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Fungal biofertilizers in Indian agriculture: perception, demand and promotion

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Since the beginning of the "Green Revolution" in the late sixties, which focused on food crop productivity, through high-yielding varieties, agrochemicals, irrigation system and chemical fertilizers were extensively used throughout India. Fertilizer was alone contributing as much as 50 per cent of the yield growth. In fact, India is the world's largest user of chemical fertilizers, consuming each year around 16 per cent of the world's N consumption, 19 per cent of phosphatic and 15 per cent of potassic nutrients of the global total (Anonymous, 2008). Total fertilizer consumption in the country was 28.3 million tonnes upto 2010-11. Importance of fertilizers in yield improvement, which is essential for achieving increased agricultural production, will further increase because there is little scope for bringing more area under cultivation and majority of Indian soils are deficient in many macro and micro-nutrients (Fertiliser Association of India ,2011). The emphasis on chemical fertilizers, which sometimes led to injudicious application, has meant that the soil be regarded as an inert substrate for plant roots, instead of a living biosphere, the rhizosphere, containing a myriad of organisms. It is now realized that in agricultural lands under intensive monoculture system, including rice, which receives heavy application of chemical fertilizers alone, productivity slowly declining and environmental quality deteriorating (Rakshit *et al*. 2015). In the light of these problems, the use of organic fertilizers, biofertilizers and other microbial products are crucial to make the agriculture industry a viable component of a healthy and pleasant ecosystem.

Exploring biofertiliser-the only option

Biofertilizers have important role to play in improving the nutrient supplies and their availability in crop husbandry. Use of biofertilizers in crop production is another factor to help in build up of soil biological properties under organic farming, besides other organic manure applications. Bio-fertilizers include selective organisms, like bacteria, fungi and algae. These organisms are capable of fixing atmospheric nitrogen and solublization of native and added nutrients in the soil and convert them into available forms to plants. They are ecofriendly, cost effective and renewable source of plant nutrients. The biofertilizer organisms can play a vital role in maintaining long term soil fertility and sustainability (Mishra *et al.* 2015). The bio-fertilizers are important to ensure a healthy future for the generations to come. Long term use of bio-fertilizers is economical, eco-friendly, more efficient, productive and accessible to marginal and small farmers over chemical fertilizers.

What is biofertilizer?

Biofertilizers are environment friendly, non-bulky, low cost, renewable sources of plant nutrients which supplement chemical fertilizers and play an important role in improving nutrient supplies and their crop availability in the years to come. Biofertilizer is a ready-to-use live formulation of such beneficial microorganisms, which on application to seed, root or soil, mobilize the availability of nutrients by their biological activity. These are nothing but selected strains of beneficial soil microorganisms cultured in the laboratory and packed in a suitable carrier, which can be used either for seed treatment or soil application. Biofertilizers generate plant nutrients like nitrogen and phosphorous through their activities in the soil or rhizosphere and make available to plants in a gradual manner. Biofertilizers are gaining momentum recently due to its availability to maintain soil health, minimize environmental pollution and cut down the use of chemicals in agriculture. In rainfed agriculture, these inputs gain added importance in view of their low cost, as most of the farmers are small and marginal and can not afford expensive chemical fertilizers (Bisen *et al*. 2015). Biofertilizers are also ideal input for reducing the cost of cultivation and for practising organic farming.

Types of biofertilizer

Biofertilizers comprise microbial inocula or assemblages of living microorganisms, which exert direct or indirect benefits on plant growth and crop yield through different mechanisms. These microorganisms are able to fix atmospheric nitrogen or solubilize phosphorus, decompose organic material, or oxidize sulphur in the soil properties that are beneficial to agricultural production in terms of nutrient supply. One type of biofertilizer are the arbuscular mycorrhizal fungi, which are probably the most abundant fungi in agricultural soil. The inocula improve crop yield because of increased availability or uptake or absorption of nutrients, stimulation of plant growth by hormone action or antibiosis and by decomposition of organic residues. The following types of biofertilizers are available to the farmers in India:

- Nitrogen fixing biofertilizers (*Rhizobium, Bradyrhizobium, Azospirillum* and *Azotobacter*).
- Phosphorous solubilising biofertilizers or PSB (*Bacillus, Pseudomonas, Aspergillus*, *Penicillium*, *Fusarium, Trichoderma*, *Mucor*, *Ovularopsis*, *Tritirachium* and *Candida*).
- Phosphate mobilizing biofertilizers (*Mycorrhiza*).
- Plant growth promoting biofertilizers (*Pseudomonas*).
- Enriched compost biofertilizers = Cellulolytic fungal cultures (*Chaetomium bostrychodes, C. olivaceum, Humicola fuscoatra, Aspergillus flavus, A. nidulans, A. niger, A. ochraceus, Fusarium solani* and *F. oxysporum*).

Fungal biofertilizer

Fungal biofertilizers comprise fungal inocula either alone or in combination, exerting direct or indirect benefits on plant growth and crop yield through different mechanisms. Selected fungal species, used as biofertilizers are mentioned in Table 1.

Mycorrhiza is a distinct morphological structure, which form mutualistic symbiotic relationships with plant roots of more than 80 per cent of plants including many important crops and forest tree species (Rai *et al*. 2013). Plants which suffer from nutrient scarcity, especially P , N, Zn, Cu, Fe, S and B develop mycorrhiza, i.e., the plants belong to different groups such as herbs, shrubs, trees, aquatic, xerophytes, epiphytes, hydrophytes or terrestrial ones (Zhu *et al*. 2008). In recent years, use of artificially produced inoculum of two dominant types of mycorrhizal fungi has increased its significance due to its multifarous role in plant growth and yield and resistance against biotic and abiotic stresses. Ectomycorrhizal (ECM) fungi form mutualistic symbioses with many tree species (Anderson and Cairney, 2007). ECM fungi help the growth and development of trees because the roots colonized with ectomycorrhiza are able to absorb and accumulate nitrogen, phosphorus, potassium and calcium more rapidly and over a longer period than nonmycorrhizal roots. ECM fungi help to break down the complex minerals and organic substances in the soil and transfer nutrients to the tree. ECM fungi also appear to increase the tolerance of trees to drought, high soil temperatures, soil toxins and extremes of soil pH. ECM fungi can also protect roots of tree from biotic stresses.The most commonly widespread ectomycorrhizal product is inoculum of *Pisolithus tinctorius* (Schwartz *et al*. 2006) with a wide host range and their inoculum can be produced and applied as vegetative mycelium in a peat or clay carrier. *Piriformospora indica* is another ECM fungus used as a biofertilizer with multifaceted traits of plant growth promotion, tolerance to both abiotic and biotic stresses and increased biomass (Tejesvi *et al*. 2010). Endomycorrhizae from mutually symbiotic relationships between fungi and plant roots, where plant roots provide carbohydrate for the fungi and the fungi transfer nutrients and water to the plant roots (Adholeya *et al*., 2005). The agriculturally produced crop plants that form endomycorrhizae of the vesicular-arbuscular mycorrhiza type are now called arbuscular mycorrhizal (AM) fungi (Raja, 2006). AM fungi belong to nine genera: *Acaulospora*, *Archaeospora*, *Enterophospora*, *Gerdemannia*, *Geosiphon*, *Gigaspora*, *Glomus*, *Paraglomus* and *Scutellospora*. AM fungi are a widespread group and are found from the arctic to tropics and are present in most agricultural and natural ecosystems. Arbuscular mycorrhiza are prominent P mobilizers, which facilitate mobilization of soluble phosphorus from distant places in soil, where plant roots cannot reach and thus increase availability of P to plants. Since mycorrhizal fungi are more efficient in the uptake of specific nutrients like P, Ca, Zn, S, N, B and resistant against soil-borne pathogens, interest in using these fungi as biofertilizers is increasing as they play an important role in plant growth, health and productivity.

Other fungal biofertilizers, which have been used to improve plant growth by enhancing phosphorus absorption in plants are phosphate solubilizing microorganisms. The commonly widespread fungi are *Penicillium, Aspergillus, Chaetomium* and *Trichoderma* species. There are a number of biofertilizers available in the market (Table 2). However applications are based on their ability to supply and mobilize plant nutrients, control plant diseases and promote plant growth and development.

Table 1. Fungal biofertilizers used in Agriculture

Organism	Reference
A. Phosphorous solubilising biofertilizers	
Aspergillus spp. (*A.tubingensis/A.niger/A.terreus/A. awamori / A. fumigates/ A. tubingensis/ A. melleus*)	Akintokun *et al*., 2007
Penicillium spp. (*P. bilaji/ P. albidum/ P. italicum/ P. simplicissimum/ P. frequentans/ P. oxalicum/ P. rubrum/ P. expansum/ P. citrinum*)	Burton and Knight, 2005; Whitelaw, 2000
Fusarium spp. (*F. moniliforme/ F. udam*)	Whitelaw, 2000; Manoharachary *et al*., 2005.
Trichoderma spp. (*T. viridi/ T. harzianum/ T. virens/ T. asperellum*)	Harman, 2000; Harman *et al*., 2004
Mucor spp. (*M. ramosissimus/ M. mucedo/ M. hiemalis*)	Kannaiyan, 2002; Manoharachary *et al*., 2005
Tritirachium spp. (*T. album/ T. egenum*)	Rai, 2006; Manoharachary *et al*., 2005
Candida spp. (*C. krissii, C. scotti*)	Rai, 2006; Manoharachary *et al*., 2005
B. Potash solubilising biofertilizers	
Aspergillus spp. (*A. fumigates, A. niger, A. terreus*)	Lian *et al*., 2008
Ectomycorrhizal fungi	Luciano *et al*., 2010
C. Zinc solubilising biofertilizers	
Saccharomyces spp.	Raj, 2007
Ericoid mycorrhiza (*Oidiodendron maius*)	Subba Rao, 2001; Martino *et al*., 2003
Penicillium simplicissimum	Franz *et al*. 1991; Schinner and Burgstaller,1989
Aspergillus niger	Wold and Suzuki,1976
D. Phosphate mobilizing biofertilizer	
Ectomycorrhiza (*Amanita* sp., *Lactarius* sp., *Pisolithus* sp., *Rhizopogon* sp., *Cenococcum* sp., *Elaphomyces* sp., *Tuber* sp., *Pisolithus tinctorius, Piriformospora indica*)	Anderson and Cairney, 2007
Arbuscular mycorrhiza, *Glomus* spp. (*G. mosseae/ G. manihotis/ G. itraradices/ G. aggregatum/ G. cerebriforme, G. deserticola, G. globiferum, G. halonatum, G. microcarpum, G. monosporum, G. radiatum, G. versiforme, G. viscosum*)	Gianinazzi and Gianinazzi, 1988; Barea, 2000; Singh and Tilak 2002; Adholeya *et al*., 2005
Acaulospora spp. (*A. foveata*, *A. scrobiculata* and *Sclerocystis clavispora*, *A. delicata*), *Geosiphon*, *Paraglomus*	Raja, 2006; Barea, 2000
Archaeospora, *Scutellospora* spp. (*S. erythropa*, *S. calospora, S. scutata*)	Rai, 2006; Barea, 2000
Enterophospora, *Gerdemannia*, *Gigaspora* (*Gigaspora rosea*)	Manoharachary *et al*., 2005; Rai, 2006
E. Biofertilizer enriching compost	
Trichoderma spp. (*T. viridi/ T. harzianum/ T. virens/ T. asperellum*)	Harman *et al*.2004; Singh and Singh, 2008
Penicillium spp. (*P. bilaji/ P. albidum/ P. italicum/ P. simplicissimum/ P. frequentans/ P. oxalicum/ P. rubrum/ P. expansum*)	Whitelaw, 2000; Rai, 2006
Aspergillus spp. (*A. tubingensis/ A. niger/ A. terreus/ A. awamori/ A. fumigatus*)	Sharma, 2002; Rai, 2006
Pleurotus spp. (*P. ostreatus/ P. flabellatus*)	
Chaetomium spp. (*C. bostrychodes, C. olivaceum*)	
Humicola fuscoatra	
Fusarium spp. (*F. solani / F. oxysporum*)	

Table 2. Fungal biofertilizers available in India

Biofertilizer	Active ingredient	Mode of action	Dose	Manufacturer
A. Phosphate solubilizing microorganisms				
Grotop PSB Powder	Phosphate Solubilizing Microorganisms (*Bacillus* sp.) ,Powder 10^7 - 10^9 cfu g^{-1} and Liquid 10^9 cfu ml^{-1}	Solubilize unavailable organic and inorganic forms of phosphorus (80%)	**Seed:** 5-10 g kg^{-1} seed **Soil**: 0.5-1 kg $acre^{-1}$ along with 40-50 kg manure **Foliar:** 3ml l^{-1} water	MD Biocoals Pvt. Ltd., Haryana
Mani Dharma's biopromoter	*Bacillus megaterium* + *Aspergillus niger*	Biopromoter facilitates root formation and plant growth. It improves soil quality with subsequent uses. It should not be mixed with antibacterial agents and inorganic fertilizers.	**Foliar:** 200g/ 200ml^{-1} of 'rice kanji' or 5% jaggary water	Mani Dharma Biotech Private Limited, Tamil Nadu
Multiplex Nalapak	Homogenous mixture of *Azotobacter* + *Azospirillium* + phosphate solubilizer + potash mobilizer	It produces amino acids, vitamins and growth promoting substances like IAA, GA and Cytokines, which helps in better growth and development of crop plants. Improves physical, chemical and biological properties of the soil.	**Soil:** 500 ml 5 kg^{-1} $acre^{-1}$ along with 100kg well decomposed FYM **Foliar:** 10g l^{-1} water	Multiplex Bio-Tech Pvt. Ltd., Karnataka
Ambiphos	Phosphate solubilizing microorganism (*Aspergillus niger*)	PSM secrete organic acids, which dissolve unavailable phosphate into soluble form and make it available to the plants.	**Foliar:** 3-5ml l^{-1} water	Ambika Biotech & Agro Services, Madhya Pradesh,
Biophos	*Bacillus megaterium* var. *phosphaticum*	PSM secrete organic acids, which dissolve unavailable phosphate into soluble form and make it available to the plants.	**Seed:** 5-10 ml kg^{-1} of seed **Seedling:** 125–250 ml in 25–50 liter of water as coating, sett treatment 125-250 ml in 60-80 l ha^{-1} for 30 minutes **Soil:** 500- 625 ml ha^{-1} mixing with 250-375 kg FYM	Biotech International Limited, Delhi
BioP-P	Phosphate solubulizing microorganism ($2x10^8$ CFU g^{-1})	PSM secrete organic acids, which dissolve unavailable phosphate into soluble form and make it available to the plants.	**Foliar:** 3-5ml l^{-1} water	Sundaram Overseas Cooperation, Gujarat
PSM	Phosphate solubilizing micro-organisms	PSM secrete organic acids, which dissolve unavailable phosphate into soluble form and make it available to the plants.	**Soil**: 0.5-1 kg $acre^{-1}$ along with 40-50 kg FYM	Shree Biocare India, Shree Biocare Solution Pvt Ltd, Gujarat
PSM	Phosphate solubilizing micro-organisms	PSM secrete organic acids, which dissolve unavailable phosphate into soluble form and make it available to the plants.	**Soil**: 0.5-1 kg ha^{-1} along with 100 kg FYM	KRIBHCO, UP
B. Enriched compost				
Multiplex Sagar (Compost Poly Culture)	Homogenous mixture of *Azospirillum*+*Trichoderma*+ *Pleurotous*	Nitrogen fixing potential, biopesticidal activity,enhances compost degradation	**Soil**: 1 kg $acre^{-1}$ along with 1000kg well decomposed FYM **Foliar**: 100 ml 10 l^{-1} water	Multiplex Bio-Tech Pvt. Ltd., Karnataka
Enriched compost Culture	*Trichoderma harzianum*+ *Aspergillus*+*Penicillium*	Enhances compost degradation	**Foliar**: 100 ml 10 l^{-1} water	Organic Biotech Pvt Limited, Maharastra
Bio- manure Culture	*Trichoderma harzianum*+ *Aspergillus*	Enhances compost degradation	**Foliar**: 100 ml 10 l^{-1} water	Uno Natural and Greens Private Limited, Tamil Nadu
LignoBiocompost culture	*Trichoderma resei, Phanerochaete chrysosporium* and *Aspergillus awamori*	Enhances compost degradation	**Foliar**: 75-100 ml 10 l^{-1} water	Peak Chemical Industries Limited, West Bengal

contd…

Table 2 contd...

