quality and packing were considered by the rural consumers while purchasing edible oil. Brand loyal consumers constitute 55 and 62 per cent in urban and rural areas respectively. In urban area switching loyalty of the brand is frequent compared to rural areas. Increasing health awareness and effective implementation of food laws will expand the market for branded edible oils in future.

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## Supply Chain Management of Bio-Products –A Case Study of Criyagen Agri and Bio-Tech Pvt. Ltd.

VINAY KUMAR, P.

BIO-PRODUCTS are produced organically with some component of biological or renewable materials and harmless to the environment. Bio-products may be growth promoters, pesticides, fertilizers, fungicides, bio-stimulators, etc. In this study,the supply chain management of bio-products of Criyagen Agri and Bio-tech Pvt. Ltd. in two districts of Karnataka, namely,Belagavi and Davanagere was analyzed. The study focused on the socio-economic profile of farmers using bio-products;factors influencing the farmers' preferences for bio-products; management aspects in supply chain of bio-products; and strategies and constraints in marketing of bio-products of the company. The primary data was collected from farmers using Criyagen's bio-products; 50 each from Belagavi and Davanagere districts resulting in a total sample size of 100 farmers. Quality was the major factor which influenced farmers' preference for bio-products of the company. For majority (28.34 %) of the farmers, improving soil health was the major reason for using bio-products of Criyagen followed by reasons such as higher yield (22.99 %), crop development (22.46 %), as an organic input (17.11 %) and popularity of the company's products (9.09 %).Technical guidance by the company was the major strategy used by the company for marketing of bio-products of the company. No discount / offer was the major constraint faced by farmers in purchase of Criyagen products. Among the various constraints, the powdery form of the product was the major constraint faced by retailers / dealers in marketing of Criyagen products.

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## Consumer's Preference For Mushrooms in Bengaluru City

KAVYASHREE, M. G.

THE present study made an attempt to analyse the profile of mushroom consumers; factors influencing the purchase of mushrooms; and sourcing and retailing of mushrooms by retailers in Bengaluru city. A sample of 100 consumers and 20 retailers were drawn for the study resulting in a total sample of 120. The primary data was collected from both consumers and retailers using a pre-tested structured schedule and the same was analysed using Measures of Central Tendency. Majority (52 %) of the consumers belonged to the age group of 21-25 years. The families of majority (88 %) of the respondents were nuclear in nature and with respect to food habit, majority (90 %) of the respondents were found to be non-vegetarians. With regard to factors influencing the purchase of mushrooms by sample consumers, deliciousness was the most important factor for majority (84 %) of the respondents. With regard to the place of consumption of mushrooms, majority (66 %) of the sample respondents consumed both at home and outside (restaurants). Button mushrooms were mainly used to prepare mushroom manchurian as opined by majority (84 %) of the respondents. The average quantity of button and oyster mushrooms procured per day by the sample retail outlets was 2.83 kgs and 2.40 kgs respectively. In the case of button mushrooms, majority (60 %) of the retailers procured from HOPCOMS. With regard to the disposal of unsold button mushrooms, majority (80 %) of the retailers preferred to dump them.

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## Eco-Tourism as a Viable and Supplementary Off-farm Activity - A Case Study of Wayanad District

RAKESH G. NAIR

Eco-tourism is recognized as an important strategy to enhance farm income througg diversification of farming activities. The main aim of this research is to examine the viability of eco-tourism as an off-farm activity in Wayanad district. It also addressed the impact of eco-tourism ventures on plantation crops and gender issues in the management of eco-tourism ventures. A sample of 42 planters engaged in eco-tourism ventures, 60 eco-tourism employees and 60 tourists was taken from three tehsils of Wayanad district using simple random sampling method. The results revealed that eco-tourism ventures is a profitable business and has a bright future for improving the economic status of planter's community. On the basis of net present value, payback period, B:G ratio and IRR, investment m eco-tounsm ventures has been found profitable in all venture-sizes, it being most profitable on large ventures, followed by medium and small ventures.The eco-tourism activities on the farm had a medium impact on plantation crops and gender issues are positively associated with the management of eco-tourism ventures. There was a significant difference in age ($t=2.36$, $p<0.05$) education ($t=2.40$, $p<0.05$) and average household income ($t=2.54$, $p<0.05$) of male and female employees working ineco-tourism ventures. Chi-square test showed a significant difference ($X^2=42.33$)) in the nature of job performed by male and female employees. The average monthly salary of male employees was Rs.14,695/- and of female employees was Rs.11,378/-.Hence, to boost eco-tourism activities the government may facilitate credit facilities to Planters who are engaged-in eco-tourism business.

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## A Study on Soldiering Process among the Technical Personnel of UAS, Bangalore

PRIYANKA, K. T.

THE term soldiering coined by Frederick W. Taylor which means workers systematically collaborating to work below capacity. Taylor's concept of soldiering is used to study the level of soldiering and factors related with soldiering among the technical personnel of UAS Bangalore. This study was taken up with the objectives to analyse the level of soldiering, factors related to soldiering and to find the suggestions to overcome the soldiering among the technical personnel of UAS, Bangalore. The soldiering was analysed in three levels like *viz.* high level, medium level and low level soldiering. Self-awareness, defining quality and productivity, organizational climate, management style, working hours and situation, competency in task, financial incentives, leadership and factors influencing counterproductive work behavior were considered as soldiering dimensions along with the factors *viz.* age, gender, education and experience of technical personnel. Medium level of soldiering was observed among the technical personnel of UAS, Bangalore. 60 per cent of Assistant Professors and Associate Professors and 53.33 per cent of Professors were under medium level of soldiering. Results of simple regression analysis showed the negative impact between financial incentives with age and job experience of Assistant Professors and similar result was observed between leadership and age. Similarly negative impact was found between job experience and working hours and situation of Associate Professors. Whereas in case of Professors negative impact was observed between self-awareness and education. Suggestions regarding the security at work, working climate, recognition and rewarding, leadership, work distribution and responsibilities were mainly highlighted by the technical personnel.

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## A Study on Consumer Preference for Value Added Ragi Products in Karnataka Pvt. Ltd.

NAVYASHREE, N.

FINGER millet commonly known as ragi is important food crop in Karnataka. The major objectives of the study were to analyse the factors influencing the consumer preference, to document the range of value added ragi products available in the market with brand and to study the marketing strategy of value added products. Chi-square technique, Henry Garrett ranking technique were employed in the study. Thirty each of the consumers were selected from Bengaluru city, Mysuru city, H. D. Kote of Karnataka. It was found that 36 per cent of the consumers fall under the age group of 30 to 45 years. 53 per cent were males and 73 per cent of the consumers were married and with respect to the family type about 99 per cent of the family belonged to nuclear type. 39 per cent were graduates and among the respondents 44 per cent were software engineers. Nutrition of ragi is the major influencing factor which influences the consumers of ragi product with a score of 70.60 fallowed by health value with garret value 65.60. It was found that fifteen different value added ragi product were available in market. Corporate companies like Britannia and MTR are present in this category. Few of value added ragi products ragi dosa and idli mix, bread, flour etc., are available. Price discount was used as major pricing strategy for promotion of ragi products. The products promotion strategy were focused more on quality and healthiness of the product.

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## An Analysis of Production and Price Behaviour of Selected Oilseeds of India

RAKESH, M. S.

INDIA is the largest producer of oilseeds in the world and oilseed sector occupies an important position in the agriculture economy of India. India‘s oilseed and edible oil sector is being increasingly exposed to international markets and the influence of policy options like the minimum support price and other policies. This study is an attempt to analyze the production, pricing behavior and market co-integration of oilseeds in India. Bagalkot and Raichur market prices were considered for price behavior and Raichur, Gulbarga, Challakere and Chitradurga market prices for market co-integration. This study uses the, Descriptive statistics, Time Series model, and Vector Error Correction Model (VECM) and Granger causality test. The results show thatincrease in the production significantly over 1990-2014 with growth rate of 2.123 per cent per annum. The price behaviour of sunflower based on seasonal index revealed that the highest price during January and September to November and groundnut price will be higher during February, March, July and August in both markets. The price signals of groundnut markets are co-integrated with unidirectional feedback mechanism is showed by co-integration model was done and it showed independent influence of markets on Gulbarga and Raichur market prices and there is bidirectional influences of prices in Chitradurga and Challakere markets so there is instantaneous feedback mechanism in prices.

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## An Exploratory Study on E-purchasing Behaviour of Consumers towards Food, Groceries, Fruits and Vegetables in Bengaluru City

SHRUTHI, B. N.

E-PURCHASING is a form of electronic commerce which allows consumers to directly buy goods and services from a seller over the internet using a web browser. Nowadays online shopping is becoming more popular among consumers. The e-purchasing behavior of consumers towards food, groceries, fruits and vegetables was analysed based on data collected from 120 sample e-purchasers in four areas of Bengaluru city namely, Electronic city, Indiranagar, Sahakarnagar and Judicial layout. The results of study revealed that the source of awareness about e-purchasing for considerable percent of consumers was friends (39.17 %) and advertisement (38.33 %). The consumers' attributes for preference towards e-purchasing was analysed through Garett Ranking Method. 'long queues in billing counter' was ranked first with a score 58.12 followed by 'preferred supermarket is too far away' with 57.87 score and 'lack of adequate time to go shop' with the score 55.75. About 77 per cent of e-purchasers had a perception that they could place orders at convenient time. This was followed by the perception of reliability of delivery as expressed by 75.83 per cent of respondents. According to e-purchasers, the main advantage of e-purchasing was saving in time (71.67 %) and energy (59.17 %). The major disadvantages in e-purchasing were difficulty in returning faulty goods (66 %) and lack of touching and feeling the product (56 %). In this backdrop the study could be helpful to business managers for reorienting e-retailing business of food and other related articles.

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# AGRICULTURAL MICROBIOLOGY

## Effect of Biochar Application on Effectiveness of Mycorrhizal Symbiosis in *Leucaena Leucocephala* in an Alfisol

CHETANA, M. C.