Biofertilizer	Active ingredient	Mode of action	Dose	Manufacturer
C. Phosphate mobilizing biofertilizer				
ManiDharma VAM	Vesicular Arbuscular Endomycorrhiza (VAM)	Solubilize phosphate and supplies P, Zn, Mn, Fe, Cu, Co and Mo to the plants. Increases the plant viguor by inducing drought resistance in young seedlings.Protects the plants from the fungal pathogens.	**Soil**: 200 g/m^2 or 2 -5 g seedling^{-1}; 50-200 g trees^{-1}; 3 – 5 kg acre^{-1} (2 - 3 cm depth).	Mani Dharma Biotech Pvt Ltd, Tamil Nadu
Ecorhiza-VAM/ Nurserrhiza-VAM	Arbuscular Mycorrhiza	Improved uptake of nutrients, root development and growth in plant	**Soil**: 3-5 kg acre^{-1} with the 200-250 kg FYM, one tablet plant^{-1} in 2-4 inch deep hole near the plant root.	TERI, New Delhi
Root Care	Mycorrhiza (*Glomus intraradices*)	Improved plant health, uptake of nutrients and reduction of environmental stress.	**Soil**: 5 kg acre^{-1}.	Ambica Biotech, MP
Mycorrhizae	10^5 propagules/kg with carrier material (Talc powder / Vermiculite)	Mobilize major nutrients like, phosphorus and potassium and certain micronutrients like zinc, calcium etc.	**Soil**: 5-10 kg of VAM ha^{-1} is recommended along with the 1 q of FYM; 25 g plant^{-1}.	Dr. Rajan Laboratories, Tamil Nadu
JOSH Super/JOSH Plus	Mycorrhizal (*Glomus intraradices*)	Root development in plant enhence growth	**Soil**: 5 kg acre^{-1} for all crops, 60 infective propagules g^{-1}	Cadila Pharmaceuticals Limited, Gujarat
Shubhodaya	Vesicular Arbuscular Mycorrhiza (with three species- 1-Isolated from desert and adoptable to harsh water strained condition. 2-Adoptable to water lodging conditions and 3-Adaptable to general and acidic/basic soil conditions.)	Improved uptake of nutrients	**Soil**: 5 -10 kg acre^{-1}	Cosme Biotech, Goa
TARI VAM	Vesicular Arbuscular Mychorrhiza	Mobilize nutrients like, phosphorus and zinc	**Soil**: 5 -10 kg acre^{-1}	TARI Biotech, Tamil Nadu
BioCarry	Vesicular Arbuscular Mycorrhiza (VAM)	Helps in efficient mobilization and uptake of fertilizers and other nutrients by plants.	**Soil**: 5 kg acre^{-1}	Sundaram Overseas Operation, Gujrat
Symbion VAM	Solid formulations of Arbuscular Mycorrhiza	Improved uptake of nutrients, root development in plant and growth	**Soil**: 5 kg acre^{-1}	T. Stanes and Company Limited, Tamil Nadu
CAMBAY's VARDHAK	Arbuscular Mycorrhiza (Powder and Tablets)	Helps in efficient mobilization of nutrients	**Soil**: 5 kg acre^{-1}; one tablet plant^{-1}	Neesa Agritech Private Limited Ahmedabad, Gujarat
Mycorrhiza – VAM	Arbuscular Mycorrhiza	Mobilize nutrients like, P, Zn, Cu and B	**Soil**:10 kg acre^{-1}	KCP Sugar and Industries Corporation Ltd
Mycorrhiza-AM Biofertilizer	Arbuscular Mycorrhiza	Helps in efficient mobilization of nutrients and improved plant growth	**Soil**: 5 kg acre^{-1}	Majestic Agronomics Pvt. Ltd., HP
Colonizer	Arbuscular Mycorrhiza (powder)	Colonizes living plants roots. Improves phosphorus uptakeand imparts stress and disease resistance.	**Soil**: 2-3 kg acre^{-1}	Krishidhan Seeds Pvt. Ltd, Maharastra

Formulation

There are a wide variety of formulation types, both liquid and solid in biofertilizers. The main types, currently used for organisms, have been classified into dry products (dusts, granules and briquettes) and suspension (water-based and emulsions). Dusts particle size ranged from 5-20 mm and contain <10% of an organism by weight. Granules are discrete masses, 5-10 mm^3 in size. Pellets are >10mm^3 and briquettes has large blocks up to several cubic centimeters. These products contain an inert carrier like charcoal, lignite, clay minerals (vermiculite, bentonite), starch polymers, dry fertilizers and ground plant residues. Choice of carrier depends on absorption, hardness, bulk density and product disintegration rate in water. The product can be coated with various materials to slow and control the rate of release, which also depends on unit size. Presently, biofertilizers are prepared as carrier based formulations and lignite is the most widely used carrier material. In the solid based bio-fertilizers, the microorganisms have a shelf life of only six months. They are not tolerant to UV rays and temperatures more than 30° C. The population density of these microbes is only 10^8 CFU/ml at the time of production. This count reduces with time. In the 4th month it reduced to 10^6 CFU /ml and at the end of 6th month the count is almost nil. Again the improper sterilization of carrier material and handling such as mixing the organism with carrier and packing serve as source of contaminations. Because of this, the inoculant packet could not hold desired biofertilizer organism for longer time period and were not found effective and did not become popular among the farmers. Further, the quality of the biofertilizer gets deteriorated. Because of these reasons, biofertilizer application could not be able to give viable results in the field. Hence, the liquid formulation of organisms with a count of 10^9 CFU/ml (*Azospirillum* and *Phosphobacteria*) was developed to avoid drawbacks of biofertilizer and to increase the quality and shelf-life of bioinoculants. Preservatives were added with the microbial cultures and packed in quality bottles. The shelf life of the microbes in these liquid bio-fertilizers is about 2 years. They are tolerant to high temperatures and ultra violet radiations. As a matter of fact the application of 1 ml of liquid bio-fertilizers is equivalent to the application of 1 kg of 5 months old carrier based bio-fertilizers.

Advantages of biofertilizer

As it is well known that synthetic fertilizers are made from nonrenewable fossil fuel resources, create nutrient imbalance in the soil and often used in excessive amounts. Soils and plants are becoming dependent on the synthetic fertilizers, which increases their negative effects. Biofertilizers are the natural way to get the benefits of synthetic fertilizers without risking the quality of soil health and crop products. Biofertilizers are known to play a number of vital roles in soil fertility, crop productivity and production in agriculture as they are eco-friendly but can not replace chemical fertilizers, which are indispensable for getting maximum crop yields. Biofertilizers can increase the crop yield by 20 to 30 per cent. In addition, biofertilizers are cost effective, when compared to synthetic fertilizers. Some of the important functions or roles of biofertilizers in agriculture are:

- Phosphate mobilizing or phosphorus solubilizing biofertilizers / microorganisms (bacteria, fungi, mycorrhiza etc.) converts insoluble soil phosphate into soluble forms by secreting several organic acids and under optimum conditions, can solubilize / mobilize about 30-50 kg P_2O_5/ha and crop yield may increase by 10 to 20 per cent.
- Mycorrhiza or arbuscular mycorrhiza, when used as biofertilizer enhance uptake of P, Zn, S and water, leading to uniform crop growth and increased yield and also enhance resistance to root diseases and improve hardiness of transplant stock (Pal *et al*. 2014).
- Liberate growth promoting substances and vitamins and help to maintain soil fertility.
- Act as antagonists and suppress the incidence of soil borne plant pathogens and thus, help in the bio-control of diseases.
- Plays important role in the recycling of plant nutrients.
- Supplement chemical fertilizers for meeting the integrated nutrient demand of the crops.
- Renewable source of nutrients.
- Sustain soil health.
- Supplement chemical fertilizers.
- Replace 25-30 per cent chemical fertilizers.
- Increase the grain yields by 10-40 per cent.
- Decompose plant residues and stabilize C:N ratio of soil.
- Improve texture, structure and water holding capacity of soil.
- No adverse effect on plant growth and soil fertility.
- Stimulates plant growth by secreting growth hormones.
- Secrete fungistatic and antibiotic like substances.
- Solubilize and mobilize nutrients.
- Eco-friendly, non-pollutants and cost effective.

Mode of action

Biofertilizers promote crop growth by several mechanisms with the primary one varying as per function of environmental conditions. Although the mechanisms of commercially available biofertilizers are not always entirely understood, growth promotion has been identified as the result of indirect or direct mechanisms. Indirect plant growth promotion may be associated with biological control. Conversely, direct growth promotion mechanism may provide some compounds essential for crop establishment, growth and stimulate nutrient uptake. Biofertilizers solubilize the insoluble forms of phosphates like tricalcium, iron and aluminium phosphates into available forms. They scavenge phosphate from soil layers, produce hormones and anti metabolites, which promote root growth. Biofertilizers decompose organic matter and help in mineralization in soil. The principal mechanism for mineral phosphate solubilization is the production of organic acids and acid phosphatases, which play a major role in the mineralization of organic phosphorus in soil. It is generally accepted that the major mechanism of mineral phosphate solubilization, is the action of organic acids synthesized by soil microorganisms. Production of organic acids, result in acidification of the microbial cell and its surroundings. The production of organic acid by phosphate solubilizing bacteria has been well documented. Gluconic acid seems to be the most frequent agent of mineral phosphate solubilization. Ketogluconic acid is another organic acid identified in strains with phosphate solubilizing ability. Strains of *Bacillus* were found to produce mixtures of lactic, isovaleric, isobutyric and acetic acids. Other organic acids, such as glycolic, oxalic, malonic and succinic, have also been identified among phosphate solubilizers. Chelating substances and inorganic acids such as sulphideric, nitric, and carbonic acid are considered as other mechanisms for phosphate solubilization. However, the effectiveness and their contribution to P release in soils seems to be less than organic acid production. In recent years, use of artificially produced inoculum of mycorrhizal fungi has increased its significance due to their multifarious role in plant growth and yield, and resistance against climatic and edaphic stresses, pathogens and pests. The mechanism of symbiosis is not fully understood. Mycorrhiza forms an association with plant roots. It penetrates in the root cortex and spreads around the roots of the plant. As the name indicates, they posses sac like structure called vesicules, which stores phosphorus as phospholipids. The other structure called arbuscule helps bringing the distant nutrients to the vesicules and root. Bjorkman (1949) postulated the carbohydrate theory and explained the development of mycorrhiza in soils, deficient in available P and N and high light intensity. Slankis (1973) found that at high light intensity, surplus carbohydrates are formed, which exuded from roots, this in turn induces the mycorrhizal fungi of soil to infect the roots. At low light intensity, carbohydrates are not produced in surplus, therefore, plant roots fail to develop mycorrhizas. Further, some biofertilizers synthesize siderophores that can solubilize and sequester nutrient from soil and provide it to plant cells, thus contributing to the nutrition and development of crops.

Biofertilizer production-Indian scenario

Biofertilizer concept goes back as early as 300 BC, when our ancestors realized the importance of legume crops bearing nodules. The perspective of biofertilizer came into existence through discovery of many organisms, capable of nitrogen fixation, P-solubilization, P- mobilization, potash solubilization and micronutrient transformation in the soil. The role of biofertilizers assume special significance because of increased cost of chemical fertilizers and their ill effects on soil health. In India, the first documented production of bio-fertilizers in the form of *Rhizobium* was in the year 1934 by M.R. Madhok (Yadav and Raychaudhuri, 2004), but the first commercial production was initiated only in 1956 at the Indian Agricultural Research Institute, New Delhi and Agricultural College and Research Institute, Coimbatore. In India, the first study on legume *Rhizobium* symbiosis was conducted by N.V. Joshi and the first commercial production started as early as in 1956. However, the Ministry of Agriculture under the Ninth Plan initiated the real effort to popularize and promote the input with the setting up of the National Project on Development and Use of Biofertilizers (NPDB) during 1983-84. *Azospirillum* and Vesicular-Arbuscular Mycorrhizae (VAM) are recent discoveries. Growth in production remained very slow till the mid sixties (Tewatia, 2007). During 1965-1990 around 30 bio-fertilizers production laboratories were set up in the country to meet the demand and a lot of schemes, formulated to popularize their use in different legume crops. Nineties saw a dramatic surge in bio-fertilizers industry with adding of new bio-fertilizers such as *Azotobacter*, *Azospirillum*, PSBs and VAM (Adholeya, 2012) added to the list and total production jump was observed ten times in between 1989 to 2000 (Bhattacharya and Dwivedi, 2004). Starting from few tonnes, production and consumption increased gradually and reached a moderate figure of 28000 MT by 2009-10 (Fertiliser Association of India, 2011). Research in the field of microbial fertilizers is in progress in different research institutes of India. Several institutes of ICAR are producing commercial microbial fertilizers. However, further researches and encouragement from the government are needed to isolate and characterize more salt tolerant microbial strains using

modern biotechnological tools. The government should campaign for the utilization of these efficient and economic fertilizers because instead of considerable efforts by scientists, majority of the farmers in India are unaware of the use and fruitfulness of these microbial fertilizers.

The share of bio-inputs in agriculture is abysmally low. The market share is not even 1 per cent in India. Relatively speaking there is more rigour in estimation of bio-fertilizer market in India, because of the presence of some large producers in production of bio-fertilizers and comparatively this is more organized than other green inputs market (Rakshit and Bhadoria, 2002). Based on the gross cropped area in India and recommended doses of bio-fertilizers, potential demand is segregated into different categories of bio-fertilizer, such as *Rhizobium*, *Azotobactors*, *Azospirillium*, BGA and phosphate solubilizer, where demand differ widely. Contrary to the world bio-fertilizers scenario, Indian bio-fertilizers industry is not restricted to *Rhizobium*. There were changes in shares, whereas the intial increase was due to *Rhizobium.* The later growth phase was largely contributed by the moderate success in *Azospirillum* and by far the best performance by phosphorous solubilizing bacteria (PSBs). Presently phosphorous solubilizing bacteria accounts for about 55 per cent compared to other nitrogenous biofertilizers, which accounts for 45 per cent (NCOF Annual Report, 2007-08). Although actual production and the distribution of bio-fertilizers are below the targeted level but there has been a positive trend in India, with respect to production. The growth rate in installed bio-fertilizer capacity is comparatively more stable than the growth rate in total production, consumption and distribution. This is an indication that there is not only a need but also a role for market development for green agriculture inputs in India. Inspite of the impressive growth rate of more than 200 per cent in production capacity and around 300 per cent growth rate experienced in production and consumption of bio-fertilizers in India. In the recent past yet it is only around 1.5 per cent of the estimated demand potential for bio-fertilizers in the country. The region wise distribution of bio-fertilizers is more dispersed in relation to chemical fertilizers across the country. As per the latest data available on bio-fertilizers, South Indian state Andhra Pradesh has overtaken another South Indian state Tamil Nadu in bio-fertilizer production to reach the top. The other major producers of bio-fertilizers are Karnataka, Kerala, Maharashtra and Madhya Pradesh. The highest number of units are located in the state of Maharashtra. A good degree of large industrial chemical fertilizer units like IFFCO, KRIBHCO, TCL, MFL, NFL and RCF are also involved in bio-fertilizer production as their corporate social responsibility along with chemical based fertilizers, insecticides and pesticides. Among the PSU's, KRIBHCO produced highest amount followed by IFFCO, MFL, NFL and RCF. Due to intensive and continued assistance from Government of India in this regard, overall production of bio-fertilizers in the country continuing with positive growth rate.

Common perception of biofertilizer

However, the market for bio-fertilizers is still not well developed and the bio-fertilizer industry has not anticipated the growth. The current strategy of marketing biofertilizer products in India is through niche markets. The scope for a particular bio-fertilizer is often perceived to be limited. Bio-fertilizers are often perceived to be more expensive than the chemical fertilizers. This is more so, since the farmers and small holders received fertilizers heavily subsided by the government, enabling a few farmers, who appreciate the benefits of use of certain biofertilizers. Another perception on biofertilizer is its slow effect on the crops as compared to chemical fertilizers. Special care (storage, mixing with powders, etc.) is also needed to handle microbial inocula, so that these remain effective for extended use. These inoculant too, favours certain environment. Concerning microbial inoculants, some users realised their potential. There was difference of opinion on the effectiveness of microbial inoculants available in the market. Some felt that the performance of these products is often disappointing, unreliable and not as claimed by the manufacturer. Some products, however, do give good results. All these perceptions contribute to influencing the user on the use of microbial inoculants and biofertilizers. The way to forward the produce is that it may satisfy the users in terms of versatility, ease of use and cost. The use of bio-fertilizers has still not spread uniformly, although there has been a steady rise in their use by certain group of farmers.

Quality control

Quality of biofertilizer is one of the most important factors resulting in their success or failure and acceptance or rejection by end-user, the farmers. Efforts to promote the use of these substances in the past have been hampered by poor and uneven quality. Survey of farmers show that poor quality of biofertilizers is largely responsible for the poor acceptance by users. Basically the quality means the number of selected microorganisms in the active form per gram or milliliter of biofertilizer. Quality standards are available only for *Rhizobium* in different countries. The required level of organisms can not be established as a general standard, because it varies from one bacterial species to another and as per conditions. Hence, specifications of biofertilizer differ from country to country and may contain parameters like the microbial density at the time of its manufacturing,

microbial density at the time of expiry, expiry period, permissible contamination, pH, moisture, microbial strain and the carrier. Quality has to be controlled at various stages of production (during mother culture stage, carrier selection, broth culture stage, mixing of broth and culture, packing and storage). Inoculant shall be packed in 50-75 micron 1000 density polythine packets and should be marked prominently the following :

- Name of the product
- Name and address of manufacturer
- Name of the carrier
- Batch number
- Date of manufacturing
- Date of expiry
- Net mass
- Crop for which intended
- Storage instruction (15-30± 0.2°C)

Countries like India have regulations for inoculant quality, but neither it is regulated properly nor are the existing regulations well enforced. Bureau of India Standards (BIS) has published necessary specifications/standards for different bio-fertilizers. But these specifications are purely voluntary in nature and are being regulated on firms and producers, who have opted for BIS certification and putting for BIS certification and putting ISI mark on their products.The general parameters of biofertilizer in India are presented in Table 3 and 4.

Gaps exist between India and some of the leading countries in all areas of biofertilizer production and application technology. These gaps are important, particularly in the field of strains, techniques used for sterilization, fermentation and carriers. The effects of these are aggravated further by poor quality control maintained by most of the producers. Under such circumstances, a significant increase in the level of penetration and demand of biofertilizers is possible only, if these gaps are reduced and strict quality control is maintained. While promotional efforts are important, but the success of such efforts will depend on the availability of biofertilizers of high and consistent quality. A system by which the quality is monitored by the central and state level authorities must be devised and enforced.

Future trend in fungal bio-fertilizers

The use of fungi as biofertilizers is not new, a most of these have been developed in the last two decades. There are numerous reports stating the success in promoting plant growth as biofertilizers. Fungal biofertilizers help to

Table 3. General parameters of biofertilizer in India

Parameter	Liquid	Powder	Granular
Appearance	Without strange smell	Brown or black	Brown
P bacteria(CFU)	>0.5-1.5x10^9 ml^{-1}	>0.1-0.3x10^9 g^{-1}	>0.1-0.2x10^9 g^{-1}
Water content (%)	-	20-35	10
Size (mm)	-	0.18	4.5
Organic matter (%C)	-	>20	>20
pH	5.5-7.0	6.0-7.5	6.0-7.5
Contamination (%)	<5	<15	<20
Valid period	>6 months	>6 months	>6 months

Table 4. Indian standard specification for phosphate solublizing inoculants

Parameter	Phsophate solubilizing inoculant
Base	Carrier based
Viable count at the time of manufacturing	10^7 cfu g^{-1} of carrier
Viable count at the time of expiry	10^6 cfu g^{-1} of carrier within 15 days
Shelf life/expiry date	Not < 6 months
pH	6.5-7.5
Moisture (%)	35-40
Carrier material	Peat, lignite peat soil, charcoal in the form of powder
Plant test phosphate solublization	Phosphate solublizing ability in the range of 35-50 per cent and in terms of zone formation, minimum 10 mm solublization zone.

minimize the use of synthetic chemical fertilizers. This is beneficial since synthetic chemical probably compounds have detrimental affects on humans and the environment (Sarma *et al*. 2012; 2014). Fungal biofertilizers are presently used on a very small scale as compared to chemical compounds. There has been little investment in the research and development of fungal products because these may have poor effect in the field. Still there is a wide gap between the unpublished research carried out in laboratories as compared to development for use in the field (Keswani *et al*. 2014). Future research therefore must develop fungal products, which have significant effect in field applications and are stable under storage. Aspects, which need to be considered for the purpose should include:

- Strains of beneficial fungi to be used
- They must be reliable and cheap to be produced on the large scale
- Strains may not be detrimental to the environment
- They must be safe to humans and the environment
- Patentability of the formulation to be possible

Greater communication is needed between researchers and industry in the early stages of development. Integration or combination of inocula or combinations with other beneficial fungi should be considered as combinations may be more effective than a individual ones. The production of fungal biofertilizers should be directed to a new focus that will search for commercial properties through the use of biotechnologies of the inoculation of fungi. Its benefits should clearly be demonstrated to the growers, both through extension and proven field trials to increase the commercial interest. Research on other ecological fungi should be pursued to find out novel biofertilizers, eg., endophytic fungi, which are symptomless colonizer of plants and some, especially grass endophytes are symbionts (Tejesvi *et al*. 2010) could be exploited. Endophytes play an important role in ecosystem processes such as decomposition and nutrient cycling and thus may be utilized as biofertilzers. Endophytes also have beneficial symbiotic relationships with the seeds and roots of many plants, such as orchids (Zhu *et al*. 2008) and could be use to improve orchid seed germination and orchid growth. Endophytic fungi may also have roles in plant growth and survival by enhancing nutrient uptake and producing growth promoting metabolites such as gibberellins and auxins (Khan *et al*. 2012). These endophytes have shown the benefit to host plant, including tolerance to herbivory, heat, salt, disease, drought and increased below and above ground biomass.

The use of mycorrhizal fungi as biofertilizers is often limited due the fact that they will not grow in artificial culture. Ways should be found out by which these fungi can grow in culture and produce inocula. As mentioned above, plate cultivation of these fungi with tissue culture plants may be a solution. *Phlebopus portentosus*, the black bolete, is purportedly mycorrhizal and forms associations with several fruit trees (coffee, mango, and jack fruit). Lumyong *et al*. (2009) have successfully grown this species on artificial media, may be good for *in vitro* cultivation. This fungus is a perfect target for a biofertilizer since it should enhance tree growth and produce an annual crop of the expensive Black Bolete, which is a sort of fungus, which demands a good price. The move towards safe and organic food production with increase biofertilizer use and thus it will result in environment and ecosystem safety. Reduction in the use of inorganic fertilizers is necessary to maintain ecosystem and develop sustainable agriculture. Research and development on fungal biofertilizers should therefore emphasize on improving effective stable strains for promoting plant growth though traditional and molecular techniques.

Constraints in bio-fertilizer use

Despite significant improvement and progress in biofertiliser technology over the years, the progress in the field of its production technology is below satisfaction. Further, there do exist obstacles for biofertilizer use. These are not only technical problems, but also socio-economic and human resource obstacles. The technical problems can be addressed through a comprehensive programme of basic and applied research up to a certain extent. Overcoming the socio-economic and human resource obstacles, would require an emphasis on education, training and the promotion of private-enterprise. The difficulties to expand the use of biofertilizer by farmers in India are as follows:

- Difficult handling of biofertilizer
- Problems with distribution
- Low quality of biofertilizer
- Can not be stored for longer period
- Lack of demonstration and low visual effect of biofertilizer
- Low in public relation and technology transfer
- Low knowledge of farmer on sustainable agriculture and environmental effect of biofertilizer

Conclusion

There is a general consensus on the benefit of bio-fertilizers usage particularly for small farmers in the context of current climate change concerns as a cheap and safe source of input for agriculture. The benefits of using fungi as biofertilizer, includes decreasing the occurrence of plant

diseases by inhibiting the growth of pathogens, suppressing the amount of inocula of pathogens, increasing in uptake of nutrient from the soil or atmosphere and producing bio-active compounds, hormones and enzymes, which stimulates plant growth. Bio-fertilizer usage has been found to reduce chemical fertilizer usage by about 20 per cent in some cases and increase the crop production. There are many commercial fungal biofertilizers available worldwide. Using fungal biofertilizers offer more environmentally friendly alternatives than chemical fertilizers. However, there are some limitations in using these products. The success can be affected by environmental conditions, while application difficulties, limited shelf life and slow action as compared to chemical products may discourage farmers the use of biofertilizers. Research on the development of fungal biofertilizers needs to be carried out so that more effective products are produced. A lot of research done in the past few decades has enabled these fungi to emerge as a potential biofertilizer, a cheap and environment friendly alternative to expensive and harmful chemical fertilizers. This aspect of an alternative to conventional route to more food grain production in a sustainable manner especially gains significance for a developing countries.The judicious and large scale utilization of this technology can prove very useful for getting maximum and long-term gains in various wasteland reclamation, reforestation and afforestation programme apart from giving a much desirable thrust in the production of important agricultural crops. The AM biofertilizer technology can be called poor man's technology. Taking into account the amount of nutrient supplied, biofertilizers are many fold cheaper than chemical fertilizers. Biofertilizers improve the quality of produce. These are cheap and economical, the cost benefit ratio is more than 1: 10. It is an ecofriendly practice, improves natural parameters of the soil. Uses of biofertilizers maximize ecological benefits and minimize environmental hazards. The demand of biofertilizers is increasing at a tremendous pace, which necessitates the establishment of more units in the field to rope of the outgrowing demand potential and the challenges of fabulous future scope.There is a great potential for the biofertilizer industry in India, producing products from local sources and natural resources. Among the fungal biofertiliser, mycorrhizal biofertilizer products will greatly appeal to the industry, mainly due to its versatility and use of environment friendly technology. Quality control of products is of great importance. This is always a challenge with microbial products, because the mass production of living organisms tends to select those best suited to mass production, rather than those found more effective in the field. Research in the field, supported by advanced technology will enhance biofertilizer use in the country as well as profitability for the small and marginal farmers.

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Effect of organic manures and biofertilizers on nutritional quality of cabbage *(Brassica oleracea var. capitata)*

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ABSTRACT

The present investigation was carried out to study the performance of cabbage as influenced by organic manures and biofertilizers at Horticulture farm, Assam Agricultural University, Jorhat during 2009 and 2010. Combined use of organic manures and biofertilizers (PSB + AZB) registered head yield at par to control (RDF). Yield was highest (23.55t ha^{-1}) under NPK (120:60:60 kg ha^{-1}), which was at par with PSB and AZB (enriched compost). Ascorbic acid, leaf P and K, ash content and minerals were recorded higher under organic along with biofertilizers (PSB + AZB) treatment. However, leaf N, moisture and protein contents were higher with recommended dose of fertilizers (120N:60P:60 K ha^{-1}). Significantly highest storage life was recorded with the treatments, application of biofertilizers (PSB + AZB) along with organic manures as compared to conventional treatment at ambient room temperature.

Key words: Cabbage, organic manures, biofertilizers, yield, quality, *Azotobacter*, PSB, FYM.

Cabbage (*Brassica oleracea* L. var. *capitata*) is an important winter vegetable crop, which provides more vitamins, minerals and fibres to our diet and also have some medicinal properties. But the cabbage is a heavy feeder and removes the N, P and K from soil to larger extent. In modern agriculture, continuous and indiscriminate use of chemical fertilizers, pesticides, herbicides etc. has adversely affected the soil fertility, biodiversity, quality of the produce and human health. There are also evidences that the intensive agriculturel has resulted in decline in vitamins and minerals content of fresh fruits and vegetables over last six decades. Use of organic manures along with biofertilizers is not only helpful in improving soil health, growth and yield and quality but also avoids chemical based farming (Sankaran, 1996; Sarkar, 2001; Bahadur *et al.* 2003; Sable and Bhamare, 2007).

Organically grown foods are more healthier and contains minerals and vitamins than conventional crops (Warman and Havard, 1997; Worthington, 2001; Magkos *et al.* 2003; Bahadur *et al.* 2003; 2004) and also improve keeping quality at room temperature and in storage of vegetables (Vogtmann *et al.* 1993; Singh, 2006; Umlong, 2010). Organically grown crop had higher dry matter content than conventionally grown crops (Fjelkner-Modig *et al.* 2000; Ghuge *et al.* 2007). A considerable scientific data have been generated, which shows that the combined and sole application of organic amendments and biofertilizers increased yield, influenced quality attributes and soil health in several vegetables (Worthington, 2001; Bahadur *et al.* 2003; 2004). However, information on effect of organic manures and biofertilizers on quality of cabbage is lacking, hence present study was carried out.

MATERIALS AND METHODS

The present work was conducted at experimental farm of Department of Horticultural, Assam Agricultural University, Jorhat during 2009 and 2010. The experimental area was not used for any agricultural activity before setting up the experiment. FYM, optimal compost, enriched compost and lime mediated organics (LMO) were used as organic manures. The sources of organic manures are produced by Department of Soil Science. The experimental site was established under a Randomized Block Design with ten treatments under open condition and each treatment replicated thrice. The treatments used were optimal compost @ 10 t ha^{-1} (T_1), T_1 + biofertilizers (PSB + AZB) (T_2), enriched compost @ 10 t ha^{-1} (T_3), T_3 + biofertilizers (PSB + AZB) (T_4), FYM @ 10 t ha^{-1} (T_5), T_5 + biofertilizers (PSB + AZB) (T_6), lime mediated organics @ 10 t ha^{-1} (T_7), T_7 + biofertilizers (PSB + AZB) (T_8), biofertilizers (PSB + AZB) (T_9) and (T_{10}) recommended dose of fertilizer (RDF 120N:60P:60K kg ha^{-1}). All the organic manures were applied once as a basal dose and being incorporated in to the soil before 15 days of transplanting of seedlings. The RDF were applied in the form of urea (N-46%), SSP (P-16%) and MOP (K-60%). Full dose of P and K along with half of N were applied as basal and rest half of N were applied as side dressed during the growth season (one month after transplanting). Four weeks old seedlings of cabbage (cv. Golden Acre) was inoculated in the form of slurry of biofertilizers (1 kg culture + 200g jaggry + 2 l water) for 15 minute before transplanting and planted

in the month of October with the spacing of 45 x 45 cm. All the other cultural practices were applied as per normal packages of practices. The observations were recorded on growth parameters and yield attributes by using standard procedure. Data were analysed as per the statistical methods given by Panse and Sukhatme (1995).

Among the quality parameters, soluble protein content in cabbage was estimated by Lowry's *et al.* (1951). Vitamin -C (mg 100 g^{-1} of fresh weight) was estimated using 2, 6-dichlorophenol indophenol visual titration method, described by Ranganna (1986) and A.O.A.C. (1995). Ash content was determined by using dry ashing methods outlined by Ranganna (1986). Storage life was determined by physiological loss in weight (%) at 10 days after storage at ambient room temperature. After harvest, fresh weight of each head and total yield was recorded and expressed as t ha^{-1}. A sample (100 g) of the head was chopped and dried in oven at 60 ± 5 ^{0}C and per cent dry matter was recorded. Afterward, dried samples were passed through 40 µm mesh sceive and stored in plastic containers for determination of mineral contents. The plant samples were processed after drying in oven at 70 ^{0}C and were pre-digested with nitric acid. Afterwards, all the plant samples were analysed for total nitrogen content by Micro Kjeldahl's method (AOAC, 1995). Phosphorus and potassium content were estimated by using tri-acid digestion (Jackson, 1973) in the ratio of 10: 4: 1(HNO_3: $HCLO_4$: H_2SO_4). The individual minerals *viz.*, Ca. Mg, S, Fe, Mn, Zn and Cu were estimated with AAS (Atomic Absorption spectrophotometers Chemito, AA 203 P, Double Beam) as used by L'vov (2005). It is based on the principle of volatilization of atoms, which absorb by light at specific wave length. The mixture are prepared and digested with diacid (9:4, mixture of HNO_3 and $HClO_4$) digestion mixture.

RESULTS AND DISCUSSION

Quality parameters

Ascorbic acid: Ascorbic acid content was found higher with combined application of organic manures and biofertilizers and also in the treatment with organic manures alone than the treatment with inorganic fertilizer. It is clear from the result that the highest ascorbic acid content was (32.68 mg 100 g^{-1}) under enriched compost (10t ha^{-1} + biofertilizers PSB + AZB). However, lower ascorbic acid content was (15.53 mg 100 g^{-1}) in RDF treatment (Table 1). The negative relationship between nitrogen levels and vitamin-C content can be seen. This might be due to exposure of plant with more of nitrogen, which increases protein production but reduces carbohydrate. Since vitamin-C is made from carbohydrate, the synthesis of vitamin-C is also reduced. Similar finding has been reported earlier (Worthington, 2001; Bahadur *et al.* 2006; Citak and Sonmez, 2010).