A greenhouse investigation was conducted to determine the effect the quantity of biochar application on VAM symbiosis in *Leucaenaleucocephala* at two levels of nutrient amendment. There were 72 experimental units in this study arising from factorial combinations of 6 biochar levels, 2 nutrient levels and 2 VAM fungal inoculation levels with 3 replicates for each treatment. Application of either nutrients or biochar did not significantly influence the extent of VAM fungal colonization in roots of *Leucaena*. Phosphorus concentration shoot and root samples of plants grown in soil inoculated with *Glomusaggregatum* and supplied with 100 units of nutrients was highest at all levels of biochar amendment. In general, application of biochar did not influence plant phosphorus concentration irrespective of nutrient amendment. Inoculation of soil with *Glomusaggregatum* significantly increased biomass production by *Leucaena*. Marked reduction in dry weight of shoot and root as well as total biomass was noticed at biochar application level of 40 g/kg soil. The regression analysis of this data indicates that biochar application influences the phosphorus uptake and biomass production in *Leucaena* particularly when nutrients were applied. The results of this study illustrate the importance of optimizing the quantity of biochar as well as and nutrient application in order to derive maximum benefit from VAM symbiosis.

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## AGRICULTURAL STATISTICS

### Statistical Study of Long Term Fertilizer Experiments

CHANDANA, S.

LONG term field experiments provide a vehicle for scientific investigation of structural relationship that governs the variability of specified crop over a period of time. The experimental data on grain yield of maize (q / ha) and various soil characteristics for a period of 25 years laid out in four replicate RBDwith eleven treatments were procured. The study period data is split into three periods having eight years data in first two periods(1986-1994 and 1995-2002)and nine years data in the period three(2003-2011). Split plot and principal component analysis were carried out to know the effect of treatment on a grain yield over a period of time. Principal component analysis found to be more appropriate as year, treatment and interaction effect in split plot analysis was significant. The results of principal component analysis clearly showed that the variance explained by the first principal component is greater than 40 percent in all the treatment in all the three periods under study. The component scores were obtained by multiplying standardised values with an eigen vector. The two way table involving the index scores of the treatments in three replicates so obtained analysed as in randomised block design. The status of the soil nutrients were analysed using multiple linear regression analysis. The individual contribution of available N,P,K and its interactions were observed to have influence on the grain yield. Polynomial regression analysis to identify the response curves over a time indicated considerable variation in growth pattern in all fertilizer treatment for grain yield of maize.

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### Crop Modeling on area and Yield of Sugarcane in selected Districts of Karnataka

MADHUSHREE, C. S.

A modest attempt has been made to obtain model for the area and yield of sugarcane along with weather parameters for Mandya and Mysuru districts of Karnataka. For the present study secondary datafor a period of 18 years from 1994 to 2011 were utilized on area and yield of sugarcane. Information on weather parameters were used to assess the impact of climatic factors on the sugarcane yield. Various models such as linear and non-linear models were fitted on the data sets forboth area and yield of sugarcane. Among the models, cubic model based on$R^2$ was found to be suitable. The identified cubic model was further used in multiple regression model to study the impact of weather parameters on sugarcane yield. The study indicated that there was significant influence of weather parameters on yield of sugarcane. Maximum temperature and Minimum temperature had apositive significant influence on yield of sugarcane for both the districts. Relative humidity showed a negative significant impact on the yield of sugarcane in Mandya district whereas a non-significant influence was observed in Mysuru district. Rainfall had a non-significant influence for Mandya district as the major area under sugarcane cultivation was irrigated whereas a significant effect for Mysuru district was observed as most of the area comes under rainfed conditions.

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## Statistical Model for Forecasting Arrival and Price Behavior of Potato in Major Regular Markets of Karnataka

PRADEEP, M.

POTATO is the most important vegetable crop in the world used for human consumption. In order to study the arrival and price behavior of potato in major regulated markets of Karnataka, eleven years data (April, 2003 to May, 2014) on monthly arrivals and prices of potato at five regulated markets viz., Bangalore, Belgaum, Chikkaballapur, Hassan and Kolar were considered for the study. The findings reveal that the arrivals and prices of potato have registered significant increase in trend for all the markets. All the markets have shown seasonal pattern in their arrivals and the current month prices was influenced by the previous month price except Bangalore being a terminal market. ARIMA model $(0,1,0)\times(1,1,1)_{12}$ was found to be ideal among the different forecast models fitted. This model was used to forecast the prices of potato in all the above markets for a duration of seven months through a lagged series. ARCH and GARCH models for prices of potato indicated no volatility. The values at risk and instability index were computed due to the absence of volatility. These were found to be high for Chikkaballapur market and low for Belgaum market.

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## Assessment of Crop Area and Production of Major Crops of Sedam Taluk of Gulbarga using Remote Sensing and GIS

SHALINI, M. N.

REMOTE sensing is the art and science of making measurements of the earth using sensors on airplanes or satellites. These sensors collect data in the form of images and provide specialized capabilities for manipulating, analysing and visualizing those satellite images. Remote sensed imagery is integrated within a Geographic Information System (GIS). Several methods exist for remote sensing image classification. They include supervised and unsupervised approaches. In supervised classification, the classifier is trained to identify the classes using training data set where as in an unsupervised classification, the classifier itself develops the spectral classes. For statistical comparison of different image classification methods test imagery obtained through IRS (Indian Remote Sensing) P6 LISS-III on 22nd December, 2011 for Sedum Taluk of Gulbarga district of Karnataka statewere used. Maximum likelihood classification, Mahalanobis distance classification, Minimum distance to means classification under supervised classification approach were performed for the test imagery using ERDAS imagine 9.1 version software. Accuracy assessment was found important to evaluate the final output of remote sensing. Accuracy of the classification of each data set and their classifiers were expressed as an error matrix from which overall accuracy, users accuracy, producers accuracy, mapping accuracy, F-measures, Kappa coefficients and sample variance of Kappa coefficients were estimated. The test of significance of Kappa coefficients were performed using Z-test. Pairwise comparison of Kappa coefficients of different classification methods were performed. Maximum likelihood classification was found to be the best with highest overall accuracy of 93.38 per cent for Sedum Taluk, Gulbarga district of Karnataka.

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## Impact of Climate Change on Cashew Crop at Selected Locations of Karnataka - A Statistical Analysis

ANITHA, R.

THE weather data for the period 1992–2011 was consider to study the impact of climate change on cashew crop productivity at Puttur and Chintamani stations. The significant difference was noticed in the mean of two-decades with respect to rainfall and sunshine hours at Puttur, minimum and maximum temperature at Chintamani stations. Minimum temperature and number of rainy days shows declining trend and rainfall shows, increasing trend in both the stations.The number of rainy days found to be significant on yield in both flowering and overall period at Puttur and humidity(PM) and rainy days found to be significant in flowering and overall period at Chintamani. Regression model was fitted for the significant variablesto obtain the expected yield, maximum yield can be obtained when the maximum temperature is at 37ºC and number of rainy days is 12 in overall period.During flowering period, when sunshine hours is at 8 and number of rainy days is 10 at Puttur station. In chintamani location, the expected maximum yield can be obtained athumidity(AM) is 85 percent and the number of rainy days is 14 during overall period and during flowering period, when minimum temperature is 12ºC and humidity(AM) is 80 percent. 5.93 and 8.30 percent of variations in the mean yield was noticed for a given interval of climatic factors during overall and flowering period respectively at Puttur.In Chintamani, 11.10 and 11.4 percent variations in the mean yield was observed for a given climatic factors during overall and flowering period.

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## Statistical Analysis of Development Pattern in Karnataka

RAMESH

AN attempt has been made in the present study to quantify the socio-economic development of different districts of Karnataka State by constructing composite index for developmental indicators. Since the development is multi-dimensional and dynamic one where it is customary to construct composite index based on various socio-economic variables for the evaluation of socio-economic development. The districts wise data on the selected 28 developmental indicators was collected for 27 districts of Karnataka from the Directorate of Economics and Statistics (DES), GOK Bengaluru for two periods i.e., 2003 and 2013. The methodology developed by the Prem Narain, Rai S.C., Shanti Sarup (2007) was used to construct the composite index. Eight developmental indices were grouped based on 28 indicators for two periods 2002-03 and 2012-13. The results revealed that, the districts such as Bengaluru, Tumkur, Belgaum and Davanagere were found to be highly developed with respect to socio-economic development; whereas the districts such as Bidar, Chamrajnagar, Kolar and Koppal have remained at the lower position in terms of the development during both the periods. The significant difference in development between two periods was examined by Slippage test and it was found to be significantly different. Based on the values of the eight development index, nine districts of the Karnataka State (33%) fall under the group of developed category during 2013 in general. Further, five districts (18%) were fall under the highly developed category and backward category each during both periods. The regional imbalance was found to be high in industrial, transport and communication sector, whereas low in general and health sector.

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## AGRONOMY

### Influence of Organic Sources of Nutrients on Growth, Productivity and Quality of Baby Corn

KEERTHIRANI, D. S.

A field experiment was conducted at University of Agricultural Sciences, GKVK, Bengaluruduring *kharif,* 2014 to study the effect of organic sources of nutrients on growth, yield and quality of baby corn. The experiment was laid out in a RCBD with nine treatments replicated thrice. Application of poultry manure and enriched biodigested liquid manure (EBDLM) each at 75 kg N eq. $ha^{-1}$+panchagavya (3 %) at 15 and 45 days after sowing (DAS)+vermiwash at 30 DAS recorded significantly higher baby corn and green fodder yield (13.75 and 42.43 t $ha^{-1}$, respectively), which was on par with application of FYM at 10 t $ha^{-1}$ + 150:75:40 kg NPK $ha^{-1}$ (14.76 and 43.88 t $ha^{-1}$, respectively). This was mainly attributed to higher growth and yield parameters. The quality parameters *viz*., protein content, total soluble solids, fibre content and moisture content and the sensory attributes *viz*., appearance, aroma, taste, colour and over all acceptability of baby corn were also superior with the application of poultry manure or vermicompost and EBDLM each at 75 kg N eq. $ha^{-1}$ + panchagavya (3 %) at 15 and 45 DAS + vermiwash at 30 DAS as compared to control. Similar trend was also observed with the available NPK status in soil. The highest B:C ratio (4.54) was obtained with FYM 10 t $ha^{-1}$+150:75:40 kg NPK $ha^{-1}$ followed by poultry manure and EBDLM each at 75 kg N eq. $ha^{-1}$ + panchagavya (3 %) at 15 and 45 DAS + vermiwash at 30 DAS (4.34).