Protein : The highest protein content (1.37g 100 g^{-1}) in cabbage was obtained (Table 1) under application of inorganic fertilizer (RDF). The increase in protein content with higher dose of nitrogen might be due to the fact that nitrogen is a major contributor of protein and amino acids, the synthesis of which is accelerated by its supply in the soil. If, nitrogen is adequate and other conditions found favourable for growth, proteins are formed from the

Table 1. Effect of organic manures and biofertilizers on quality parameters and yield of cabbage

Manure/biofertilizer	PLW(%)	Moisture content (%)	Dry matter of head (%)	Ash content (%)	Ascorbic acid content (mg 100g^{-1})	Protein content (g 100g^{-1})	Yield (t ha^{-1})
Optimal compost (10 t ha^{-1})	13.16	91.00	5.23	9.24	24.12	0.76	18.02
T_1 + Biofertilizers PSB + AZB (1 kg culture + 200 g jaggery + 2 l water)	14.57	91.93	6.63	8.94	25.87	0.80	19.61
Enriched compost (10 t ha^{-1})	13.82	91.41	6.07	9.39	23.16	0.91	20.65
T_3 + Biofertilizers PSB + AZB	14.40	91.71	6.67	9.43	32.68	0.94	21.90
FYM (10 t ha^{-1})	13.53	92.09	6.42	8.32	22.10	0.84	16.66
T_5 + Biofertilizers PSB + AZB	14.53	90.64	6.87	8.02	24.36	0.83	18.28
Lime mediated organics (10 t ha^{-1})	16.73	89.54	5.33	7.47	21.71	0.80	19.69
T_7 + Biofertilizers PSB + AZB	14.77	90.37	5.65	7.47	24.32	0.83	20.86
Biofertilizers PSB + AZB	12.50	91.54	6.02	8.10	17.16	0.67	12.53
RDF (120N:60P:60K kg ha^{-1})	24.90	93.17	4.59	6.14	15.53	1.37	23.35
C.D (5%)	0.79	1.38	1.04	0.27	0.35	0.23	2.37

manufactured carbohydrates. Similarly, higher level of protein with increasing nitrogen rate has been clearly demonstrated in potato (Kumpulainen, 2001) and brinjal (Shelke *et al.* 2001).

Ash : Ash content represented the total amount of non combustible substances present in the plant product. Ash content of organically grown cabbage was found significantly higher (Table 1) as compared to conventionally grown crops. The higher (9.43%) ash content was recorded under enriched compost (10t ha^{-1} + biofertilizers PSB+AZB). Probably, this might be due to less intense use of fertilizer in organic agriculture and therefore organic vegetable are smaller and contains less water content (Basker, 1992). The minimum ash content (6.14%) was recorded in treatment RDF.

Moisture and dry matter: The maximum moisture content (93.17%) and lowest dry matter (4.59) were recorded in treatment RDF (120N:60P:60K kg ha^{-1}). Moisture content and dry matter of product is correlated to each other. Highest dry matter content (6.87%) in organic product, FYM + PSB + AZB (Table 1) can be explained by the fact that the lower nitrogen supply under organic management, plants tend to enhance synthesis of nitrogen poor molecules (polyphenols, cellulose, starch) instead of the synthesis of nitrogen rich compounds such as amino acids, proteins, or alkaloids, which resulted in an increase in the dry matter content of the product (Fjelkner-Modig *et al.* 2000; Herencia *et al.* 2011). Similar results were obtained by Piper and Barlette (2009) and Bahadur *et al.* (2006). According to them the higher dry matter in organically grown tomato may be because of higher moisture content in conventionally grown crops, which might be responsible for lower soluble and total solid contents due to dilution.

Physiological loss in weight : The physiological loss in weight (PLW) was highest (24.90 %) in RDF (Table 1) and differ significantly from other treatments. However, the higher shelf life (12.5% PLW) was recorded under biofertilizers (PSB + AZB).The application of biofertilizers probably reduced the respiration rate, which in turn resulted in higher storage life and reduction in PLW. The higher moisture content in inorganic cabbage leads to more percentage of respiration, rotting and decaying due to increased microbial activity and ultimately decrease in its shelf life. Results similar to our findings are reported in cucumber (Mali, 2004); bitter gourd (Mulani *et al.* 2007) and carrot (Umlong, 2010).

M**ineral :** The significantly higher mineral contents, particularly Fe, Mn, and Cu were recorded with the treatment enriched compost (10t ha^{-1} + biofertilizers PSB+AZB). However, among other mineral, Ca content was highest (Table 2) in lime mediated organics (10t ha^{-1}), while Mg content was highest in lime mediated organics (10t ha^{-1} + biofertilizers (PSB+AZB). The zinc content of all organically grown cabbage was found significantly higher than the inorganic treatment (RDF). The zinc content was maximum in optimal compost (10t ha^{-1}) + biofertilizers PSB+AZB). Application of organic nutrient sources increased the quality parameters because soil that has been managed organically has congenial environment for microorganisms, which produce compounds that influence the plant to absorb more micronutrients from soil. It is also reported that substances such as citrate and lactate, when combined with soil minerals, enhanced their availablity to plant roots. This is especially important for iron as many soil contains adequate iron but in unavailable form. Moreover, application of biofertilizers in the treatment along with the manures may result in increased uptake of all macro and micronutrients,

Table 2. Effect of organic manures and biofertilizers on mineral contents of cabbage

Manure/biofertilizer	Ca (mg $100g^{-1}$)	Mg (mg $100g^{-1}$)	S (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)
Optimal compost (10 t ha^{-1})	23.06	9.03	0.26	229.68	18.52	62.93	7.12
T_1 + Biofertilizers PSB + AZB (1 kg culture + 200 g jaggery + 2 l water)	23.87	9.87	0.41	82.28	18.52	80.36	7.12
Enriched compost (10 t ha^{-1})	29.80	10.00	0.27	89.48	17.67	36.10	8.56
T_3 + Biofertilizers PSB + AZB	39.33	12.56	0.40	236.80	22.98	26.82	12.91
FYM (10 t ha^{-1})	33.66	11.68	0.29	166.08	22.07	55.40	10.23
T_5 + Biofertilizers PSB + AZB	36.00	13.58	0.34	194.26	18.52	39.08	12.23
Lime mediated organics (10 t ha^{-1})	42.06	11.07	0.38	173.12	16.34	36.12	3.20
T_7 + Biofertilizers PSB + AZB	41.37	13.95	0.27	63.44	17.67	33.15	3.20
Biofertilizers PSB + AZB	21.50	9.23	0.21	101.14	17.62	33.10	2.60
RDF (120N:60P:60K kg ha^{-1})	20.35.	8.78	0.17	48.60	13.2	23.86	2.60
C.D (5%)	0.46	0.48	0.02	0.86	0.36	0.55	0.20

which might be one of the reason for increase in mineral content of cabbage. Similarly, an increased mineral content of vegetables due to addition of manures and biofertilizers over conventionally grown vegetables are reported by several workers (Woese *et al.* 1997; Worthington, 2001; Shelke *et al.* 2001; Magkos *et al.* 2003; Shankar *et al.* 2009).

Leaf NPK : The highest nitrogen content (2.27%) was recorded under treatment RDF (Table 3). This might be due to the amount of nitrogen added as chemical fertilizer in comparison to compost. However, in organic plots, the nitrogen is not immediately available for plant uptake until mineralization. This attributed to the slow availability of adequate nutrients throughout the crop growth period. Conversely, in chemical fertilization, nitrogen is immediately available to plants and an increase in plant uptake. Similar results are reported by Worthington (2001), Shankar *et al.* (2009) and Herencia *et al.* (2011). Opposite to nitrogen, the phosphorus content in general was higher in organic treatments. The increase in phosphorus content might be due to increased availablity of soil phosphorus because of solubilizing effect of organic acids, which are produced from decomposing organic manures. Further, PSB helps in solubilizing the insoluble phosphorus into soluble form and also reduce the fixation of phosphorus, hence, the availability and the absorption of phosphate by the plant was more. Similar, results have been reported by Reddy (1999) and Herencia *et al.* (2011).

The maximum (5.50%) potassium content (Table 3) was in enriched compost (10t ha^{-1} + biofertilizers PSB+AZB). This might be due to organic matter, which increased the level of exchange capacity of soil and could increase the level of available potassium in soil. On the other hand, this soil showed more microbial activity because of organic manures (Melero *et al.* 2006). It is known that microorganisms can solubilise mineral in the rock and can provide a continuous supply of potassium for the plant growth. The results are in conformity with the findings of Harencia *et al.* (2007), Warman and Havard (1997) and Umlong (2010).

Yield

The highest yield (23.35 t ha^{-1}) was recorded in RDF (Table 1), which was at par with enriched compost + biofertilizers (21.90 t ha^{-1}). Higher yield under RDF might be due to the higher level of nutrient added to the soil and uptake by the plant, leading plant height, number of leaves resulting in early head formation (Poinker *et al.* 2006; Thakur *et al.* 2010). Irrespective of types of organic manures, in all cases the treatments with biofertilizers recorded more yield than the treatments without biofertilizers.

The results of the present investigation revealed that the treatment receiving organic sources of nutrient was found to be best in all quality parameters except nitrogen and moisture contents in cabbage.

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Table 3. Effect of organic manures and biofertilizers on NPK content of cabbage leaf

Manure/biofertilizer	Nitrogen (%)	Phosphorus (%)	Potassium (%)
Optimal compost (10 t ha^{-1})	1.64	0.60	4.80
T_1 + Biofertilizers PSB + AZB (1 kg culture + 200 g jaggery + 2 l water)	2.08	0.70	4.90
Enriched compost (10 t ha^{-1})	2.04	0.80	5.28
T_3 + Biofertilizers PSB + AZB	2.12	0.99	5.50
FYM (10 t ha^{-1})	1.23	0.60	4.99
T_5 + Biofertilizers PSB + AZB	1.89	0.90	5.20
Lime mediated organics (10 t ha^{-1})	1.56	0.50	4.60
T_7 + Biofertilizers PSB + AZB	1.76	0.60	4.70
Biofertilizers PSB + AZB	1.25	0.50	4.20
RDF (120N:60P:60K kg ha^{-1})	2.27	0.40	2.70
C.D (5%)	0.12	0.03	0.14

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Impact of organic amendments on physical properties of theri soil and yield of groundnut

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ABSTRACT

A field experiment was conducted at Poochikadu district, Tuticorin during the year 2010-2011 to evaluate the effect of different organic amendments and their combination on various physical properties of theri soil and groundnut crop. Results revealed that the yield of pods was high with the combination of farm yard manure and composted coir pith in equal amount (12.5 t ha^{-1}). Bulk and particle density of the soil have decreased as compared to control. The water holding capacity, pore space, saturated moisture, hydraulic conductivity and permeability were found increased considerably. Thus it can be inferred that the application of amendments in the proper combination may be a good strategy to reclaim the theri soils of South India.

Key words: FYM, soil amendment, physical properties, yield, groundnut.

Groundnut, besides being a premier oilseed crop has now emerged as an important food crop because of excellent nutritional quality. Groundnut is an energy rich crop, but mostly grown under energy starved condition. Use of plant nutrients in lower quantity is one of the most important factors for low productivity in groundnut. The addition of organic materials are the only practical means of increasing aggregate stability of semi-arid soils. It also improves the soil physical properties, i.e., hydraulic conductivity and water holding capacity (Barzegar, 2002). The type of plants present in an area have a great impact on the quality of soil of that area as the plants and soil are strongly influenced by each other. Many soils do not have high degree of natural fertility for crop plants. Long period of cropping without addition of nutrients can impoverish a soil. In the present investigation, work has been conducted to find out the effect of organic amendments like FYM, comosted coir pith (CCP) and tank silt (TS) for the favourable change in physical properties of theri soil and yield of groundnut in south India.

MATERIALS AND METHODS

Field experiment was conducted at Poochikadu village, district Tuticorin, Tamil Nadu, which lies at 8°516' latitude and 78°052' longitude. Experimental field was prepared by ploughing and additions of treatments before 30 days of cultivation. The treatments used were farm yard manure (FYM), composted coir pith (CCP), tank silt (TS), FYM + CCP, CPP + TS, FYM + TS, FYM + CPP + TS and control (without any treatment). The organic amendments and their combinations were applied @ 12 t ha^{-1}. Groundnut (*Arachis hypogea.L*) cv. TMV-7 was grown, which has duration of 105 days. Soil samples were collected using V shaped cut at the depth of 15 cm, air-dried, ground, mixed, passed through 2mm sieve and analysed for their physical properties. The physical properties, particle density (PD), bulk density (BD), water holding capacity (WHC), pore space (PS) and saturated moisture (SM) were analysed by Keen Raczkowski (KR) box as given by Keen and Raczkowski (1921). Hydraaulic conductivity (HC) and permeability (PE) were analysed using Constant Head Permeater as given by Israelsen and Hansen (1962). The data were statistically analysed using analysis of variance (ANOVA) and least significant difference (LSD) to test the differences between individual treatments (Gomez and Gomez, 1984). Statistical software SPSS (Statistical Package for Social Sciences, Version 16.0) was used to compute the correlation (r - values) for all possible correlations among soil parameters (Montegomery *et al*. 2003). The software was used to calculate the regression parameters A and B of the straight line Y=A+BX by applying the well-known method of least squares (Wonnacott and Wonnacot, 1981; Gupta, 1974).

RESULTS AND DISCUSSION

Physical properties

Bulk density: The value of BD decreased in combined organic amendment treatments as compared to individual (Table 1). Among the various combinations, the minimum value (1.43 g cm^{-3}) of BD was noticed in FYM + CPP + TS. Similar conclusions were drawn by Melis *et al*. (2008), who opined

that bulk density decreased positively with increasing organic matter sources such as tobacco waste and manure. According to Jeyamangalam *et al*. (2011) BD was the lower with FYM+CPP+TS at equal combinations (12.5 t ha^{-1}) in comparison to control, which is in the line of present findings.

Particle density: The value of PD also decreased due to the effect of organic manure. Generally in the normal soil the particle density is 2.65 g cm^{-3}. The minimum value (2.25 g cm^{-3}) of PD was in FYM+CPP+TS plot, while it was 2.49 g cm^{-3} in control. The decrease was about 9.85 per cent. Almost similar results were reported by Jeyamangalam *et al.* (2012) in combination of FYM, CPP and TS.

Water holding capacity: The WHC increased due to addition of organic manure (Table 1) and it was high (30.53%) in FYM+CPP plot, which was 27.27 per cent more than control. It is reported (US.2009/0113791) that coconut coir pith has a high water holding capacity, ideal porosity, high cation exchange capacity and high stability (slow rate of degradation due to high lignin to cellulose ratio which prevents oxidation). Similar results were obtained by Saha *et al*. (2010), who reported the importance of the continuous application of balanced nutrition through lime, FYM, and microbial inoculants, induced substantial buildup of SOC (68.58%), associated with improvement in soil aggregate size (48.82%) and stability (39.57%), water retention and porosity (32.41%) of the soil over fertilizer NPK.

Pore space: The PS increased with the addition of organic manure (Table 1), which was higher (43.67%) in FYM+CPP as compared to control (35.55%). This is in line with the findings of Maragatham and Samuel (2010), who revealed that the bulk density decreased with the increase in coir pith particle size. Total porosity and aeration porosity increased along with the increase in particle size.

Saturated moisture: Addition of organic manure increased the SM (Table 1) and found more (31.08%) in FYM+CPP plot, which was 25.54 per cent higher than control plot. Report of Palve *et al.* (2011) confirmed the above result, who found that SM and its efficiency were cent per cent in treatment RDF with FYM (5 t ha^{-1}). Earlier report of Jeyamangalm *et al.* (2014) also confirms the present findings.

Hydraulic conductivity: The value of HC increased due to addition of various organic manure/amendments, FYM, CPP and TS. It was highest (0.33 cm hr^{-1}) in TS amended plot (Table 1) as compared to control (0.23 cm hr^{-1}). The available water in soil receiving tank sediment was 60 per cent higher than unamended native soil. Amended soil took 20 days to deplete from field capacity to wilting point as against 12 days with control (Osman *et al.* 1997), which is in the line of the present results.