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### Growth, Productivity and Disease Incidence of Potato (*Solanum tuberosum* L.) as Influenced by Nitrogen, Potassium Levels and Micronutrients

IRFFAN, M. M.

A field experiment was conducted during Kharif 2014 at College of Agriculture, Hassan, University of Agricultural Sciences, Bengaluru to study the effect of different levels of nitrogen , potassium and micronutrients on growth, yield, quality, nutrient uptake and economics of potato in red sandy loam soil. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications and twelve treatment combinations . The investigation revealed that, 125 % recommended N and K + 0.5 % $ZnSO_4^*$ + 0.2 % Borax* @ 45 DAP recorded significantly higher plant height (68 cm), number of shoots (4.2 $plant^{-1}$), number of leaves (88 $plant^{-1}$), total dry matter production (65 g $plant^{-1}$) and late blight incidence and severity recorded (9 %) 75 DAP and tuber weight (279.5 g $plant^{-1}$), number of tubers (4.9 $plant^{-1}$), tuber yield (23.3 t $ha^{-1}$), protein content (13.9 %) and nutrient uptake (104.7, 36.4 and 103.7 kg N, $P_2O_5$ and $K_2O$ $ha^{-1}$) at harvest. However, it was on par with 75 % recommended N and K + 0.5 % $ZnSO_4^*$ + 0.2 % Borax* @ 45 DAP. Higher net returns ($^1$ .156049 $ha^{-1}$) and B:C ratio (3.4) was recorded in 75 % recommended N and K + 0.5 % $ZnSO_4^*$ + 0.2 % Borax* @ 45 DAP.

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## Use of Jeevamrutha and Farm Yard Manure on Growth and Yield of Fieldbean (*Lablba purpureus var. lignosus*)

SIDDAPPA

A field experiment was conducted at organic farming block of UAS, GKVK, Bengaluru, during *kharif* 2014 to study the effect of jeevamrutha and farm yard manure (FYM) application on growth and yield of fieldbean. The experiment was laid out in a RCBD with three replications of two factors at different levels. The treatment combination include three FYM levels (100%, 150% and 200% N equivalents through FYM) and four jeevamrutha levels (0, 500, 1000 l $ha^{-1}$ and 1500 l $ha^{-1}$). Application of FYM at 200 % N equivalent recorded significantly higher grain yield (1136 kg $ha^{-1}$) an increase of 16.7 % compared to FYM at 100 % N equivalent (946 kg $ha^{-1}$). Similarly application of jeevamrutha at 1500 l $ha^{-1}$ recorded significantly higher grain yield (1246 kg $ha^{-1}$) an increase of 35.1 % compared to without jeevamrutha application (808 kg $ha^{-1}$). These treatments also showed similar trend with respect to growth and yield parameters and also nutrient concentration in plants (nitrogen, phosphorus and potassium). There was significant improvement in soil nutrient status (available N, $P_2O_5$ and $K_2O$) and soil microbial load (bacteria, fungi, actinomycetes, phosphate solubilizer and N-fixer) as FYM and jeevamrutha levels increases after harvest of the crop. Higher B:C ratio (1.99) was realized with FYM at 200 % N equivalent + jeevamrutha at 1500 L $ha^{-1}$ followed by 150 % N equivalent through FYM + jeevamrutha at 1500 l $ha^{-1}$ (1.91).

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## Effect of Farmyard Manure and Biodigester Liquid Manure on Growth and Yield of Irrigated Sunflower (*Helianthus annuus* L.)

PRADEEPA PATEEL, G.

A field experiment was conducted at the Agricultural Research Station, Kathalagere (Davanagere District, Karnataka) during *rabi*, 2010 to study the effect of FYM and biodigester liquid manure (BDLM) on growth and yield of irrigated sunflower and soil nutrient status after harvest of the crop. The experiment consisted of 14 treatments involving combination of different levels of FYM (5.0, 7.5 and 10.0 t $ha^{-1}$) and BDLM equivalent to 40, 60, 80 and 100 kg N $ha^{-1}$ along with recommended FYM + recommended dose of fertilizers (RDF) and RDF alone. The experiment was laid out in randomized completely block design with three replications. The application of FYM at 10 t + BDLM equivalent to 100 kg N $ha^{-1}$ recorded significantly higher achene yield of sunflower (2333 kg $ha^{-1}$), oil content (39.37 %), oil yield (918.57 kg $ha^{-1}$), uptake of N, P, K by sunflower (118.52, 23.84 and 111.84 kg $ha^{-1}$, respectively), net returns (` 42829 $ha^{-1}$) and B:C ratio (3.40) than application of RDF alone (1108 kg $ha^{-1}$ achene yield, 31.44 % oil content, 348.4 kg $ha^{-1}$ oil yield, uptake of 56.77 kg N, 6.78 kg P and 45.49 kg K $ha^{-1}$, 18701 $ha^{-1}$ net returns with B:C ratio of 2.85), but was on par with application of FYM at 7.5 t + BDLM equivalent to 100 kg N $ha^{-1}$ and FYM at 7.5 t $ha^{-1}$ + RDF. Availability of N, P and K in the soil after harvest of sunflower was lower with the application of RDF alone. Significantly higher soil bacterial, fungal and actinomycetes population were observed with application of FYM at 10 t + BDLM equivalent to 100 kg N $ha^{-1}$ than with application of RDF alone.

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## CROP PHYSIOLOGY

### Evaluation of Diverse Pigeonpea (*Cajanus Cajan* Mill Sp.) Germplasm Lines for High Phosphorus Uptake through Acid Phosphatase Activity

MANIKANTA, S.

PLANTS have developed several adaptive mechanisms to enhance the availability and uptake of P in response to P deficiency. Increasing the synthesis and activity of acid phosphatase is one of the important mechanisms known to play a vital role in aiding plants to acquire more P under P deficient conditions. Therefore identifying genotypes efficient in P uptake by the virtue of high acid phosphatase activity under low P supply would be an ideal approach to improve crop productivity. Keeping this in view, one hundred and twenty germplasm-lines of pigeonpea were grown under normal conditions, from them fifteen contrasting lines were selected based on acid phosphatase (APase) activity. Further, these selected lines were regrown and APase activity was reconfirmed under similar conditions. The consistency of the genotypes was examined by correlating the APase activity of first and second experiment and only four consistant contrasting lines were selected. Two more germplasm-lines identified earlier were included for further investigation. It was observed that selected germplasm-lines like GCPB O6, ICP 3226 and KP 9655 produced more root volume, root length, root dry weight, root-shoot ratio, rhizosphere APase activity, root APase activity and high P solubalization under deficient and organic P conditions. Hence these germplasm-lines were identified as P efficient germplam-lines suitable to be grown in low P soils. Genes encoding purple acid phosphatases were found to be highly expressed under P deficient conditions, confirming the role of Apase in acquiring P under deficient conditions.

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## FOOD SCIENCE AND NUTRITION

### Development of Shelf Stable Fermented Vegetable Products

DEEPA, L.

SAUERKRAUT is a traditional fermented vegetable food made from cut and salted cabbage. In the present study sauerkraut like fermented products using indigenous vegetables like Bitter gourd (BGS), Drumstick leaves (DLS),Chakramuni leaves (CLS) and Gogu leaves (GLS) were developed. Control sauerkraut was standardized with 100% cabbage. Experimental sauerkrauts were standardized using vegetables in different proportions (5%, 25% and 50%) with cabbage. Among the variations, sauerkraut with 75% cabbage +25% vegetable combination was selected for further study. Scores for the developed fermented products were in the range of "liked slightly to liked moderately". Two sauerkraut samples (DLS and BGS) were incorporated in fillings and were accepted up to 50% for chapathi rolls and up to 25% for stuffed breads. Colour of all combinations of sauerkrauts ranged with the hue of yellow, yield ranged between 2.81 to 2.93 per cent and toughness ranged from 44.65 to 45.60. Nutritional analysis of sauerkraut combinations showed that CLS had higher content of protein (1.85g/100g), fat (1.02g/100g) and energy (36.03 Kcal/100g). Total ash and crude fibre were found higher in DLS. The calcium, iron and zinc composition of sauerkraut ranged from 30.90 to 102.00mg/100g, 0.93 to 1.12mg/100 g and 0.28 to 0.39mg/100g per gram respectively. Vitamin C and vitamin $B_{12}$ were found higher in CLS and BGS respectively. Storage study results revealed that the developed fermented products can be successfully stored for twenty one days at room temperature. Thus, shelf- stable as well as acceptable value added products can be developed from vegetables by fermentation.

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## Health and Nutritional Status of Male Industrial Workers in Bangalore City

HARISH, N.

NON Communicable Diseases (NCD's) are emerging as the leading causes of death in the country affecting productivity.Hence the present study on "Health and Nutritional status of male industrial workers in Bangalore city" was conducted in the year 2012-13 in Bharath Heavy Electronics Limited (BHEL), Bangalore. The study covered 100 male industrial workers comprising 32 sedentary, 32 moderate and 36 heavy industrial workers. Information on socio-economic background, food habits, food consumption pattern, dietary intake, anthropometric measurements, incidence of NCD's and knowledge, attitude and practice of food consumption was recorded. Present study revealed that, majority of the subjects was in the age group 25-50 years. Cent per cent of the heavy workers consumed four meals per day, 91.7 per cent of heavy workers were non vegetarians, the mean height of the workers was 165-170 cm and mean weight ranges from 67- 71.1kg in sedentary workers.Overall, 56 per centof the workers were overweight. Among that, 65 per cent were moderate workers and 50 per cent were sedentary workers. Blood sugar level revealed that 43.75 per cent of sedentary and 31.25 per cent of moderate workers were diabetic.Forty eight per cent of the workers belonged to stage-1 hypertension of which 50 per centwere sedentary workers. Based on the results, it could be inferred that 65 per cent of the workers had poor knowledge. Hence, more care need to be taken to manage the diabetes and hypertension through education, diet and healthy lifestyle to improve the productivity of the employees.

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## FORESTRY AND ENVIRONMENTAL SCIENCES

## Biodegradation of *Calophyllum inophyllum* Fruit Husk

HEMANTH, N.

AN experiment was conducted to study the Biodegradation of *Calophyllum inophullum* fruit husk with de-oiled cake as a source of N and Di-Ammonium Phosphate as a source of P with and without microbial consortium consisting of mixture of *Trichoderma viridae, Phanaerochyte crysosporium* and *Trichurus spiralis* under the laboratory conditions. The fruit husk was subjected to decomposition for a period of 90 days in plastic containers of capacity five kgs. The initial CN ratio of fruit husk was 64:1 which has reduced to 16:1 and contained N (2.40%), P (0.84%) and K (1.76%) in the treatment with Calophyllum fruit husk + de-oiled cake + microbial consortium + DAP satisfying the degree of compost maturity, NPK content and C: N ratio. The treatment with Calophyllum fruit husk + de-oiled cake + microbial consortium recorded significantly higher loss in weight of the substrate. The effect of enriched bio-compost thus obtained after 90 days of decomposition was tested on maize crop under green house conditions. It was found to have enhanced growth parameters in terms of total height of the plant, number of leaves and total biomass on maize crop in the treatment Calophyllum fruit husk + de-oiled cake + microbial consortium + DAP and was also on par with the treatment with Calophyllum fruit husk + de-oiled cake + microbial consortium indicating, that in the presence of oil cake as a source of N, microbial consortium can bring about faster decomposition of Calophyllum fruit husk and also can influence the plant growth.

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## Biogas Production Potential of Deoiled Cakes of Neem (*Azadirachta indica*) and Pongamia (*Pongamia pinnata*)

PRIYANKA PRASAD

THIS study presents summary of results obtained in the anaerobic digestion of neem and pongamia oil cakes with different proportions of cow dung. The study revealed that pH of cow dung slurry in the beginning was 7.8, neem cake slurry 5.0 and pongamia cake 5.8, suggesting significant differences in pH among the bio-gas substrates used. Two months after anaerobic digestion, there was an increase in pH with increase in proportion of cow dung. However, there were no changes in EC in experiment. There was an increase in total-N and P in biogas spent slurry after anaerobic digestion. There was no definite trend with reference to total-K. There was decrease in organic matter content at the end of experiment in biogas slurry. The volatile solids also decreased in biogas substrates from the start of experiment to the end of anaerobic digestion. There was decrease in C: N at the end of the experiment. Significantly, very low C/N ratio was recorded in treatments 4:1 cowdung: neem cake and 1:1 cowdung: pongamia cake (3.24) at the end of 60 days. There was decrease in COD and volatile fatty acids at the end. The cumulative biogas for nine weeks was significant only cow dung (T1) (15755 cc) followed by 4:1 cow dung: neem cake (T7). This suggests, that oil cakes can serve as good feed stocks for biogas production.

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# GENETICS AND PLANT BREEDING

## Identification of Potential Restorers for Development of Heterotic Rice Hybrids (*Oryza sativa* L.)

MADHURI, R.

DEVELOPING high yielding heterotic hybrids, the first step is to identify restorers that can efficiently restore the fertility of $F_1$s. Hence, the present investigation was carried out at the Zonal Agricultural Research Station, V. C. Farm, Mandya during *kharif* 2014 to identify potential restorers in order to develop new heterotic hybrids. Among 100 parental lines evaluated, 87 were identified as restorers and 13 as partial restorers. Seven testers and ten CMS lines were crossed in line×tester design to produce seventy hybrids. The seven testers were validated with four SSR markers *viz.*, RM1, RM6100, RM6344 and RM1108, linked to fertility restoration which showed positive association with pheno typic fertility restoration based on pollen fertility and spikelet fertility of the hybrids. All the testers except MSN71 and MSN15-16 were identified as effective restorers for all ten CMS lines.The predominance of non-additive gene action for all the characters studied was noticed from the ratio of GCA to SCA variance. The variation in the performance of hybrids was by and large due to the lines for most of the traits followed by interaction effect of line×testers. The lines CMS1A,CMS2A,CMS4A, CMS5A and CMS9A and five testers *viz.*,MSN-36, KMR-3, PBK093-1-4-4-2-1, PBK095-5-4-5-1and PBK091-3-7-1-1 were identified as good general combiners as they recorded high (H) overall *gca* status. Among the hybrids CMS1A×KMR-3 and CMS9A×PBK091-3-7-1-1 were best specific combiners. Most of the hybrids which involved KMR-3 and PBK091-3-7-1-1aste sters exhibited significant heterosis over standard checks for seed yield.

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## Line × Tester Analysis for Fruit Yield and Late Blight Resistance in Tomato (*Solanum* spp.)

MOHAMMED HUSSEIN NOOR

AN investigation was carried out to study the combining ability, heterosis and reaction to late blight disease in tomato. The experiments were conducted to evaluate 27 and 50 hybrids (5 lines with 10 testers in L x T mating design) during *rabi* 2014 and summer 2015 respectivelyin RCBD with two replications. The analysis of variance in both experiments revealed significant differences among the genotypes tested for all the traits.Among the lines, EC 771594, EC 77160, EC 771585 and testerLA 2138-A, EC 676790 were identified as good general combiners for most of the traits studied. Among the hybrids Arka Meghali x LA 0475, EC 771594 x CLN 13149**,** EC771585 x LA0475 and EC 771594 x LA 2138-A recorded higher *per se* performance and SCA for most of yield, yield attributes with late blight disease resistance during summer 2015. The GCA to SCA variance ratio being less than unity for all the characters studiedrevealed predominance of non-additive components of variance which is always favorable for heterosis breeding for improvement of thesetraits. Present study identified late blight resistant good combiners ArkaMeghali x LA 0475, EC 771594 x CLN 13149, EC771585 x LA0475and EC 771594 x LA 2138-A which provide good scope for commercial exploitation of heterosis in Tomato.

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## SSR Marker Assay-Based Polymorphism among the Dolichos Bean (*Lablab purpureus* L.) Germplasm Accessions Differing in Photoperiod-Induced Sensitivity to Flowering Time

LAXMI KAMAGONDA

PHOTOPERIOD is one of the important environmental factors that influence productivity and adaptation of dolichos bean through its effect on days to flowering. Thirty six dolichos bean germplasm accessions were characterized for photoperiod-induced sensitivity to flowering time (PSFT)and were assayed using SSR markers during 2014 at Department of Genetics and Plant Breeding (GPB), University of Agricultural Sciences (UAS), Bengaluru. The germplasm accessions differed for their degree of PSFT which varied from 0.63 to 1.00 depending on the extent of delay in flowering during long days compared to that in short days. The accessions were classified as photoperiod sensitive (>22 days delay in flowering), moderately photoperiod sensitive (9-22 days delay in flowering) and photoperiod insensitive (up to 8 days delay in flowering).The degree of PSFT was independent of growth habit, pod and seed traits. Twenty-three of 33 SSR markers among the 36 accessions were found polymorphic. The number of alleles per SSR locus varied from 1 to 3 with an average of 2.1 alleles. The estimates of Polymorphic information content (PIC) ranged from 0.00 to 0.62 with an average of 0.24 among germplasm accessions. The three pairs of germplasm accessions such as GL 385 and GL 576, GL 385 and GL 506 and GL 382 and GL 576 were not only contrasting for PSFT but also polymorphic to most number (7-10) of SSR markers. It is suggested to use these pairs of germplasm accessions as putative parents for developing populations for SSR marker-assisted mapping genomic regions controlling PSFT in dolichos bean

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## HORTICULTURE

### Effect of Integrated Nutrient Management on Growth, Yield and Quality of Tomato (*Solanum lycopersicum* L.) var. Arka Rakshak

SIDDALING P. NAGONI

AN investigation on the effect of Integrated Nutrient Management on tomato (*Solanumlycopersicum*L.) var. ArkaRakshak was carried out during 2013-14 at Precision Farming Development Centre (PFDC), Department of Horticulture, University of Agricultural Sciences, Gandhi KrishiViganana Kendra, Bengaluru. The study consisting of 15 treatments with and without biofertil-izers along with Recommended Dose of Nutrient (RDF 250 kg each of NPK $ha^{-1}$) with 3 replications was laid out in RCBD.The growth parameters *viz.,* plant height (114.40, 118.30 and 125.20 cm) and number of branches (12.20, 15.20 and 18.30) was highest in combined application of 75 per cent RDF + *Azotobacter*+ Phosphorus Solubilizing Bacterium + VAM ($T_{15}$) at 45, 90 and 135 days after transplanting respectively. The yield, economics and quality characters *viz.,* fruit weight (70 g), number of fruits per plant (80), fruit yield per plant and fruit yield $ha^{-1}$ (7.56 kg and 134.39 t $ha^{-1}$ ) benefit : cost ratio (1:2.36), firmness of fruit (3.93 $kg/cm^2$), TSS (4.85 $^0$B), ascorbic acid (15.68 mg/100 g), lycopene content (6.51 mg/100 g) and shelf life (19.60 days at 1% polyethen cover ) were maximum with the same treatment combination ($T_{15}$). All the growth, yield and quality characters were lowest in the treatment $T_1$ i.e. RDF (250 kg each of NPK $ha^{-1}$). By the study it can be concluded that the Integrated approach with both inorganic and bio-fertilizers is economically viable with regard to growth, yield, and quality of tomato compared to application of RDF alone.

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## PLANT BIOTECNOLOGY

### Quantification of Iron and Zinc in Brown, White and Cooked White Rice (*Oryza sativa* L.) in Elite Accessions and SNPs Associated with Transporters

SAURABH PANDEY

IRON and Zinc are the key ingredient in crop management and human nutrition. Rice is the major dietary source for the population in India but it is deficient in iron and zinc.An effort was made to quantify the iron and zinc content in brown, white and cooked white rice and to study the effect of nucleotide variations in genes associated with zinc. 14 genotypes were selected and grown in field at UAS, GKVK inRCBD, during *Kharif*-2014. PCV and GCV were highest for number of tillers and productive tillers, grain yield per plant, kernel length before cooking and elongation ratio.Quality parameterlike zinc in brown rice showed negative effect on yield. Highly positively significant correlation was observed for grain yield with number of productive tillers. Literature survey revealed genes belonging to transporter family *OsZIP*are involved in transporting zinc.Primers were designed specific to thesegenes. The primer profile at gel level were monomorphic for all the primers. Sequencing the amplicons of primersOsZIP2-1 and OsZIP7-2 revealed that variations were present in all these amplicons but nucleotide changes at ninthposition of OsZIP2-1 were significantly associated with brown ricezinc content.Nucleotide changes at 25, 40 and 551 positions of OsZIP7-2 were significantly associated with grain iron content. Although OsZIP2-1 and OsZIP7-2 were monomorphic at gel levelnucleotide variations were significantly associated with grain iron and zinc content. The markers identified in this study can be used for improving the grain iron and zinc in rice.