Permeability: The PE was also highest (Table 1) in TS plot (3.27 mm hr^{-1}) in comparison to control (2.33 mm hr^{-1}). The results were in accordance with Malathesh (2005), who concluded that the farm yard manure seems to act directly by increasing crop yields either by acceleration of respiratory process by cell permeability or by hormone growth action. It supplies nitrogen, phosphorus and sulphur in available forms to the plants through biological decomposition. Indirectly, it improves physical properties of soil such as aggregation, aeration, permeability and water holding capacity.

Yield: The yield of pods in groundnut (Table 1) was highest (3135 kg ha^{-1}) in TS+CPP. It was 40.51 per cent higher than control plot. Jeevan Rao and Ramalakshmi (2009) reported that increased availability of nutrients enhanced the uptake of nutrients resulting in improved yields.

Table 1. Effect of organic amendments on physical properties of theri soil before groundnut harvest.

Organic amendments (12.5 t ha^{-1})	BD (g cm^{-3})	PD (g cm^{-3})	WHC (%)	PS (%)	SM (%)	HC (cm hr^{-1})	PE (mm hr^{-1})	Yield (kg ha^{-1})
FYM	1.58	2.46	25.43	38.21	24.18	0.25	2.48	2773
CPP	1.55	2.48	25.36	42.29	28.94	0.26	2.62	3065
TS	1.50	2.45	26.71	39.89	27.20	0.33	3.27	2833
FYM+CPP	1.43	2.49	30.53	43.67	31.08	0.28	2.78	2945
CPP+TS	1.49	2.37	26.76	39.57	27.76	0.23	2.34	3135
FYM+TS	1.52	2.34	23.97	36.95	25.14	0.26	2.56	2498
FYM+CPP+TS	1.43	2.25	25.85	37.57	26.54	0.27	2.64	2868
Control	1.60	2.49	22.21	35.55	23.14	0.23	2.33	1865
CD(P=0.05)	0.55	0.49	6.53	7.80	7.47	0.08	0.97	343.55

BD - Bulk density, PD - Particle density, WHC – Water holding capacity, SM – Saturated moisture, PS – Pore space, HC – Hydraulic conductivity, PE - Permeability

Table 2. Correlation between physical parameters and groundnut yield in soil (theri) amended with organic amendments

	Yield	BD	PD	WHC	PS	SM	HC	PE
Yield	1							
BD	-0.538	1						
PD	-0.206	0.523	1					
WHC	0.711*	-0.734*	0.084	1				
PS	0.725*	-0.421	0.375	0.831*	1			
SM	0.743*	-0.668	0.112	0.863**	0.939**	1		
HC	0.286	-0.364	0.100	0.445	0.403	0.396	1	
PE	0.286	-0.364	0.100	0.444	0.403	0.396	1.000**	1

* significant at 0.05 level, ** significant at the 0.01 level

Correlation in yield and physical characters

The organic amendment application (12.5 t ha^{-1}) showed positive correlation with WHC (r=0.711*, p=0.048), PS (r=0.725*, p=0.042) and SM (r=0.743*, p=0.035) and groundnut yield (Table 2). The step wise regression (SWR) equation is :

$$Y = -363.77 + 116.31^{*} SM \qquad R^2 = 55\%^{***}$$
$$(1149.31)\ (42.79)$$

Here, BD (0.169), PD (0.625), HC (0.492) >> P=0.05. Therefore, these parameters are not contributing yield.

Solving for SM the linear equation given is

$$SM = \frac{Y+363.7}{116.3}$$

As the value of SM is increased yield is also increased. It means, a unit increase in the value of amendment would produce 116.31 unit increase of SM.

The above findings revealed that organic farming could be able to sustain the soil fertility for a longer period by meeting the demands of present and future generations. Considering the salient findings in perspective, organic farming favourably influenced the soil physical properties over the inorganic, which in turn paved way for better crop yield and quality. Yield in CPP+TS (12.5 t ha^{-1}) was highest (3135 kg ha^{-1}), which was 40.51 per cent more than control. The findings of present study may be associated with the supply of essential nutrients by continuous mineralization of organic manures, enhanced inherent nutrient supplying capacity of the soil and its favourable effect on soil physical properties.

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Effect of organic manures on growth, yield and economics of coriander (*Coriandrum sativum* L.)

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ABSTRACT

The experiments were conducted on effect of nutrient supplementation through organic manures on coriander at Horticultural Research Farm, Tirhut College of Agriculture, Dholi (RAU, Pusa) for 3 consecutive years (2009-2012). The treatments used were FYM 100% (10t ha^{-1}), vermicompost (5t ha^{-1}), FYM (50%) + vermicmopost (50%), FYM (25%) + vermicompost (75%), FYM (75%) + vermicompost (25%), RDF (50 N : 40P : 30kg ha^{-1}), FYM (15t ha^{-1}) + RDF (50N : 40P : 30K kg ha^{-1}) and control. Results revealed that the treatment FYM (15 t ha^{-1}) + RDF (50N : 40P : 30K kg ha^{-1}) was the best in improving the growth attributes of coriander and increased the yield 105.26 per cent over control and gave the highest net return of Rs.68,370 (ha^{-1}) with benefit-cost ratio of 2.67. The next effective treatment was RDF (50N : 40P : 30K kg ha^{-1}), which improved the growth parameters and increased yield by 78.19 per cent over control and gave the highest net return (Rs.56,970 ha^{-1}) and benefit-cost ratio (2.50).

Key words: Organic manure, growth, yield, coriander, economics.

India is the largest producer of coriander (*Coriandrum sativum* L.) in the world with the area of 5.21 lakh ha with annual production of 3.08 lakh millions tones and an average yield of 575 kg ha^{-1} (Anonymous, 2003). The interaction of chemical fertilizers with the soils is considered less favorable to the soil environment in comparison to organic sources of nutrients, which supply not only major but also trace elements and also beneficial organism to the plants. Application of organic manures along with inorganic fertilizers into soil result an increase in productivity of the system and also sustain the soil health for longer period. The integrated application of organics with inorganic source of nutrient reduces the dependence on chemical inputs and also provides micro-nutrients as well as modifies the soil physical behavior and increases the efficiency of applied nutrient. Integration of chemical and organic source and their efficient management has shown promise in sustaining the productivity and soil health. Integrated nutrient supply is important as a soil ameliorant in alleviating the adverse soil ecological conditions and in improving soil fertility and productivity. Keeping these facts in view, the present study was under taken to evaluate the nutrients supplementation through organic manures on coriander and results are reported.

MATERIALS AND METHODS

The field experiments were conducted at experimental field of Department of Horticulture, Tirhut College of Agriculture, Dholi, RAU, Pusa during 3 consecutive years 2009 to 2012. The experiment was conducted in fixed plot under Randomized Block Design (RBD) with 8 treatments and 3 replications. Treatments selected for study were FYM (100%) @10t ha^{-1} (T_1), vermicompost (100%) @5t ha^{-1} (T_2), FYM (50%) + 50% vermicompost (T_3), FYM (25%) + 75% vermicompost (T_4), FYM (75%) + 25% vermicompost (T_5), RDF 50N : 40P : 30K kg ha^{-1} (T_6), FYM@15t ha^{-1} + RDF 50N : 40P : 30K kg ha^{-1} (T_7) and control (T_8). Fertilizers NPK were applied as urea, single supper phosphate and murate of potash. All the organic and inorganic manures were applied before sowing of seeds or final field preparation except nitrogenous fertilizer. Nitrogenous fertilizer was applied in two equal split doses as top dressing. First dose of nitrogenous fertilizer was applied after 40 days of sowing and second before flower bud initiation. The soil of experimental plot was calcareous (loam) with available organic carbon (3.90 kg ha^{-1}), nitrogen (174.35 kg ha^{-1}), phosphorus (18.0 kg ha^{-1}) and potassium (116.24 kg ha^{-1}) having soil pH 7.3 with normal electric conductivity. The disease free healthy seed of coriander cv. Pant Haritima was sown during the fourth week of October every year. The plot size of the experimental plot was 3.0 x 2.0 m with spacing of 30 x 20 cm. Observations on different growth and yield parameters were recorded on 5 plants selected randomly and data obtained were analysed statistically.

RESULTS AND DISCUSSION

Growth and yield

The plant height was significantly increased with all

treatment, i.e., organic, inorganic and integrated nutrient management as compared to control (Table 1). Among the treatments, recommended dose of integrated nutrient management, T_7 (FYM @15t ha^{-1}+ N : P : K , 50 : 40 : 30 kg ha^{-1}) gave the highest plant height (144.5cm) followed by recommended dose of inorganic fertilizers, T_6 (N : P : K 50 : 40 : 30 kg ha^{-1}) with plant height of 141.54 cm. The lowest plant height (130.04 cm) was recorded in vermicompost (100%). Plant height is an important yield attributes in coriander and it has been reported that the soluble fertilizers applied through drip showed superior performance for plant height of coriander. Similar results were reported by Vasmate *et al.* (2007) in coriander. Increased plant height may be due to increased uptake of nitrogen, which being the constituent of protein and protoplasm, vigorously induce the vegetative development of the plant. The plant height in single dose of manures was comparatively low, which could be due to poor nutrient absorption from soil. Recommended integrated nutrient management gave the maximum plant height, compared to control and other organic and chemical/ inorganic fertilizers. The increased water holding capacity, reduction of bulk density, improved particle density, pore space, texture and soil available nutrient status, favorably influenced the root growth and development, thereby indirectly influencing the plant height.

The number of primary branches per plant was significantly increased with all the treatments except FYM (25%) + vermicompost (75%) as compared to control (Table 1). Among the treatments, FYM (15t ha^{-1}) + RDF (50N : 40P : 30K kg ha^{-1}) gave the highest number of primary branches (9.73 plant^{-1}) followed by RDF (9.35 plant^{-1}). The lowest number of primary branches (7.87 plant^{-1}) was recorded with FYM (25%) + vermicompost (75%). Similarly the secondary branches also increased significantly (28.98 plant^{-1}) with the treatment FYM (15t ha^{-1}) + RDF (50N : 40P : 30K kg ha^{-1}) followed by RDF (50N : 40P : 30 K kg ha^{-1}), which produced 25.49 secondary branches (plant^{-1}). The lowest number of secondary branches (19.20 plant^{-1}) was noticed with FYM (25%) + vermicompost (75%). More number of primary and secondary branches might be attributed to the more balance C : N ratio, abundant supply of available nutrients from soil with comparatively lesser retention in roots and more translocation to arial parts for protoplasmic proteins and synthesis of other compounds. Similar results were also reported in coriander (Sahu *et al.* 2014; Vasmate *et al*. 2007) and in fenugreek (Singh, 2013).

The highest number of umbels (74.64 plant^{-1}), umbellets (6.98 umbel^{-1}) and grains (55.24 umbel^{-1}) were in FYM (15t ha^{-1}) + RDF (50N : 40P : 30K kg ha^{-1}) as compared to control (Table 1). The lowest number of umbel (52.62 plant^{-1}) and grains (40.20 umbel^{-1}) were recorded with vermicompost (100%) @5t ha^{-1}. The yield was maximum (2.73t ha^{-1}) with FYM (15t ha^{-1}) + RDF (50N : 40P : 30K kg ha^{-1}) followed by RDF (50N : 40P : 30K kg ha^{-1}), where it was 2.37t ha^{-1}. The lowest yield (1.64t ha^{-1}) was recorded with FYM (25%) + vermicompost (75%) excluding control. The increased yield in integrated nutrient management might be due to enhanced uptake of N, P and K, which results in better vegetative growth, while phosphorus improves the root growth and productive ability. FYM had increased the soil organic matter and improved the soil structure and biological activity of soil. This would have reduce the loss of nitrogen by increased cation and anion exchange capacities in soil thereby enhancing the seed yield in umbel, umbellets and yield. Further, by improving the structure of the soil by more aggregation, water holding capacity and air permeability are increased. This comprehensive change in soil might have improved the vegetative growth and yield. Similar results were obtained in coriander (Sahu *et al.* 2014; Vasmate *et al.* 2008; Abdou *et al.* 2004, Azzaz *et al.* 2009) fennel (Singh,

Table 1. Effect of nutrient supplementation through organic manures for growth and yield of coriander.

Character / Treatment	Plant height (cm)	No. of primary braches (plant^{-1})	No. of secondary branches (plant^{-1})	No. of umbels (plant^{-1})	No. of umbellets (umbel^{-1})	No. of grains (umbel^{-1})	Yield (t ha^{-1})	Yield increase over control (%)
FYM 100% (10t ha^{-1})	135.04	8.28	20.91	58.44	6.13	43.47	1.95	46.62
Vermicompost 100% (5t ha^{-1})	130.04	8.13	19.78	52.62	6.33	40.20	1.79	34.59
FYM 50% + vermicomost (50%)	135.51	8.51	22.48	56.60	6.20	45.69	2.09	57.14
FYM 25% + vermicomost (75%)	131.62	7.87	19.20	53.35	6.00	41.27	1.64	23.30
FYM 75% + vermicomost (25%)	136.29	8.71	21.82	62.40	6.08	46.15	2.09	57.14
RDF alone (50N : 40P : 30K kg ha^{-1})	141.54	9.35	25.49	68.69	6.55	51.49	2.37	78.19
FYM (15t ha^{-1}) + RDF (50N : 40P : 30K kg ha^{-1})	144.55	9.73	28.98	74.64	6.98	55.24	2.73	105.26
Control (No treatment)	122.04	7.26	16.32	43.20	5.27	31.64	1.33	-
CD (p= 0.05)	6.72	0.68	3.97	6.95	0.48	5.03	0.32	-

Table 2. Economics of nutrient supplementation through organic manures on coriander crop.

Character / Treatment	Yield (t ha^{-1})	Gross return (Rs. ha^{-1})	Total variable & fixed cost (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Cost-benefit ratio
FYM 100% (10t ha^{-1})	1.95	78,000	39,000	39,000	2.00
Vermicompost 100% (5t ha^{-1})	1.79	71,600	65,000	6,600	1.10
FYM 50% + vermicompost (50%)	2.09	83,600	52,000	31,600	1.60
FYM 25% + vermicompost (75%)	1.64	65,600	58,000	7,600	1.13
FYM 75% + vermicompost (25%)	2.09	83,600	45,500	38,100	1.83
RDF alone (50N : 40P : 30K kg ha^{-1})	2.37	94,800	37,830	56,970	2.50
FYM (15t ha^{-1}) + RDF (50N : 40P : 30K kg ha^{-1})	2.73	1,09,200	40,830	68,370	2.67
Control (No treatment)	1.33	53,200	35,000	18,200	1.52

Selling rate – (Rs. 4000 q^{-1}), fixed cost – (Rs. 35000 ha^{-1}) for each treatment and control, FYM – (Rs. 40 q^{-1}), Vermicompost – (Rs. 600 q^{-1}), Urea – (Rs. 281, 50kg bag^{-1}), S.S.P – (Rs. 480, 50kg bag^{-1}), M.O.P – (Rs. 425, 50kg bag^{-1}).

2012) and fenugreek (Singh, 2013). Among the treatments FYM (15t ha^{-1}) + RDF (50N : 40P : 30K kg ha^{-1}) gave the highest plant height, number of primary branches per plant, number of secondary branches, number of umbels, number of umbellets, number of grains and yield per hectare. Integration of different organic and inorganic sources of plant nutrients, increased the yield and related attributes of coriander. This is possible due to balanced C : N ratio and more decomposition, mineralization, availability of native and applied macro and micro-nutrients. All these might have accelerated the synthesis of carbohydrate and its better translocation from sink to source, which probably have led to an improvement in yield and yield related attributes. Similar observations were also made earlier in coriander (Sahu *et. al.* 2014; Salem and Awad, 2005; Vasmate *et al.* 2008), fennel (Abdou *et al.* 2004; Azzaz *et al.* 2009; Bardan and Safwat, 2004; Singh, 2012; Godara *et al*. 2014), fenugreek (Singh, 2013) and nigella (Valadavadi *and* Farahani, 2011).

Economics

The total added fixed and variable cost was maximum (Rs.65,000) in treatment vermicompost (5t ha^{-1}) followed by FYM (25%) + vermicompost (75%), i.e., Rs.58,000.00 (Table 2). Similarly gross and net returns were maximum (Rs.1,09,200.00 & 68,370) with the treatment FYM (15t ha^{-1}) + RDF (50N : 40P : 30K kg ha^{-1}). The benefit cost ratio was markedly influenced by different treatments, which was maximum (2.67) in the treatment FYM (15 t ha^{-1}) + RDF (50N : 40P : 30K kg ha^{-1}). The next better treatment was RDF (50N : 40P : 30K kg ha^{-1}) with cost-benefit ratio of 2.50 (Table 2).