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## Screening of Sweet Sorghum (*Sorghum bicolor* L.) Genotypes for Higher Ethanol Production

SADASHIVA D. CHIKKALAKI

DUE to the increasing price and depletion of fossil fuels there a necessity to find an alternative source of fuel. Sweet sorghum (*Sorghum bicolor* (L.) Moench) which is similar to grain sorghum with sugar-rich stalks and a water-use efficient crop has a very good potential as an alternative feed stock for ethanol. Production cost of cultivation of sweet sorghum is 3 times lower than sugarcane. Similar to sugarcane, sweet sorghum juice extracted from stalks is high in sugars that are readily fermentable. In the present study fifteen sweet sorghum genotypes were screened for higher ethanol production. Genomic DNA was isolated using CTAB (2 %) method from young leaves. These genotypes were analysed for genetic diversity using SSR markers. SSR markers have particular importance because of their abundant distribution, highly polymorphic, reliable, and co-dominance nature. Matured plants juice was extracted from the stalk of the plants, RSSV 138 and URJA genotypes showed highest total sugar concentration of 14.78 % and 14.39 % respectively. The juice was fermented using *Saccharomyces cerevisiae* among which RSSV 138 and CSH 22SS genotypes showed highest ethanol yield of 13.25 g/l and 13.01 g/l respectively. From this study the sweet sorghum genotypes having high sugar concentration were identified and can be used for bioethanol production.

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## Development of Gene Based Markers for the Functional Genes Located in Fusarium wilt Resistance Locus in Chickpea (*Cicer arietinum* L.)

SUNIL SUBRAMANYA, A. E.

*Fusarium* wilt is an important biotic stress limiting the productivity of chickpea worldwide. The present investigation explored available genomic resources from NCBI and transcriptome data from CTDB and identified the relative positions of $A07C_{417}$ and TS-72 linked to *Fusarium* wilt resistance. These two markers were separated by a distance of 1559.353 kb on chromosome Ca4, flanking a total number of 100 genes. The prediction of microsatellites in the identified QTL region revealed 57 per cent of genes contains SSRs. Among these repeat motifs, mono-nucleotide repeats were found in highest frequency followed by di-, tri, penta- and tetra-nucleotide repeats. Among the 13 SSR primers synthesized, UASBC-4 and UASBC-6 showed polymorphism between susceptible parent JG-62 and resistant parent WR-315. The joint segregation analysis of UASBC-4 and UASBC-6 with wilt reaction using 61 $F_{12}$ RILs (JG-62 X WR-315) showed significant deviation from digenic inheritance ratio of 1:1:1:1 indicating linkage between UASBC-4 and UASBC-6 with wilt resistance and also among themselves. The single marker analysis confirmed the association of UASBC-4 and UASBC-6 with wilt reaction. Further, an RAPD marker $A07C_{417}$ linked to *Fusarium* wilt resistance was converted into more reliable CAPS marker. The segregation of CAPS marker in sixty one $F_{12}$ RILs showed an expected monogenic ratio of 1:1 and joint segregation with wilt reaction showed significant deviation from digenic ratio of 1:1:1:1, suggesting linkage between CAPS marker and wilt resistance. The *in silico* mapping of CAPS marker showed significant similarity with LOC101491241 on Ca4 with putative function of wound responsive family protein.

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## Molecular Characterization of Spotted Spiral Ginger (*Costus Pictus*) – an Insulin Plant

SANTOSH, G. M.

PRESENT investigation of molecular characterization of spotted spiral Zinger was carried out with popular two species *Costus pictus* and *Costus igneus*. For comparative advantages sampleswere collected from different locations of varied climatic conditions, Bangalore, Kerala and Tamilnadu. Various biochemical constituents were analyzed which includes Total protein, Total sugars, Micronutrients, Ascorbic acid content and crude fiber. *Costus pictus* shown to have higher amount of all the biochemical constituents as compared to *Costus igneus.* Preliminary quantitative phytochemical screening for different secondary metabolites(steroids, alkaloids, triterpenoids, phenols, glycosides, quionones, coumarins, flvanoids, furaniods and tannins) were also done with two different conditions, normal and elevated temperature by soxhlet method. Plant samples were extracted and analysed with different extractants like Hexane, Ethyl acetate, methanol and water.Methanol and Ethyl acetate extracts shown to have higher amount of alkaloids, glycosides and triterpenoids. SDS-PAGE analysis has shown thicker bands in all the three leaf samples of *Costus pictus* as compared to *Costus igneus* and analysis further confirms the presence of significant quantity of protein in leaf samples. The bioactive chemical Corosolic acid also referred as "Glucosol" reported to have active reduction in blood glucose level. Corosolic acid is reported to have a vital role as anti-diabetic and anti-obesity agent. In present study, for the first time HPLC reports the presence of Corosolic acid in leaf samples of *Costus pictus.*

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## Phenotypic Characterization and Molecular Profiling of Sweet and Non-sweet Corn Genotypes and their $F_1$s for Soluble Sugar Content in the Stem

BHAVYA, C.

CORN is among the top five cereals in the world and third most important food crop in India. The sweet corn is also becoming increasingly popular in India and other Asian countries. Sweetcorn altogether with non-sweet corn produces huge volume of biomass residue that will be an alternative raw material for biofuel production. In this study both phenotypic and molecular level diversity were analyzed with respect to soluble sugar content in the stem among sweet (15) and non-sweet (7) corn parents and their hybrids (66) during *Kharif* 2014. Sweetcorn hybrid- Madhuri used as check. Analysis of variance revealed that there was significant variation for all the traits studied at both 10 and 20 days post silk emergence. Traits which account for soluble sugars in the stem showed significant positive correlation with plant height, number of internodes, plant weight, stem weight, stem girth, juice volume and juice extraction percentage. Sweet × non-sweet crosses were found to have highest positive significant mid-parent heterosis for stem sugars indicating that cytoplasm of the sweet corn had significant effect on these traits. Ten PCR primers specific to the *ZmSUT1* gene responsible for sucrose transport in corn were designed using NCBI database. Out of these, ZmSUT1b, ZmSUT1c and ZmSUT1f were found to be polymorphic, indicating the presence of genotypic variation among them for the trait of interest. It is suggested that the biomass of sweetcorn along with hybrids developed using sweetcorn as female parent will be suitable resources as biofuel feedstock.

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## Morphological and Molecular Evaluation of Pole and Bush type French bean (*Phaseolus vulgaris* L.) Accessions for Iron And Zinc Content

NAYANA, K. N.

FRENCH bean or common bean is one of the nutritionally important leguminous crops grown for the tender pods and seeds. It is a major source of dietary proteins, carbohydrates, fibre and micronutrients. French bean seeds exhibit variability for seed mineral accumulation, particularly seed Fe and Zn, thus the present study was carried out. Fourty four accessions were grown in field condition and various morphological traits were studied and the Fe and Zn content were estimated through ICP-OE Spectroscopy. The studies revealed that the pole type accessions exhibited slightly higher mean Fe and Zn content over bush types. The pole type accessions IC318852 (203.66 mg $Kg^{-1}$) and IC319827 (195.20 mg $Kg^{-1}$) showed higher Fe content and L line (69.40 mg $Kg^{-1}$) and EC500745 (67.80 mg $Kg^{-1}$) showed higher Zn content. The above accessions were screened using SSR markers linked to Fe and Zn content, nine SSR primers amplified, five markers were linked to seed Fe and Zn content (BMd16, BMd33, BMd47, BM139 and BM181) and were monomorphic. However, the other three markers specific to Fe content (BM211, BM170 and BMd160) and one marker was specific to Zn content (BM154) were amplified only in selected accessions, indicating larger polymorphism among the French bean accessions. The above SSR markers can be used in future crop improvement programmes involving biofortification of French bean for Fe and Zn content.

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## Distribution of Micronutrients Within Grains of rice (*Oryza sativa* L.) Genotypes Under Aerobic Condition

KARTHIK P. BHAT

IN India, rice is the staple food and major component of diet, but lacks micronutrients in its polished form as major portion of micronutrients are lost during polishing. An effort was made to study the relative expression of micronutrient transporters within different grain parts of the grain before and after polishing. 12 genotypes contrasting for grain zinc and iron were selected and grown in field under aerobic condition at GKVK, following RCBD design, during *Kharif*-2014. High GCV and PCV coupled with high heritability and GAM was observed for plant height, shoot dry weight, grain size, brown rice zinc content, and white rice iron content. Significant positive correlation was observed for iron content in brown rice with test weight and brown rice zinc content with white rice zinc content. Several transporter genes like *OsZIP4*, *OsFER1*, *OsNAS1*, *OsNAS2*, *OsYSL2*, *OsYSL15*, *OsYSL18 etc.* were found responsible for micronutrient transport into rice grains. Gene specific primers were designed for these genes. Relatively higher expression of OsZIP4a, OsNAS2a, and OsYSL15b were found in embryo and endosperm of Moroberekan which had highest brown and white rice zinc content. Relatively higher expression of OsYSL2b and OsYSL2c was found in embryo and relatively lower expression of OsZIP4a was found in endosperm of AM 72 which suffered higher loss of zinc and iron due to polishing. The study suggested that among several genes studied *OsZIP4*, *OsYSL2*, *OsYSL15*, and *OsNAS2* were found to play a major role in zinc and iron accumulation within different parts of rice grain.

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## Immunodiagnosis of Cucumber Mosaic virus (CMV) with Polyclonal Antibodies Raised Against Coat Protein (Cp) Gene of the Virus

MANISHA PANDEY

CUCUMBER Mosaic Virus (CMV) disease is one of the most common disease affecting cucumber. It has a wide host range causing severe damage in many economically important agricultural as well as ornamental crops, resulting in remarkable yield loss. CMV is difficult to diagnose due to the periodic change in symptoms, hence methods of early detection and identification of virus which can be employed in both laboratory and field, play a critical role in virus disease management. Cloning and expression of CMV CP gene is an important strategy for obtaining large scale recombinant protein that can be used in antibody production and further these antibodies with higher specificity, play a critical role in carrying out serological tests. In this study CMV CP gene (~657 bp) was isolated using RT-PCR with gene specific primers which was cloned into pRSET B expression vector and expressed in *E. coli* DH5á cells. Coat protein of ~25 KDa was isolated and purified by using Ni-NTA column. Dot immunobinding assay (DIBA) and plate enzyme linked immuno sorbent assay (ELISA) were standardized for expressed CMV CP and CMV infected plants using the antibodies raised against the whole virus, with optimum titre values at 1:100 dilution of antigen and 1:1000 dilution of primary and secondary antibody.

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## Molecular Diversity Analysis in Elite Tomato *(Solanum lycopersicum* L.) Genotypes Selected for Fruit Quality Traits

BRIJESH PATIL, M. P.

TOMATO *(Solanum lycopersicum* L.) is an important source of several minerals and vitamins. Exhibits wide degree of variability with respect to growth habit, fruit size, fruit shape, fruit color and yield per plant etc. Twenty exotic and indigenous accessions of tomato were screened for variability in terms of morphological, biochemical and molecular diversity. Fifteen were indeterminate type and five were determinate type. The accessions with best morphological characters identified were *viz.*, EC-620545 (higher fruit weight-162.00 g and high fruit yield 8.24 kg/plant), EC-16786 (higher fruits/cluster-8), EC-I59053 (high lycopene content-10.12 mg/100 g), EC-168283 (high ascorbic acid content-18.07 mg/100g) and EC-151568 (high TSS-8.08°Brix). High GCV(21.18 to 40.32) and PCV(25.44 to 41.08) values were recorded for plant height, fruit firmness, total solids, TSS, fruit length, fruit width, fruit weight, number of clusters per plant, number of fruits per cluster and yield. Very high GCV and PCV values were recorded for lycopene content (71.00; 71.23) and as corbic acid content (59.10; 59.31). The heritability estimate were very high for plant height, number of days from flowering to fruit set, fruit pH, fruit firmness, total solids, lycopene content, TSS, ascorbic acid, fruit length, fruit width, fruit weight, number of clusters per plant, number of fruits per cluster and yield per plant. The molecular diversity was assessed using thirty SSR markers, out of which fifteen were polymorphic and shown highest similarity matrix between EC-165690, EC-168283, EC-2495 14, EC-249515, EC-320574-1, EC-362944 and EC-151568. Hence, these markers can be used to measure the genetic relation between the accessions during crop improvement.

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## Indirect Regeneration of *Japonica* Rice (*Oryza sativa* L. spp. *japonica*) Varieties Azucena and Moroberekan through anther Culture

AVINASH SHARMA

RICE (*Oryza sativa* L.) is one of the most important food crops of Southeast Asia, which feeds half of the world population. Anther culture is an efficient and convenient technique for rapid production of doubled haploids which are useful in crop breeding programs. Present study involved evaluation of two *japonica* rice varieties Azucena and Moroberekan cultured on 17 callus induction treatments on N6 medium and 19 regeneration treatments on MS medium. Highest callus induction frequency was observed in Azucena in treatment $T_4$ (2, 4-D 2 mg $L^{-1}$ + Kinetin 1 mg $L^{-1}$) (49.99 %) followed by Moroberekan in treatment $T_{11}$ (2, 4-D 1 mg $L^{-1}$ + NAA 2 mg $L^{-1}$ + Kinetin 0.5 mg $L^{-1}$) (48.64 %). Highest shoot regeneration frequency was recorded in Azucena in treatment $T_{10}$ (Kinetin 0.5 mg $L^{-1}$ + BAP 2 mg $L^{-1}$ + NAA 1 mg $L^{-1}$) (83.33 %) followed by Moroberekan in treatment $T_{16}$ (Kinetin 2 mg $L^{-1}$ + BAP 1 mg $L^{-1}$ + NAA 1 mg $L^{-1}$) (80.0 %). Plantlet regeneration did not occur in Azucena. Highest plantlet regeneration frequency was recorded in Moroberekan in treatment $T_{16}$ (Kinetin 2 mg $L^{-1}$ + BAP 1 mg $L^{-1}$ + NAA 1 mg $L^{-1}$) (80.0 %) followed by in treatment $T_{10}$ (Kinetin 0.5 mg $L^{-1}$ + BAP 2 mg $L^{-1}$ + NAA 1 mg $L^{-1}$) (55.55 %). These results suggest that growth regulators and their concentration, along with genotype have significant effect on callus induction and regeneration from anthers in rice.

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# PLANT PATHOLOGY

## Investigations on Pigeonpea Wilt Disease Caused by *Fusariumudum* Butler with Special Reference to Host Plant Resistance

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*FUSARIUMUDUM* is one of the serious pathogen which causes wilt disease in pigeonpea plants; in severe condition it causes yield loss up to 100 per cent in susceptible genotypes. Sixty nine AVT-IVT genotypes, 29 state and nationally released varieties, 30 ICRISAT genotypes and 10 host differentials were evaluated against *Fusarium* wilt and 52 genotypes were showed resistant reaction. Field resistance of fifteen pigeonpea genotypes *viz*., BRG 3, BRG 5, BSMR 853, BSMR 571, BWR 133, GRG 140, ICP 87119, ICP 8858, ICP 8863, ICP 9174, IPA 8F, IPA 204, KPL 43, KPL 44 and MAHABEEJ 105 were confirmed in greenhouse by using root dip inoculation technique and this technique was found to reduce the time required for screening. *Fusariumudum*was detected in pigeonpea seeds and extent of internal seed infection varied from 3 per cent in BRG 3 to 26 per cent in BRG 4. Hilum recorded maximum infection (25 %) of *F. udum* followed by seed coat (16 %) whereas minimum infection (1 %) was recorded in embryo in pigeonpea seed. Seed transmissibility studies revealed that *Fusariumudum*was seed transmitted from pigeonpea seeds to seedlings and extent of seed transmission ranged from 2.75 per cent in BRG 3 to 16.5 percent in BRG 4. Seed treatment with Carbendazim and Carbendazim + Mancozeb were found to be effective in reducing seed borne infection of *F.udum*at 2 and 2.5 g/kg seed, respectively.

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## Biocontrol of Bacterial Blight of Pomegranate Caused by *Xanthomonas axonopodis* pv. *Punicae* (Hingorani and Singh) Vauterin *et al.*

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BACTERIAL blight (*Xanthomonas axonopodis* pv. *Punicae*) is a devastating disease in pomegranate growing regions. Survey revealed highest PDI (43.74 %) in plants at Tumkur district, followed by Hassan (40.27 %), Chitradurga (38.43 %) and Kolar (25.10 per cent). A total of 53 bacteria isolated from pomegranate Phylloplane were characterized based on morphological, biochemical and PCR amplified 16S rRNA primer assay (Using NCBI data base) and identified as *Bacillus*, *Alcaligenes*, *Myroides, Brevibacterium*, *Pantoea*, *Proteus*, *Enterobacter*, *Lysinibacillus, Paenibacillus* and *Stenotrophomonas* species. *In vitro* evaluation, 27 phylloplane bacteria revealed potential biocontrol ability against pathogen. Maximum inhibition of pathogen at 25 per cent nutrient concentration has detected in 14 isolates of phylloplane bacteria. Further 18 isolates showed maximum inhibition at pH 9. Wherein, pH 5 recorded no inhibitions. Growth of all the phylloplane bacterial isolates was maximum in 100 per cent nutrient concentration and pH 7. Assay of secondary metabolites from 14 phylloplane bacteria, *Bacillus subtilis* (P49) and *Bacterium fjat* (P31) exhibited maximum inhibition of pathogen growth. *In vitro* evaluation, Neem leaf extract at 40 per cent concentration showed maximum inhibition (2.67 cm) followed by Thulasi (2.07cm) and Ekka (1.93 cm). Field application of *Bacillus subtilis* (P49) and *Bacterium fjat* (P31) recorded maximum disease reduction (78.8 and 77.46 %) on leaves followed by (76.48 and 67.65 %) on fruits respectively. Application of secondary metabolites also showed maximum reduction of disease by P49 and P31 (81.69 and 73.25 per cent) on leaves followed by fruits (76.48 and 69.12 %), respectively

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## Studies on Organic Management of Wilt Disease in Chickpea

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CHICKPEA is one of the major grain legume crops widely grown in the Indian sub-continent, which accounts for almost 75 per cent of world's production. Fusarium wilt is the most serious disease on chickpea causing 10-15 per cent yield loss each year. The pathogen isolated from infected plants identified as *Fusarium oxysporum* f. sp. *ciceri* based on morphological and cultural characters. Highest radial growth of pathogen was observed on malt extract agar with glucose or dextrose as carbon source and calcium nitrate as nitrogen source, temperature of 30ºC and pH of 6.5. Native biocontrol agents isolated from rhizosphere of chickpea were *Trichoderma viride*, *T. harzianum* and *Pseudomonas fluorescens* based on morphological and biochemical tests. *In vitro* evaluation of bio agents, *T. viride* followed by *P. fluorescens* inhibited the growth and multiplication of *F. oxysporum* f. sp. *ciceri* by 63.64 per cent and 59.17 per cent respectively. Lemon grass leaf extract significantly inhibited growth (26.38 %) of *F. oxysporum* f. sp. *ciceri* followed by simarouba (25.20 %) and thulsi (25.06 %). Application of *T. viride* (native strain) @ 20g/sqm followed by intercropping with sorghum and mulching reduced the soil population of *F. oxysporum* f. sp. *ciceri* and wilt incidence significantly (11.49 %) as 26.87 per cent in control with higher dry weight (29.5 g/plant) and yield (1238 kg/ha).