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Effect of cattle urine and cowdung slurry as seed treatment on germination and growth of *Khirni* (*Manilkara hexandra* L.)

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ABSTRACT

The field experiment was carried out at Krishi Vigyan Kendra, Lanja, Dist. Ratnagiri during the period 2009-10 to study the effect of cattle urine and cowdung slurry on germination and growth of *Khirni*. The results indicated that there was significant effect of soaking seed with cattle urine and cowdung slurry over control. The significantly early (15.24 days) and maximum (66.11%) germination were recorded in treatment having 12 hrs soaking in cattle urine + 12 hrs keeping in cow dung slurry with rapid growth of plant. The seedling height (33.19 cm), number of leaves (17.23 seedling^{-1}), length of primary roots (15.71 cm) and number of tertiary roots (41 seedling^{-1}) were also higher with treatment 12 hrs soaking in urine + 12 hrs keeping in cowdung slurry.

Key words : *Khirni*, cattle urine, cowdung slurry, germination, growth.

Khirni (*Manilkara hexandra* L.) used as rootstock for sapota (*Manilkara achras (*Mill) Fosberg) a commercial tropical fruit crop of India. The poor germination of rootstock *Khirni* seeds (Anonymous, 2006), limited availability of rootstock plants and slow growth rate of seedlings to attain the suitable size for grafting are the major problem in nursery practices of sapota. The use of bio-regulators in enhancing seed germination and seedling growth of numerous plant species is well known (Tendolkar, 1978; Singh *et al*, 1989; Pampanna and Sulikeri, 2001). In addition synthetic chemicals and other naturally available bioproducts of organics are known to contain vital plant growth substances, which enhance the growth and development of plant (Anonymous, 1993). Keeping this in view, the present investigation was carried out to see the effect of different cattle urine concentrations and slurry on the germination, growth and development of *Khirni* seedling to be used as root stock for sapota grafting production.

MATERIALS AND METHODS

The present investigation was carried out at nursery of Krishi Vigyan Kendra, Lanja, Dist. Ratnagiri, Maharashtra during 2009-10. The fresh seeds of *Khirni* was collected from the full grown ripe fruits from Palghar, Dist. Thane. The experiment was conducted in a complete Randomized Block Design and each treatment replicated thrice. There were 100 seeds in each treatment and replication. In order to improve the seed germination of *Khirni*, the pre-soaking seed treatments used were 8 hrs soaking in cattle urine (10%), 8 hrs soaking in cattle urine (20%), 12 hrs soaking in cattle urine (10%), 12 hrs soaking in cattle urine (20%), 24 hrs soaking in cattle urine (10 %), 24 hrs soaking in cattle urine (20%), 12 hrs in cattle urine soaking + 12 hrs keeping in cowdung slurry, 12 hrs hot water soaking + 12 hrs keeping in cowdung slurry, 24 hrs soaking in cold water and control. After seed treatment each seed was sown in polybags of 12.5 X 18.5 cm, filled with 3 part lateritic soil and 1 part FYM as potting mixture. Data on days for germination and germination percentage were recorded. These germinated seedlings were kept in nursery shed and recommended cultural practices like irrigation, weeding, plant protection measure, etc. were followed. The growth performance was recorded at 330 days after sowing by measuring height, girth of seedlings, length of tap root and primary roots, counting number of leaves and secondary and tertiary roots on randomly selected 15 plants in each treatment. All the data were statistically analysed by the method suggested by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

The significantly early germination (15.24 days after sowing) and the maximum germination (66.11%) were recorded (Table 1) in treatment, 12 hrs soaking in cattle urine + 12 hrs keeping in cow dung slurry followed by 24 hrs soaking in cattle urine (20%). The higher germination percentage in cattle urine and cowdung slurry treatment may be attributed to the presence of growth promoting substances (auxins) in cattle cowdung. These results are in agreement with the findings of Anonymous (1993) and Shirol *et al.* (2005), who found the pre-soaking of *Khirni* rootstock seeds in

Table 1. Effect of different pre-soaking treatments of cattle urine and cowdung slurry on germination of *Khirni* seed.

Treatment	Cattle urine/cowdung slurry	Germination time (Day)	Germination (%)
T1	8 hrs soaking in cattle urine (10%)	19.81	46.67
T 2	8 hrs soaking in cattle urine (20%)	18.16	48.12
T 3	12 hrs soaking in cattle urine (10%)	17.24	48.67
T 4	12 hrs soaking in cattle urine (20%)	18.11	50.77
T 5	24 hrs soaking in cattle urine (10%)	17.76	50.87
T 6	24 hrs soaking in cattle urine (20%)	16.74	64.22
T 7	12 hrs soaking in cattle urine + 12 hrs keeping in cow dung slurry	15.24	66.11
T 8	12 hrs soaking in hot water + 12 hrs keeping in cow dung slurry	17.21	61.14
T 9	24 hrs soaking in cold water	18.66	46.18
T10	Control (untreated)	19.71	27.71
	CD at 5%	2.69	18.22

Table 2. Effect of different pre-soaking treatments of cattle urine and cowdung slurry on growth of *Khirni* seedlings at 330 days after sowing.

Treatment	Height of seedling (cm)	Number of leaves (seedling^{-1})	Girth (cm)	Tap root length (cm)	Primary root length (cm)	Secondary root (No.)	Tertiary root (No.)
T_1	26.45	14.11	0.8	8.2	12.13	3	34
T_2	28.34	12.12	0.8	8.3	12.11	3	35
T_3	31.15	14.14	0.8	4.3	11.41	4	36
T_4	30.15	14.12	0.8	7.8	13.22	3	38
T_5	26.17	13.18	0.8	7.6	12.12	3	33
T_6	28.18	14.22	0.7	8.8	12.12	2	36
T_7	33.19	17.23	0.7	10.12	15.17	3	41
T_8	30.15	15.12	0.7	8.4	10.71	3	32
T_9	32.14	16.14	0.8	9.3	12.56	2	37
T_{10}	25.45	11.74	0.7	7.0	10.10	2	26
CD at 5%	3.83	2.06	N.S.	N.S.	6.11	N.S.	15.70

cowdung slurry for 24 hours was effective to get higher germination.

The pre-sowing seed treatments with cattle urine and cowdung slurry significantly influenced the height of seedlings, number of leaves seedling^{-1}, primary root length and number of tertiary roots (Table 2), while girth of seedling, tap root length and number of secondary roots showed no significance differences. The maximum seedling height (33.19 cm) and number of leaves (17.23 seedling^{-1}), longest primary roots (15.71cm) and more number of tertiary roots (41 seedling^{-1}) were obtained in the seedlings having treatment of 12 hrs soaking in cattle urine + 12 hrs keeping in cow dung slurry. The next better treatment was 24 hrs soaking in cold water. The rapid growth of seedlings in cattle urine and cowdung slurry treatment might be due to the presence of growth promoting substances (auxins) and nutrients in cattle urine and cowdung.

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Influence of seed fortification on seed quality parameters of maize, paddy and ragi

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ABSTRACT

The experiment conducted to study the effect of spent wash and cow urine on the germination and vigour of maize, paddy and ragi seed samples revealed that irrespective of crops, the spent wash and cow urine increased the seed quality parameters in terms of seed germination, seedling vigour and field emergence suggesting thereby that these at 10 or 20.0 and 30 or 40 per cent, respectively can be used as a seed fortification treatment to get better seed quality. Cow urine treatment reduced seed mycoflora also.

Key words: Seed treatment, spent wash, cow urine, seed germination, seed vigour.

The major constraints for higher productivity in dry lands are the inadequacy of soil moisture and poor fertility status of the soil. Consistency and stability in production is the need of the hour, hence efforts in this direction alone can help in harnessing the tremendous potential of the crop. Identification of suitable growth stimulants and nutrient solutions with mode of inoculation will favour the production of quality seedling at short periods and enhancing the initial seed vigour which have a major role on increasing the productivity. In crop plants, nutrients may be applied through soil and foliar spray or added as seed treatments. Soil application of fertilizers is considered to be the most effective and easily manageable way, but because of nutrients availability being influenced by soil chemical and physical properties, the plant roots are unable to absorb these nutrients adequately from dry topsoil. Similarly, foliar sprays have been more effective in yield improvement and grain enrichment, but high cost has restricted its wider adaption, particularly by resource-poor farmers. Moreover, foliar application is done at later growth stages when crop stands are already established. Soil and foliar applications are the most prevalent methods of nutrient addition but the cost involved and difficulty in obtaining high quality nutrient fertilizers are major concerns in developing countries. At the initial phases of seed germination nutrients are mobilized from endosperm or cotyledon, while further phases required nutrients from soil or from some other means. At initial stages seedling can't absorb nutrient from soil. Nutrient seed treatments, which include seed fortification and seed coating or pelleting, are an attractive and easy alternative.

Seed fortification is a physiological method of seed invigouration that aids in improving the initial stamina of the seed that helps in improving the initial field establishment and that of the final yield. It is the impregnation of the needy substance into the seed through the imbibitions phase enriching the endogenous level of needy bioactive substances. In seed fortification, seeds are partially hydrated to allow metabolic events to occur without actual germination, and then re-dried (near to their original weight) to permit routine handling. Such seeds germinate faster than non-fortified seeds. Hence, the utility of inorganic nutrients as seed fortification agents were evaluated for improving the germination and field emergence of maize, paddy and ragi.

MATERIALS AND METHODS

The genetically pure seeds of maize, paddy and ragi were obtained from AICRP's of respective crops, Zonal Agricultural Research Station, Mandya and used for the study. The investigation was carried out in seed lab, ZARS, VC farm, Mandya during 2013. Pre-sowing seed treatment was imposed using freshly collected cow urine and spent wash. Cow urine and spent wash samples were then diluted with water to concentration of 10, 20, 30 and 40 per cent. Seeds of the above crops were fortified with spent wash and cow urine in four different concentrations (10%, 20%, 30% and 40%) with the soaking durations of 6 h along with water. The unfortified seed served as control. The soaked seeds were surface dried for one day under laboratory conditions and were evaluated for the initial seed quality characteristics. The experiment was laid out in factorial Complete

Randomized Design with three replications. Wherever necessary, the percent values were transformed to Arc-sine values before analysis for easy interpretation.

Germination per cent was determined as per ISTA rules for seed testing (ISTA, 2006). The seeds were placed in rolled paper towels. Hundred seeds of four replications were tested at a constant temperature of 25°C. The numbers of normal seedlings were evaluated on 14th day and per cent germination was expressed on normal seedling basis. From the standard germination test, ten normal seedlings were selected at random in each replication on final count. The shoot length was measured from collar region to the point of attachment of cotyledons and root length from the collar region to the tip of the primary root, sum of shoot and root length constitute the seedling length and mean was calculated and expressed in centimeters. Seedling vigour index was computed by adopting the formula as suggested by Abdul-Baki and Anderson (1973) and expressed in whole number.

Seedling vigour index-I = Germination (%) x Mean seedling length (cm)

Seedling vigour index-II = Germination (%) x seedling dry weigh (mg)

Field emergence was calculated by sowing one hundred seeds from each treatment in four replications in the field. The emergence counts were made on 14th day after sowing and expressed in per cent.

Seed mycoflora: Detection and identification of storage fungi in seeds was done by blotter method as recommended by ISTA (Anon., 2006). Twenty-five seeds in four replication were plated equidistantly on two layers of moistened blotters in the petri plates and were incubated at 30°C temperature. After 7 days, the number of infected seeds (fungal colonies) were counted and expressed in percentage.

The data was analysed statistically by following Completely Randomized Design (CRD) and adopting "Fischer's Analysis of Variance Technique" and critical difference values were calculated at 5 per cent probability level (where "F" test was significant). Dunnett's "t" test was then performed to compare control with all other treatments (Panse and Sukhatme,1967).

RESULTS AND DISCUSSION

During fortification, the first phase of germination ends with completion of imbibitions process and hence the time taken from sowing to emergence is much reduced (Hegarty, 1970). Fortification of seed increased the germination by promoting embryo growth. The improvement in field emergence due to seed fortification could also be ascribed to activation of cells, which results in the enhancement of mitochondrial activity leading to the formation of more higher energy compounds and vital biochemicals, which were made available during the early phase of germination.

As far as germination percentage was concerned, the response of three cereal crops to different concentration of spent wash and cow urine did not vary significantly. However, highest germination (92.0 %) in seeds fortified with 30 per cent cow urine and lowest (86.0 %) in seeds fortified with 20 per cent spent wash was observed.

The treatment of 30 per cent cow urine was found to improve all the initial seed quality parameters except field emergence (Table 1, 2). It was also observed that the same treatment had recorded significantly higher values of mean seedling length (21.22 cm), seedling dry weight (24.40 mg) seedling vigour index-I (1973) and seedling vigour index-II (2260), which was statistically on par with seeds fortified with 40 per cent cow urine (21.18, 22.71, 1963 and 2088), whereas lowest seed quality parameters was noticed in seeds fortified with 20 per cent spent wash (16.66,14.68,1489 and 1310). Besides, the lower fungal load (4.00 % and 5.33%) was observed in seeds fortified either with 30 and 40 per cent cow urine. However, fungal load increased (18.67 %), when seeds were fortified with 20 per cent spent wash (Table 3).

Beneficial effect of seed fortification was also noticed in improvement of field emergence of the crops. The field emergence also showed 26.0 per cent increase in cow urine (30.0 %) followed by 40.0 per cent cow urine over control and other treatments. The reasons for increased seed physiological parameters may be due to the fact that cow urine contains physiological active substances *viz*., growth regulators, nutrients (about 1.0 per cent nitrogen, traces of P_2O_5 and 1.0 per cent K_20) (Kamalam Joseph and Rajappan Nair,1989; Chawla,1986) and cow urine acts as antifungal and antibacterial compound, which is lethal to *Rhizophus* spp. and *Aspergillus flavens* (Vijayalakshmi and Saranya, 2010) which is evident from seed health test, which exhibited lower fungal load (4.00%).The results were in accordance with the observation of Sivasubramaniam *et al*. (2012) and Kamalam Joseph and Rajappan Nair (1989), where cow urine was used for rice seed treatment.

Lower initial seed quality parameters in seeds fortified with 20 per cent spent wash is due to accumulation of fungal load on the seed is evident from seed health test, which exhibited higher fungal load (18.67 %).

Table 1. Seed quality parameter as influenced by seed fortification in maize, paddy and ragi.

Treatment	Germination (%)			Field emergence (%)			Root length(cm)			Shoot length(cm)		
	Maize	Paddy	Ragi	Maize	Paddy	Ragi	Maize	Paddy	Ragi	Maize	Paddy	Ragi
Water control	80	88	92	72	80	81	9.34	14.35	3.61	14.52	7.71	4.26
Spent wash (10%)	87	87	93	78	75	84	8.17	12	4.37	15.55	9	4.26
Spent wash (20%)	89	89	91	78	79	78	12.17	11.44	3.63	14.12	9.2	4.32
Spent wash (30%)	78	91	88	68	81	82	10.08	13.72	4.14	12.87	7.41	4.33
Spent wash (40%)	91	93	85	82	82	77	13.79	14.37	3.82	15.51	7.69	4.14
Cow urine (10%)	91	91	84	82	81	74	10.53	12.47	4.24	14.1	12.22	6.72
Cow urine (20%)	93	89	92	82	79	82	16.85	12.77	4.51	13.84	6.96	4.38
Cow urine (30%)	95	91	91	85	81	82	14.79	14.76	6.06	16.44	8.05	4.62
Cow urine (40%)	96	90	87	84	79	77	16.87	14.16	4.55	14.62	8.15	4.45
Mean	89	90	89	79	80	80	12.51	13.34	4.33	14.62	8.49	4.61
	S.Em ±		C.D(P=0.05)	S.Em ±		C.D(P=0.05)	S.Em ±		C.D(P=0.05)	S.Em ±		C.D(P=0.05)
Crop (C)	0.59		NS	0.56		1.59	0.06		0.17	0.15		0.42
Treatments (T)	1.03		NS	0.97		2.76	0.1		0.29	0.25		0.72
C × T	1.78		5.04	1.69		4.78	0.18		0.51	0.44		1.25

Table 2. Effect of seed fortification with spent wash and cow urine on root length (cm) and shoot length (cm) of maize, paddy and ragi seedlings

Treatment	Mean seedling length(cm)			Seedling dry weight(mg)			Seedling vigour index-I			Seedling vigour index-II		
	Maize	Paddy	Ragi	Maize	Paddy	Ragi	Maize	Paddy	Ragi	Maize	Paddy	Ragi
Water control	22.03	21.6	7.87	26.31	17.5	7.88	1762	1901	724	2105	1540	725
Spent wash (10%)	23.11	18.3	8.63	25.06	23.75	10.78	2011	1592	803	2180	2066	1003
Spent wash (20%)	21.24	20.29	8.46	24.06	13.75	6.22	1890	1806	770	2141	1224	566
Spent wash (30%)	23.13	22.21	7.96	22.88	25.5	9.43	1804	2021	700	1785	2321	830
Spent wash (40%)	32.46	22.2	7.96	28.13	31.25	7.97	2954	2065	677	2560	2906	677
Cow urine (10%)	26.10	22.66	10.96	32.06	26.25	10.91	2375	2062	921	2917	2389	916
Cow urine (20%)	30.50	18.65	8.89	30.88	27.5	6.77	2837	1660	818	2872	2448	623
Cow urine (30%)	31.23	21.64	10.8	29.25	32.5	11.46	2967	1969	983	2779	2958	1043
Cow urine (40%)	32.43	22.13	9	27.13	30.5	10.5	3113	1992	783	2604	2745	914
Mean	26.91	21.08	8.95	27.31	25.39	9.10	2413	1896	798	2438	2288	811
	S.Em ±		C.D(P=0.05)	S.Em ±		C.D(P=0.05)	S.Em ±		C.D(P=0.05)	S.Em ±		C.D(P=0.05)
Crop (C)	0.21		0.58	0.64		1.81	25.57		72.49	58.61		166.15
Treatments (T)	0.36		1.01	1.11		3.13	44.29		125.55	101.51		287.77
C × T	0.62		1.75	1.91		5.43	76.71		217.47	175.82		498.44

Seed quality in terms of mean seedling length, seedling dry weight, seedling vigour index I and II and field emergence differed significantly among crops except germination percentage. The maize crop had higher mean seedling length (26.91cm), seedling dry weights (27.31 mg), seedling vigour index I (2413) and II (2438) and field emergence (79.0 %) followed by paddy and lowest was observed in ragi. With respect to seed health (Table 2), the maize crop was recorded

Table 3. Effect of seed fortification with spent wash and cow urine on seed health status of maize, paddy and ragi

Treatment	Seed mycoflora (%)			
	Maize	Paddy	Ragi	Mean
Water control	12.00(20.08)	18.00(24.48)	4.00(9.32)	11.33(17.96)
Spent wash (10%)	40.00(38.63)	6.00(11.48)	8.00(16.07)	18.00(22.06)
Spent wash (20%)	44.00(41.53)	8.00(16.07)	4.00(9.32)	18.67(22.31)
Spent wash (30%)	40.00(39.16)	8.00 (16.42)	2.00(6.55)	16.67(20.71)
Spent wash (40%)	50.00(44.98)	2.00(6.55)	4.00(9.32)	18.67(20.28)
Cow urine (10%)	22.00(27.55)	10.00(18.37)	2.00(6.55)	11.33(17.49)
Cow urine (20%)	30.00(33.12)	0.00(0.00)	4.00(9.32)	11.33(14.15)
Cow urine (30%)	8.00(16.42)	4.00(9.32)	0.00(0.00)	4.00(8.58)
Cow urine (40%)	10.00(18.37)	4.00(9.32)	2.00(6.55)	5.33(11.41)
Mean	28.44(31.10)	6.67(12.45)	3.33(8.11)	-
	S.Em ±		C.D(P=0.05)	
Crop (C)	1.24		3.51	
Treatments (T)	2.14		6.08	
C × T	3.71		10.52	

highest fungal load (28.44 %) followed by paddy and lowest was noticed in ragi (3.3%). Variation of seed crop response to fortification might be attributed to the difference in their structural and biochemical composition of seeds. Genes are important in determining predictable seed germination and seedling establishment in some crop (Abdullah *et al*. 2011). Seed vigor is a quantitative character controlled by multigenes (Betty *et al.* 2000). In interaction effect seeds fortified with 40.0 per cent cow urine showed better seed quality parameters *viz*., germination (96.0 %), field emergence (84.0 %), mean seedling length (32.43 cm) and seedling vigour index-I (3116) followed by seeds fortification with 30 per cent cow urine in case of maize.

It was concluded that cow urine (30.0/40.0 %) recording higher initial seed quality parameters in maize, paddy and ragi crops could be used as seed fortification treatment.

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Relative performance of rice varieties under transplanted conditions

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ABSTRACT

Field experiment on the tested rice varieties revealed that PP-369, Gemini and FP-72 excelled to all with regard to tillers/m^2 (267.67,259.33 & 257.00) effective tillers/m^2 (265.00, 218.00 & 215.67), panicle length (24.90 cm, 24.87 cm & 23.6 cm), and grain per panicle (138.00, 132.67 & 131.33). Further, among these the PP-369 excelled to all with regard to grain yield (67.67q ha^{-1}) and straw yield (96.00q ha^{-1}) closely followed by Gemini (65.33 & 92.33q ha^{-1}) and FP-72 (61.67 & 85.00q ha^{-1}), mainly due to superiority in number of tillers/m^2, number of effective tillers/m^2 and number of grain $panicle^{-1}$. Variety PP-369 proved to be most economically viable with regard to maximum NMR (Rs 46851 ha^{-1}) with the highest B:C ratio (2.95) over other varieties.

Key words: Rice, varieties, phenology, growth, yield, economics.

Rice *(Oryza sativa* L.) is the main staple food crop of more than half of the world's population. Rice is extensively grown in eastern, northern and southern states of India under both irrigated and rainfed production system. The area under rice in Madhya Pradesh is 1.76 million hectares with an annual production of 1.87 million tonnes, but productivity is quite low (1.06 t ha^{-1}). Only 23 per cent of land area under rice is covered by high yielding varieties (HYVs). To meet out the demands of increasing population and to maintain self sufficiency, these production level need to be increased up to 120 million tonnes by the year 2020. The HYVs are, practically feasible and readily adoptable option to increase the rice production. The *i*mportance of HYVs becomes more relevant in the context of increasing demand of rice. The high yielding variety programmes resulted in increased production in areas, where the new varieties are established. But, these varieties are different in their biology viz. maturity period, growth characters, phonological characters, morphological characters, yield attributing characters and yield potential. These characters determine ultimate acceptability of HYVs by farmer and consumers. The development of recent HYVs have shown better yield potential than the previous varieties mainly due to presence of longer sink (Singh *et al*. 2005). After the evolution of high yielding varieties it becomes imperative to make a comparative assessment of growth studies and their influence on grain yield to maximize the net returns, hence the present investigation was undertaken.

MATERIALS AND METHODS

Field experiment was conducted at Breeder Seed Production Farm, College of Agriculture, Jabalpur on relative performance of rice varieties under transplanted conditions during *Kharif*, 2011 in sandy clay loam soil. The varieties selected for study were Jagraty, Mehak, Sadhika, PP-369, Jasper, Johar, Gemini, FP-72, FP-18, FP-108, FP-24, NP-504, NP-360, NP-549 and Kranti. The experiment was conducted under Randomized Block Design and each treatment was replicated thrice. A uniform dose of fertilizers (120 kg N + 60 kg P_20_5 + 40 kg K_20 ha^{-1} was applied to all varieties. About 25 days old seedlings were transplanted on July, 22, 2011 by using one seedling per hill with the planting geometry of 20 cm x 20 cm. Observations were recorded during entire growing season on different phenological parameters, growth parameters, yield attributing characters and yield. Finally economic viability of the treatments (varieties) were worked-out on hectare basis in terms of cost of the cultivation, gross monetary returns (GMR), net monetary returns (NMR) and benefit-cost ratio (B:C ratio).

RESULTS AND DISCUSSION

Phenological parameters: Out of 15 varieties tested, NP-504 (102 DAT), NP-360 (108DAT) and Johar (109 DAT) matured earliest. These varieties started tillering in 13 to 20 DAT and panicle emergence in 70 to 79 DAT (Table 1).

Table 1. Phenological characters of different rice varieties evaluated under transplanted condition

Rice variety	Tillering emergence (Days)	Maximum tillering (Days)	Panicle emergence (Days)	Maturity (Days)
Jagraty	16	49	75	110
Mehak	16	55	72	115
Sadhika	19	43	75	125
PP-369	22	49	75	130
Jasper	17	55	80	116
Johar	20	55	79	109
Gemini	18	56	78	110
FP-72	18	51	80	115
FP-18	18	65	80	124
FP-108	20	55	81	127
FP-24	20	52	74	123
NP-504	13	42	70	102
NP-360	15	55	75	108
NP-549	17	56	75	114
Kranti	17	55	75	115

Table 2. Growth parameters of different evaluated rice varieties under transplanted condition

Rice variety	Plant height (cm)		Tillers/m^2	
	90 DAT	Maturity	90 DAT	Maturity
Jagraty	71.43	70.22	256.33	247.67
Mehak	59.67	59.03	197.03	188.49
Sadhika	68.66	68.07	187.67	183.42
PP-369	77.42	75.53	267.67	266.33
Jasper	69.28	65.25	217.33	213.32
Johar	69.35	68.37	253.00	247.67
Gemini	73.42	72.41	259.33	257.67
FP-72	72.05	61.37	257.00	250.67
FP-18	62.08	68.14	211.67	208.64
FP-108	66.00	62.31	211.67	208.24
FP-24	62.67	61.45	245.00	215.67
NP-504	62.42	62.34	230.00	221.67
NP-360	59.44	58.27	184.00	177.34
NP-549	66.40	65.91	217.67	216.20
Kranti	65.73	64.59	227.94	222.33
CD at 5%	8.18	15.94	17.03	11.43

Three other varieties, viz., PP-369, FP-18 and Sadhika are late maturing and takes 130, 127 and 125 DAT, respectively. These varieties showed first tiller and panicle emergence in 19 to 22 DAT and 75 to 81 DAT. Maturity time for remaining 9 varieties were 114 to 118 DAT and thus considered as medium maturing ones**.** These are also in middle for first time emergence of tillers (15 to 18 DAT) and panicle emergence (75 to 76 DAT).

Growth parameters: Tested rice varieties differed significantly with each other in their growth parameter. The variety PP-369 had the tallest plants (77.42cm), while shortest plants were noted in NP-360 (59.44cm), which was at par to Mehak and FP-18 (Table 2). The plant-height of remaining varieties ranged from 62.42 to 73.42 cm. Tillering ability of the varieties also showed difference, which was maximum in PP-369 (267.67 tillers/m^2) followed by Gemini (259.33/m^2), FP-72 (257.00/m^2) and Jagraty (256.33/m^2). Variety NP-360 had the lowest number of tillers/m^2 (184.00). In other varieties tiller number varied from 210 to 250 tillers/m^2 and can be kept under intermediatory. Similar results are observed and reported in different high yielding varieties by Ghosh 2001 and Kalita *et al*. (2007).

Yield attributing characters: Evaluated rice varieties showed marked variations for various yield attributing characters, i.e., effective tillers/m^2, panicle length, grains panicle^{-1}, test-weight and sterility percentage (Table 3). The varieties PP-369 had highest numbers of effective tillers (267.67/m^2) closely followed by Gemini (218.00/m^2). Good numbers of tillers were also found in FP-72 (215.67/m^2), Jagraty (256.33/m^2), Johar (211.33/m^2) and in FP 108 (211.00/m^2). Variety NP-360 had the lowest effective tillers/m^2 (192.33). The longest panicle (24.90cm) and maximum number of seeds ((138.00 panicle^{-1}) were in PP-369, The next best varieties were, Gemini, FP-72, Jagraty and Johar for these characters (Table 3). Varieties PP-369 was on top with test-weight (26.46g) and found at par to Gemini, FP-72 (25.77g) and Jagraty (25.40g). The lowest test weight of seed (18.85g) was in NP-360, which differ non significantly with FP-18(18.96g) and Jasper (19.57 g). The similar result are also reported by earlier workers (Goswami, 2000; Kumar and Subbaiah, 2001) from Andhra Pradesh.

Grain and straw yield: The grain yield (Table 4) was highest in variety PP-369 (67.67q ha^{-1}) but found at par with Gemini (65.33q ha^{-1}), FP-72 (61.67q ha^{-1}) and Kranti (57.67 67q ha^{-1}). The next best varieties for grain yield were Jagraty (56.6767q ha^{-1}), NP-549 (54.67 q ha^{-1}), Johar (51.00 q ha^{-1}) and Mehak (50.67 q ha^{-1}). The conventionally grown NP-360 in the region had the lowest (34.33q ha^{-1}) yield. Straw yield (Table 4) was also maximum in Sadhika (96.00 q ha^{-1}), Gemini (92.33 q ha^{-1}) and Jagraty (90.67 q ha^{-1}). The lowest yielder was in NP-360 (60.33 q ha^{-1}). The results were in close conformity with the finding of Maiti *et al*. 2003, Mishra and Verma 2003.

Economic viability: Cost of cultivation was almost same (Rs. 24022/- ha^{-1}) for all the varieties as similar production

Table 3. Yield attributing characters of different rice varieties evaluated under transplanted conditions

Rice variety	Effective tillers/m^2	Panicle length (cm)	Number of grains panicle^{-1}	Test weight (g)	Sterlity (%)
Jagraty	215.67	23.59	128.33	25.40	10.87
Mehak	203.33	23.40	122.33	24.93	12.91
Sadhika	202.67	23.45	117.33	22.94	11.29
PP-369	265.00	24.90	138.00	26.46	10.58
Jasper	195.33	22.36	122.00	19.57	12.20
Johar	211.33	23.53	126.67	25.34	11.16
Gemini	218.00	24.87	132.67	25.77	10.97
FP-72	215.67	23.61	131.33	25.77	11.14
FP-18	196.67	22.19	115.00	18.96	11.73
FP-108	211.00	22.51	126.67	24.37	11.90
FP-24	196.00	22.27	105.00	23.45	13.77
NP-504	199.33	22.62	125.33	25.33	12.47
NP-360	192.33	21.95	96.67	18.85	16.00
NP-549	202.67	22.12	123.67	24.33	11.58
Kranti	205.33	22.55	125.00	24.70	11.36
CD at 5%	19.54	2.04	11.33	2.07	1.82

Table 4. Grain and straw yield of different varieties evaluated under transplanted conditions

Rice variety	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
Jagraty	56.67	90.67	38.47
Mehak	50.67	78.33	39.27
Sadhika	47.33	77.67	37.88
PP-369	67.67	96.00	41.21
Jasper	48.67	82.67	37.04
Johar	51.00	83.33	37.97
Gemini	65.33	92.33	41.45
FP-72	61.67	85.00	42.04
FP-18	46.33	70.00	38.98
FP-108	42.17	68.00	38.27
FP-24	37.00	66.67	36.37
NP-504	50.33	65.00	40.15
NP-360	34.33	60.33	34.32
NP-549	54.67	79.00	39.33
Kranti	57.67	82.67	40.36
CD at 5%	4.88	3.99	2.30

technology used for experimental field. While considering the gross monthly return (GMR), variety PP-369 (Table 5) fetched the highest value (Rs. 70873/- ha^{-1}) closely followed by Gemini (Rs. 70427/- ha^{-1}), Jagraty (Rs. 62107/- ha^{-1} and FP-72 (Rs. 66767/- ha^{-1}). The GMR was minimum (Rs. 37953'/- ha^{-1}) with NP-360 closely followed by FP-24 (Rs. 41000/- ha^{-1}) and FP-108 (Rs. 46247/- ha^{-1}). The B:C ratio was maximum (2.95) with PP-369 and closely followed by Gemini (2.93), FP-72(2.77), Jagraty (2.58) and NP-549 (2.47). It was minimum (1.57) with NP-360 (Table 5) The similar results are also reported by Maiti *et al.* (2003).