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## SEED SCIENCE AND TECHNOLOGY

### Seed Quality and Storability as Influenced by Seed Production Locations and Seed Treatment in Rice (*Oryza sativa* L.) Hybrid KRH-4 during Storage

BALAPPA SATTIGERI

THE experiment was conducted at Department of Seed Science and Technology U.A.S, G.K.V.K, Bengaluru, to investigate the "Seed quality and storability as influenced by seed production locations and seed treatment in rice (*Oryza sativa* L.) hybrid KRH-4 during storage**.** Freshly harvested seeds were collected from three different locations *viz*., $L_1$-Mandya, $L_2$-Tumkur, $L_3$-Kollegala and studied for seed quality. The experiment comprised of three containers *viz*., Cloth bag, Polythene bag 700 gauge and Super grain bag with seven seed treatments. Seeds stored for twelve months under ambient condition and observations were recorded on seed quality parameters bimonthly up to twelve months. Among the different locations, seeds produced at Mandya had better seed storability in super grain bag than cloth bag and polythene bag. Among seed treatments Spinosad 45 SC @ 2 ppm had better seed quality parameters such as moisture content (10.37 %), test weight (19.0 g), germination (80.08 %), seedling vigour index-II (847), electrical conductivity of seed leachates (3.84 $dSm^{-1}$), pH of seed lechates (7.28), alpha amylase activity (0.29 cm), total dehydrogenase activity (0.37 $A_{480\,nm}$), seed infection (15.06 %), seed infestation (19.78 %) and field emergence (77.64 %). However, Kollegala location recorded lower seed quality parameters in both containers and seed treatments. This study could be concluded, that rice hybrid KRH-4 could be stored for twelve months safely in super grain bag treated with spinosad 45 SC @ 2 ppm without affecting the seed quality.

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### Influence of Different Growing Conditions, Micronutrients and Biostimulant application on Growth, Seed Yield and Quality of Marigold (*Tageteserecta*L.) cv. Arka Bangara

SYED SALMAN ARIF

A field and laboratory experiments were conducted during *Rabi* 2014-15 at Department of Horticulture and Department of Seed Science and Technology, UAS, GKVK, Bengaluru. The results revealed that open field condition recorded higher growth and seed yield attributes *viz*., plant height (80.73 cm), number of branches (15.13), flowering duration (73.4 days), number of flowers per plant (46.75), weight of the flower per plant (462 g), flower diameter (6.20 cm), number of seeds per flower (138.83), seed yield per plot (149 g), seed yield per hectare (593 kg). Among the micronutrients and biostimulantspray of humic acid 0.2 % + $FeSO_4$ 0.5 % + $ZnSO_4$ 0.5 % at 30 and 45 DAT was recorded higher growth, seed yield and quality attributes *viz*., plant height (86.63 cm), number of branches (16.40), days to 50 per cent flowering (27.5), flowering duration (76.3 days), number of flower per plant (53.23), weight of the flowers per plant (573 g), flower diameter (6.61 cm), number of seeds per flower (147.83), seed yield per plot (162 g), seed yield per hectare (644 kg), seed recovery (84 %), germination (87.17 %), test weight (3.32 g), seedling length (12.29 cm) and seedling dry weight (12.14 mg) SVI-I and SVI-II (1071 and 1059, respectively) with lower electrical conductivity (0.162 $dSm^{-1}$). Combination of open field condition with humic acid 0.2 % + $FeSO_4$ 0.5 % + $ZnSO_4$ 0.5 % at 30 and 45 DAT has recorded highest net return (Rs. 4,28,790) and highest benefit cost ratio (1:1.97).

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## Influence of Panchagavya on Vegetable Seed Production of Cowpea [*Vigna unguiculata* (L.) walp] Genotypes

SUMALATHA, G. M.

THE field and laboratory experiments were conducted at Regional Institute on Organic Farming and Department of Seed Science and Technology, UAS, GKVK, Bengaluru, during 2014-2015 to study, the influence of panchagavya on vegetable seed production of cowpea genotypes. The results revealed that PKB-4 recorded highest plant height (75.61 cm), number of branches (5.46) whereas, AV-5 recorded less number of days for 50 % flowering (53.67), highest germination (83.39 %), seedling vigour index-I (2718) seed yield plant$^{-1}$ (14.74 g), cleaned seed yield (1.22 Kg plot$^{-1}$). Among different concentrations, panchagavya at 5 % recorded significant improvement in plant height (85.94 cm), number of branches (6.47), less number of days for 50 % flowering (52.67 %), highest germination (88.88 %), seedling vigour index-I (3319), seed yield plant $^{-1}$ (14.80 g), cleaned seed yield (1.27 Kg plot$^{-1}$) compared to control. Among harvesting intervals, Subsequent formed pods showed better seed quality parameters *viz.,* germination (84.22 %), seedling vigour index-I (3038), protein (16.78 %) compared to first formed pods. During accelerated ageing test (0 to 10 days) after 10 days of test, genotype AV-5 recorded lower reduction of seed quality attributes like germination (3.85 %), seedling vigour index-I (33), total dehydrogenase activity (0.93 OD value), field emergence (1.00 %) compared to other genotypes. The investigation revealed that panchagavya at 5 % with subsequent formed pods registered higher seed yield and quality parameters, Irrespective of the genotypes and panchagavya spray, accelerated ageing test revealed progressive decline in seed quality parameters as ageing period advanced.

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# SERICULTURE

## Studies on Residual Toxicity Effect of Pesticides and Nitrate on Performance of Mulberry Silkworm

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THE rearing was carried out at Department of Sericulture GKVK, UAS, Bangalore during 2014-2015 to study the Residual toxicity effect of pesticides and nitrate on performance of mulberry silkworm. Fifteen samples of soil and mulberry leaves were analyzed for pesticide residue. Among them only nine samples had detectable level of pesticide residue in soil, out of this only one sample (F4K) contained residue of cypermethrin(0.55ppm) above MRL (0.01ppm). Similarly in mulberry leaves only one sample (F12C) contained residue of Chlorantraniliprole (0.29ppm) on par with(0.29ppm). Highest soil nitrate residue at 30cm depth was recorded in F1K (357.14ppm).Highest nitrate residue content in bottom leaves were recorded in F9C (71.98ppm).Larval mortality was highest in silkworms fed with leaves 10DAS[I instar (96%), II instar(96%), III instar(90.33%),IV instar(21%)and V instar(30.67% after Chlorantraniliprolesprayed mulberry leaves in first rearing and in second rearing I instar (97%), II instar (96%), III instar (92.33%), IV instar (22.67%) and V instar (32.67%) respectively].Fourth moult duration was recorded maximum in silkworms reared on leaves 10DAS(26.53h and 24.53h)) in first and second rearing. Maximum instar duration was recorded in silkworms fed with 10DAS[IV instar(126.79h) and V instar (241h)] and second rearing [IV instar(124.95h) and V instar(221h)]. Larval, cocoon shell and filament weight, ERR, cocoon yield, shell ratio, filament length and denier was least in 10DAS (19.57g, 1.23g, 0.20g, 0.10g, 26.33%, 29.23g, 14.89%, 599.58m and 2.09, respectively). In second rearing these parameters were least in 10DAS (17.57 g, 1.21g, 0.19 g, 0.09 g, 24.67 %, 28.30g, 14.83 %, 596.39 m and 2.08, respectively).

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## Evaluation of Microbes for Composting of Silkworm Rearing Waste

NAJMUS SAHER

THE experiment entitled Evaluation of microbes for composting of silkworm rearing waste was carried out at farmer's field and the analysis of the samples were carried out in Department of Soil Science and Agricultural Chemistry, UAS, GKVK, Bengaluru during 2014-15. The organic carbon content of the silkworm rearing waste significantly decreased (22.35 %) over the period of composting due to the continuous mineralization of organic matter. The major constituents of silkworm rearing waste *viz.,* Nitrogen, Phosphorus and Potassium after decomposition significantly increased (1.42, 0.54 and 0.94 %, respectively) as the day progress which was evident in the analysis of samples from 90 to 180 days of interval. Since inoculation of microbes hastened and improved the decomposition process and enriched the compost with nutrients. The micronutrients content like iron (4865.47 ppm), manganese (446.60 ppm), copper (94.48 ppm) and zinc (255.93 ppm) were also found to increase with composting. The silkworm waste inoculated with *Trichoderma viride* and *Pleurotus* sp. have recorded better results compared to other treatments. The recalcitrant compounds *viz.,* cellulose and lignin decreased significantly (13.46 and 14.53 %, respectively) over the period of 180 days when silkworm rearing waste (75 %) and FYM (25 %) mixed with *Pleurotus* sp. The waste combination of silkworm rearing waste (75 %) and FYM (25 %) with microbe has yielded quick decomposition compared to the treatment with 100 per cent silkworm rearing waste without inoculation of microbes. The waste combination of silkworm rearing waste (50 %) and FYM (50 %) with microbe has decomposed quickly (71.08 %, recovery) compared to the other treatments.

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## Feasibility of Different Mulches on Growth and Yield of $V_1$ Mulberry and Rearing Parameters

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FIELD and rearing experiment was carried out at Department of Sericulture, UAS, GKVK, Bangalore during 2014-15 to study the Feasibility of different mulches on growth and yield of $V_1$ mulberry and rearing parameters. Different mulches used for the study were, *Glyricidia,* Weed mulch, Forest litter, Mulberry twigs, Polythene, and Shade net.Among the different mulches *Glyricidia* mulched plots recorded higher growth and yield parameters *viz.,*Plant height (195.87cm and 184.83cm), number of branches per plant (24.19 and 19.70), numberof leaves per plant (201.27 and 176.50), singleleaf area (195.18cm$^2$ and 189.61cm$^2$), leaf to shoot ratio (15.97 and 14.22), leaf yield per plant (384.76 and 354.34g/plant) and higher leaf moisture content (74.77% and 69.97%) during both rainy and winter seasons respectively. Highest leaf nitrogen (2.1% and 2.0%), phosphorus (0.38% and 0.32%), potassium content (1.88% and 1.76%), soil moisture (13.79%) and soil NPK content (230.54, 38.52 and 201.28kg/ha) in mulberry were recorded in *Glyricidia* mulched plots at 60DAM during rainy and winter season. Highest larval weight (30.14 and 28.33g/10larvae) was recorded whensilkworms were fed with mulberry plant mulched with *Glyricidia* in all the instars during rainy and winter seasons. Maximum single cocoon weight (1.82 and 1.78g), pupal weight (1.48 and 1.42g), shell weight (0.34 and 0.36g) and shell ratio (18.97 and 20.23%), silk filament length (823.64m and 806.81m) and filament weight (0.34 and 0.29g) were also recorded when silkworms were fed with mulberry grown by application of *Glyricidia* mulch during rainy and winter season and followed by Mulberrytwigs mulched plots for growth and rearing parameters.

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## SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

### Studies on Response of Paddy to different Amendments and Nutrient Management Practices in Sodic Soil

PRAKHYATH, K. M.

A field experiment was conducted during *kharif* 2014 at ZARS, V. C. Farm, Mandya to study the response of paddy to different amendments and nutrient management practices in sodic soil. The experiment was laid out with nutrient management practices (RDF, STCR, and SSNM) as main plot and amendments (gypsum, pressmud and mangala setright) as subplot treatment under split plot design. Results revealed that application of RDF recorded significantly higher grain yield (2.27 t $ha^{-1}$) as compared to SSNM (2.11 t $ha^{-1}$) and STCR (2.15 t $ha^{-1}$) treatment. Application of pressmud @ 100 per cent GR recorded significantly higher grain and straw yield (2.59 t $ha^{-1}$ and 6.04 t $ha^{-1}$ respectively) of paddy over control. But it was on par with application of 400 kg $ha^{-1}$ setright (2.46 t $ha^{-1}$) and significantly higher uptake of nutrients was also recorded in same treatment (61.53, 27.37, 91.26 kg NPK $ha^{-1}$). Application RDF with pressmud @ 100 % GR significantly increased the grain and straw yield of paddy (2.93 t $ha^{-1}$ and 6.23 t $ha^{-1}$, respectively) compared to other combinations. The significant reduction in soil pH (8.50) was recorded due to application of gypsum @ 100 % GR and While exchangeable sodium and ESP were reduced significantly due to application of setright @ 400 kg $ha^{-1}$ treatment (1.78 cmol $kg^{-1}$ and 6.52, respectively). Thus application of pressmud @ 100 % GR or setright @ 400 kg $ha^{-1}$along with RDF is more beneficial in enhancing the crop yield as well as correcting soil sodicity.

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### Effect of Diatomite on Crop Productivity and Soil Properties in Potato-Maize Cropping Sequence

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A field experiment was conducted to study the effect of diatomite on crop productivity and soil properties in Potato-Maize cropping sequence at College of Agriculture, Hassan, Karnataka. Potato was raised as main crop and maize as residual crop during *Kharif* and *Rabi* seasons of 2013-14, respectively. Sixteen treatments comprising four nutrient levels (0, 50%, 75% and 100% of POP) as main plot and four diatomite levels (0, 150, 300 and 600 kg $ha^{-1}$) as sub plot treatments were laid out in a split plot design with three replications. The 100 per cent POP for potato (125:100:125 kg NPK $ha^{-1}$ + 25 t FYM $ha^{-1}$) was taken as control treatment. The data reviled that application of diatomite @300 kg $ha^{-1}$ with 50 % POP gave significantly higher potato tuber yield (16.08 t $ha^{-1}$) with higher "A" grade size tubers (>75 g) than control (12.47 t $ha^{-1}$). It has increased 28.95 per cent in tuber yield over control. It also recorded significantly higher content and total uptake of NPK and Si by potato over control. Application of diatomite significantly reduced the incidence of late blight disease from 37.72 per cent (control) to 9.41 per cent (50% POP + diatomite @600 kg $ha^{-1}$). The available macro and micro nutrients content in soil after harvest of potato crop increased due to application of graded levels of nutrients and Si content due to application of diatomite. The residual crop maize recorded significantly higher growth and yield parameters with application of 100 per cent POP + DE @150 kg $ha^{-1}$ over other treatments.

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## Studies on Response of Maize (*Zea mays* L.) in Acid Soil as Influenced by Ameliorants

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A field experiment was carried out in an acid soil during *kharif* 2014 at Arasihalli of Hassan district to study the relative efficiency of two soil ameliorants *viz.,* lime and *Setright* on growth and yield of maize in fourteen treatment combinations replicated thrice using Randomized Complete Block Design. Ameliorant lime ($CaCO_3$) at two levels (500 kg $ha^{-1}$ and 100 % LR) and *Setright* at four levels (250, 500, 750 kg $ha^{-1}$ and 100 % LR) were applied along with RDF 15 days before sowing (DBS) and at the time of sowing whereas, RDF alone was considered as control. The initial pH of surface soil was 4.9 with low base saturation (28 %). The soil pH increased with increasing levels of ameliorant application. The treatments which received ameliorants 15 DBS recorded higher grain yield compared to application at the time of sowing. Application of RDF + *Setright* @ 750 kg $ha^{-1}$ (82.67 q $ha^{-1}$) 15 DBS recorded higher grain yield followed by RDF + *Setright* @ 500 kg $ha^{-1}$ (79.80 q $ha^{-1}$) and both treatments were found on par. The available N, P, K, Ca, Mg and S status improved with application of ameliorants. Though higher net returns was obtained in RDF + *Setright* @ 750 kg $ha^{-1}$ the B:C ratio was higher in treatment RDF + *Setright* @ 500 kg $ha^{-1}$ (3.62). Hence, application of *Setright* @ 500 kg $ha^{-1}$ 15 DBS performed better for amelioration of acid soil and profitable maize cultivation.

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## Characterization of Biochar, Nutrient Release and its Effect on Growth and Yield of Aerobic Rice

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AN experiment was conducted to characterize biochar, nutrient release and its effect on growth and yield of aerobic rice at UAS, GKVK, Bengaluru in 2014. Three different biochars *viz.,* wood (WB), bamboo (BB) and rice husk biochar (RHB) and four levels of application (2, 4, 8 and 16 t / $ha^{-1}$) were the treatments. An incubation study was conducted to know the nutrient and Si elease from different biochars in acidic, neutral and alkaline soil at field capacity moisture regime. Among different sources, application of WB recorded higher pH and exchangeable bases while RHB recorded higher available $P_2O_5$ and 0.01 M $CaCl_2$ - Si in all soils. Independent of biochar type, increased rate of application increased the pH, available $P_2O_3$ exchangeable bases and 0.01 M $CaCl_2$ - Si content of soils. Significant decrease in DTPA extractable Fe and Mn were observed with application of WB in acidic and neutral soil while with RHB in alkaline soil. In a pot culture study, significantly higher yield of straw and grain were recorded with the application of RHB @ 8 and 4 t $ha^{-1}$in.acidic and neutral soil, respectively while WB @ 4 t $ha^{-1}$ in alkaline soil. Si and other nutrients content in straw and grain increased.with application rates of biochar. With the application of different sources and levels of biochar in different soils, yield responses of straw and grain ranged from -36.56 to 55.18 per cent and -51.00 to 46.47 per cent, respectively.

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## Effect of Basic Slag and Lime on Growth and Yield of Cowpea and Paddy and Release of Nutrients in Acid Soil

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BASIC slag a byproduct of steel industry was compared with lime to study the effect of on soil properties, growth and yield of cowpea and paddy. Two separate field experiments were conducted in acid soils at Kadumane and Alasulige village located in hilly zone of Sakleshpura taluk during Summer 2013 and *Kharif* 2014 with five treatment combinations replicated four times for cowpea and ten treatment combinations replicated thrice for paddy using RCBD design. Basic slag was alkaline in nature (11.2) with medium EC. The total Ca, Fe and Si content were 24.8, 11.29 and 8.2% per cent, respectively. The experimental results revealed that application of 25:40:25 kg NPK $ha^{-1}$recorded significantly higher seed (8.21q $ha^{-1}$) and haulm (14.14 q $ha^{-1}$) yield of cowpea. Significantly higher grain (50.32 q $ha^{-1}$) and straw (65.93 q $ha^{-1}$) yield of paddy, nutrient content and uptake was recorded in treatment which received 100:50:50 kg NPK $ha^{-1}$ + basic slag @ 2 t $ha^{-1}$ as compared to other treatments. In both the experimental sites soil properties *viz.* soil pH, EC, available nitrogen, phosphorus, silicon and exchangeable Ca content were higher whereas, DTPA extractable micronutrient contents and acidity parameters *viz.* exchangeable acidity, potential acidity and total acidity were lower in treatments receiving basic slag and lime compared to farmer's practice. The study clearly indicated that in acidic soils, application of basic slag or lime @ 2 t $ha^{-1}$ and NPK is more beneficial in enhancing the crop yield, crop productivity as well as available nutrient status of soil.

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## Response of Maize (*Zea Mays* L.) to Soil and Foliar Application of Micronutrients Mixture in Alfisols of Southern Dry Zone of Karnataka

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FIELD experiment was conducted during *Kharif* 2015 at College of Agriculture V.C. Farm, Mandya to study the response of maize to soil and foliar application of micronutrients mixture in *Alfisols* of southern dry zone of Karnataka. The experiment was laid out in RCBD with eleven treatments and replicated thrice. Foliar micronutrient mixtures viz., $MM_1$ (100g $ZnSO_4$, 100g $MnSO_4$, 75g $FeSO_4$, 100g $CuSO_4$ and 50g $H_3BO_3$ $100L^{-1}$) and $MM_2$ (double dose of $MM_1$) sprayed at 30 and 45 DAS and soil micronutrient mixtures viz., $MM_3$ (10kg $ZnSO_4$, 6kg $MnSO_4$, 8kg $FeSO_4$, 4kg $CuSO_4$& 2kg $H_3BO_3$ $ha^{-1}$) and $MM_4$ (deficient nutrients of Zn and B @ 10 & 2 kg $ha^{-1}$) applied as basal were tested with control (RDF+FYM) and Standard Fertilizer Practice (RDF+FYM+$ZnSO_4$ @ 10kg $ha^{-1}$). The results revealed that the highest kernel and stover yield of maize (82.00 and 83.67 q $ha^{-1}$, respectively) were recorded with combined application of soil ($MM_3$) and foliar ($MM_2$) micronutrients mixture along with RDF+FYM and which was significantly higher than that of control and SFP. The percent increase in kernel and stover yield were 42.28 and 42.61 %, respectively over control and 20.58 and 16.21 %, respectively over SFP. The higher yield was attributed to significant improvement in growth and yield attributing parameters and higher uptake of both micro and macro nutrients by maize. This treatment was found more profitable with higher gross and net returns with B:C ratio of 2.51 compared to other treatments.

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