Table 5. Economic viability of different rice varieties evaluated under transplanted conditions

Rice variety	Gross monetary returns (Rs ha^{-1})	Net monetary returns (Rs ha^{-1})	B:C ratio
Jagraty	62107	38085	2.58
Mehak	55367	31345	2.30
Sadhika	51993	27971	2.16
PP-369	70873	46851	2.95
Jasper	53627	31605	2.23
Johar	56000	31978	2.33
Gemini	70427	46405	2.93
FP-72	66767	42745	2.77
FP-18	50653	26631	2.10
FP-108	46247	22225	1.92
FP-24	41000	16978	1.70
NP-504	54233	30144	2.25
NP-360	37953	13931	1.57
NP-549	59407	35385	2.47
Kranti	62633	38611	1.60
CD at 5%	3171.35	5399.05	-

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Identification of suitable and profitable *rabi* crops for high altitude and tribal areas of Andhra Pradesh

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ABSTRACT

Field experiments were conducted at Agricultural Research Station, Seethampeta, Andhra Pradesh, India to find out the suitable and profitable *rabi* crops for higher altitude and tribal area of AP during three consecutive *rabi* seasons 2008-09, 2009-10 and 2010-11. Crops selected were irrigated dry crops viz., horse gram, maize, sunflower, ground nut, Bengal gram, soybean, mustard and rajmah beans. The results indicate that, among different crops, maize, sunflower and mustard are the most viable option as these crops recorded higher yield, production efficiency, economic efficiency, value cost ratio, water use efficiency, energy productivity, net returns and rupee returned per rupee invested. However, while selecting the crops sound nutrient management strategy must be followed to maintain soil fertility due to their exhaustive nature.

Key words: *Rabi* crops, yield, energetic, economics, water use, altitude, tribal.

Cropping system play an important role in using the inputs in a synergistic manner. Continuous cropping with the same crop over years is widely regarded as high risk system, unlikely to be sustainable because of probable buildup of adverse biotic factors. Crop diversification identified as an important and essential strategy to improve farm income, soil and environment health consistently. Viable cropping system with new rewarding crops may infuse new opportunities and challenges and demonstrate the potential for land productivity with use of resources efficiently. Identification of appropriate crop in a system may help to achieve more returns and maximum input use efficiency by developing cohesion among the resources applied. Diversification of cropping system is necessary to get higher yield, returns, maintain soil health, preserve environment and meet daily requirement of human and animals (Samui *et al.* 2004).Continuous adoption of same cropping sequence over years result in declining the efficiency and productivity of the system (Kumar and Yadav, 2005). Horse gram is predominantly grown as second crop over years in irrigated uplands in tribal areas of north coastal districts of Andhra Pradesh. Therefore, it is thought to be worthwhile to study the different non-traditional crops during *rabi* in comparison to horse gram, which is traditional existing crop, to identify a profitable and efficient crop for tribal areas of north coastal districts of Andhra Pradesh.

MATERIALS AND METHODS

Field experiments were conducted at Agricultural Research Station, Seethampeta, Andhra Prtadesh, India for three consecutive years during *rabi* season of 2008-09, 2009-10 and 2010-11. The soil was sandy clay loam having pH 6.8, organic carbon 0.65 per cent and available nitrogen 245 kg ha^{-1}, P_2O_5 25.8 kg ha^{-1} and K_2O 295 kg ha^{-1}. The trial was laid out in Randomized Block Design with four replications consisting eight irrigated dry crops, horse gram (Local), sunflower (NDSH1), maize (DHM 107), mustard (Varun), Bengal gram (Annegiri), soybean (JS 335), rajmah bean (Chintapalli Red) and groundnut (Vemana). After harvest of rainy season rice, the *rabi* crops were sown during 1st week of January during all the three years of investigation and harvested as and when matured. Grain/seed and stower from the net plot was thoroughly sun dried to 14 per cent moisture content, weighed and expressed in kg ha^{-1}. Water was measured using water meters and Parshall flume. Economic parameters like gross returns, net returns and rupee returned per rupee invested were worked out treatment–wise, taking prevailing market rates for different inputs and outputs. Energetics was calculated as per the procedure given by Panesar and Bhatnagar (1994). Horse gram equivalent yield (HEY), production efficiency (PE) and economic efficiency (EE) were calculated using the formulae given by Singh *et al.* (2005). Value cost ratio was worked out by dividing additional yield with additional expenditure. Nitrogen was estimated by modified Microkjeldahl method, the available P by Olsen *et al.* (1954) and K by flame photometer (Jackson, 1973). Data were analysed using ANOVA and the significance was tested by Fisher's least significance difference (p= 0.05).

RESULTS AND DISCUSSION

Results revealed that, among different irrigated dry crops cultivated during *rabi* after *kharif* rice, maize recorded the highest grain yield followed by sunflower and groundnut (Table 1). Bengal gram was the only crop recorded lower seed yield than control, i.e., horse gram. Stower yield was also significantly higher with maize followed by sunflower and soybean. Similar results of higher yields of maize, sunflower after *kharif* rice has been reported by Reddy (2001), whereas horse gram equivalent yield was significantly higher in sunflower, however it was at par with maize and mustard. In terms of horse gram equivalent yield Bengal gram and soybean recorded conspicuously lower values among different irrigated dry crops tested.

The highest production efficiency was recorded in sunflower (226.00 %) followed by maize (221.00 %), mustard (200.00 %), while it was lowest (Table 1) in Bengal gram (97.00%) and soybean (95.00%). The economic efficiency was higher in maize followed by sunflower and mustard. The economic efficiency was in negative side with Bengal gram and very low with groundnut and soybean. The value cost ratio was also higher with maize (0.11) followed by mustard (0.10) and sunflower (0.09). Relatively higher production and profits with maize, sunflower and mustard among the test crops manifested the efficiencies too. Similar results of best performance by maize, sunflower and mustard after *kharif* rice were also reported by Kumar *et al.* (2005).

Among different crops, water used was lower in horse gram, Bengal gram and mustard, while it was higher with groundnut and maize (Table 2). The water use efficiency was higher with maize followed by sunflower and mustard because of higher production with less water use. However, the water use efficiency was less with Bengal gram due to lesser output, though it consumed relatively lower water. Similarly, it was also conspicuously low in groundnut due to higher water consumption with relatively lesser yield. Similar results of higher water use efficiency in maize and mustard crops was reported by Parihar *et al*. (1999). Energy intake was higher in groundnut followed by maize crops because of higher energy requirement through fertilizer in maize and higher energy requirement through seed for groundnut (Table 2). Energy output was higher in maize, sunflower and groundnut. Energy use efficiency was higher in maize followed by sunflower and mustard, while it was lower in Bengal gram and rajmah bean. Maize recorded the highest energy productivity followed by sunflower. The energy productivity was lowest in Bengal gram and groundnut. These results are in corroboration with findings of Parihar *et al.* (1999).

The post crop soil available nitrogen status was significantly declined with cultivation of maize and sunflower after three years than initial due to their exhaustive nature and higher nitrogen requirement (Table 1). There was no marked change in status of available phosphorus after three years of the study over initial with different test crops except maize. It shows that the current phosphorus application was not in line with the crop requirement and suggests slight increase in phosphorus dose over existing in case of maize. The available potassium status was significantly

declined with maize and sunflower, which shows the need of higher replenishment of potassium in double cropped

Table 1. Performance of different irrigated dry *rabi* crops in terms of yield, efficiency and available N, P and K status after *kharif* rice.

(Over three years)

Rabi crop	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Horse gram equivalent yield (kg ha^{-1})	Production efficiency (%)	Economic efficiency (%)	Value cost ratio	Post crop soil available NPK (kg ha^{-1})		
							N	P	K
Horse gram	776.00	1081.00	776.00	-	-	-	244.00	25.33	293.00
Sunflower	1856.00	2495.00	2531.00	226.00	284.00	0.09	219.00	21.91	272.00
Maize	4982.00	5627.00	2491.00	221.00	333.00	0.11	203.00	20.15	266.00
Mustard	1138.00	1529.00	2327.00	200.00	280.00	0.10	238.00	22.50	289.00
Bengal gram	739.00	1190.00	1512.00	95.00	-26.00	0.04	240.00	24.68	282.00
Soybean	1121.00	1855.00	1529.00	97.00	20.00	0.05	239.00	25.17	285.00
Rajmah beans	1054.00	1383.00	1917.00	147.00	155.00	0.08	236.00	25.07	290.00
Groundnut	1262.00	1422.00	2007.00	159.00	13.00	0.05	237.00	23.29	281.00
CD at 0.5 %	480.00	398.00	433.00	-	-	-	19.00	4.33	21.00

Table 2. Performance of different irrigated dry *rabi* crops in terms of water use efficiency, energetic and economics after *kharif* rice.

(Over three years)

Rabi crop	Water used (mm)	WUE (kg ha^{-1} mm^{-1})	Energy input (MJ)	Energy output (MJ)	Energy use efficiency (MJ^{-1})	Energy productivity (kg MJ^{-1})	Cost of cultivation (Rs ha^{-1})	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	Rupee per rupee invested
Horse gram	300.00	2.59	4650.00	11401.00	2.45	167.00	10435.00	17063.00	6628.00	0.64
Sunflower	550.00	3.38	8750.00	46410.00	5.30	212.00	30263.00	55692.00	25429.00	0.84
Maize	600.00	8.30	10550.00	73230.00	6.94	472.00	26102.00	54798.00	28696.00	1.10
Mustard	450.00	2.53	6875.00	28438.00	4.14	165.00	26015.00	51188.00	25173.00	0.97
Bengal gram	450.00	1.64	7050.00	10866.00	1.54	105.00	28370.00	33264.00	4894.00	0.17
Soybean	500.00	2.24	7202.00	16485.00	2.29	156.00	25695.00	33642.00	7947.00	0.31
Rajmah bean	500.00	2.11	8525.00	15497.00	1.82	124.00	25250.00	42168.00	16918.00	0.67
Groundnut	600.00	2.10	11750.00	31538.00	2.68	107.00	36675.00	44153.00	7478.00	0.20
CD at 0.5%	-	-	1006.00	5389.00	-	-	2188.00	5493.00	1065.00	0.19

WUE = Water use efficiency.

areas. Cereal to cereal cropping sequences are more exhaustive and put heavy demand on soil resources as compared to cereal-legume and cereal-oilseed sequences (Bora *et al.,* 2011) .The result amply demonstrate that the legume crops are capable in maintaining the soil fertility status than non-legumes. Palaniappan and Sivaraman (1994) also reported the stability of soil health with inclusion of legume crops in double cropped areas.

Data on economics of different crops after rice in sandy clay loam soil reveals that, groundnut recorded significantly higher cost of cultivation than other crops, while horse gram recorded the lowest (Table 2). Gross returns were significantly higher in sunflower followed by maize and mustard .The higher gross returns were owing to higher yield in maize and higher sale price in mustard. Net returns were significantly higher in maize followed by sunflower and mustard as compared to other crops. The results are in agreement with those of Kumar *et al.* (2005). Net returns of Bengal gram were lesser than horse gram, groundnut and soybean than other crops but found at par with horse gram. Rupee returned per rupee invested was also higher in maize followed by mustard and sunflower, whereas it was lowest in Bengal gram followed by soybean and groundnut.

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Relative susceptibility of some genotypes (*Pisum sativum* L.) against sucking pests of field pea

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ABSTRACT

Among 15 pea genotypes screened, three genotypes *viz*., Pant P 167, IPFD 10-13 and IPFD 10-12 were found resistant against aphid, while only genotype IPFD 10-13 was found resistant against leafhopper and thrips. The results further indicated that Pant P 167, IPFD 10-13 and IPFD 10-12 proved resistant against whitefly. Based on overall performance, IPFD 10-13 genotype of field pea was found to exhibit multiple resistance against all the evaluated sucking pests. The yield of marketable seeds of field pea was highest in the genotype IPFD 10-13 (3416.66 kg ha^{-1}) followed by genotypes Pant P 167, IPFD 10-12 and IPF 99-25(ch) with yield of 3229.16, 2937.50 and 2916.66 kg ha^{-1}.

Key words: Relative susceptibility, genotypes, sucking pests, field pea.

FieId pea (*Pisum sastivum* L.) is an important crop among *Rabi* pulses and it holds an unique position in the country due to its multiple uses. It has the second importance among all the grain legumes after soybean (Mihailovic *et al*. 2005; Singh and Bhatt, 2012). In India, field pea is grown in an area of 0.77 million hectare with a production of 0.71 million tonnes and productivity 1032 kg ha^{-1} (Anonymous, 2009) and grown in various states of India. It is attacked and damaged by different types of insects like sucking pests and pod borers. Among the various pests, aphid, whitefly and leafhopper causes considerable loss in the yield of field pea by sucking the sap from the ventral surface of leaves. As a result of feeding by these pests, the affected parts become yellowish, leaves wrinkle and curl downward and are ultimately shed off. Besides the feeding, these insects exude honey dew, which favours the development of sooty mould, affecting the photosynthesis of the plant resulting in stunted growth. The reduction in pea yield due to pea aphid infestation is 42 per cent under field condition (Warrington *et al*. 1987). However, in changing scenario of pest management programme, host plant resistance plays an important role. In view of above, an attempt has been made to evaluate field pea genotypes against sucking pests under field conditions and results are reported.

MATERIALS AND METHODS

The field experiment was conducted with 15 field pea genotypes at Centre of Excellence for Research on Pulses, S.D.A.U, Sardarkrushinagar, Gujarat in Randomized Block Design during *Rabi*, 2012. The gross plot size was 4×0.6 m and the net 3.6×0.6 m. The seeds of different field pea genotypes was sown with spacing of 30×10 m. The crop was raised adopting standard package of practices except plant protection measures. Five plants were selected randomly and tagged in each plot to record the pests population. Observations were recorded at weekly intervals during morning hrs starting from 2 weeks after sowing till the maturity of the crop. The pest population and yield data were subjected to statistical analysis. The criteria for categorizing genotypes as resistant (R) or susceptible (S) were as per description of Rana *et al*. (1998). They proposed that the varieties showing less incidence of pest than a value obtained by subtracting standard deviation from mean per cent incidence of pest should be considered as resistant and vice-versa. If, general mean aphid index is 1.91 and Standard Deviation (S.D.) 0.67, then the cut off value will be 1.91 – 0.67, i.e., 1.24 (aphid index plant^{-1}).

RESULTS AND DISCUSSION

Among 15 field pea genotypes screened, Pant P 167, IPFD 10-13 and IPFD 10-12 were found resistant against aphid (*Aphis craccivora*) as these genotypes showed less than 1.24 aphid index (plant^{-1}), while remaining 12 genotypes recorded aphid population more than 1.24 and proved susceptible to this pest (Table 1). The genotype Pant P 161, IPF 99-25(ch), RFP 2009-4, HFP 716, IPFD 99-13(ch), IPFD 1-10(ch), LFP 477, HFP-4, HFP 715, HUDP 954, KPMR 400(ch) and DF-1 had the aphid population index in the range of 1.79 to 2.94 (plant^{-1}) and categorized as susceptible. Out of 15 genotypes, only genotype IPFD 10-13 was found resistant

Table 1. Reaction of different fields pea genotypes against various sucking insect pests.

Sl. No.	Genotype	Mean number of pest (adults/nymphs 3 compound leaf^{-1})				Grain yield (kg ha^{-1})
		Aphid	Leafhopper	Whitefly	Thrips	
1	DF-1	2.94 S	3.63 S	5.10 S	1.85 S	1333.33
2	HFP-4	2.58 S	1.94 S	2.75 S	1.35 S	2500.00
3	HUDP 954	2.59 S	3.34 S	4.25 S	2.85 S	1572.91
4	KPMR 400(ch)	2.59 S	3.87 S	4.65 S	2.75 S	1447.91
5	HFP 715	2.58 S	3.34 S	3.75 S	1.85 S	2135.41
6	Pant P 167	0.83 R_1	1.19 S	1.25 R_1	0.85 S	3229.16
7	IPFD 1-10(ch)	2.03 S	2.44 S	3.35 S	1.35 S	2374.99
8	LFP 477	2.05 S	2.80 S	3.15 S	1.85 S	2312.50
9	IPFD 10-13	0.90 R_2	0.88 R_1	1.25 R_1	0.75 R_1	3416.66
10	Pant P 161	1.41 S	1.38 S	2.30 S	1.10 S	2906.24
11	IPF 99-25(ch)	1.41 S	1.19 S	1.80 S	0.90 S	2916.66
12	IPFD 99-13(ch)	2.01 S	1.38 S	2.30 S	1.20 S	2833.33
13	IPFD 10-12	1.10 R_3	1.19 S	1.25 R_2	0.85 S	2937.50
14	RFP 2009-4	1.79 S	1.38 S	2.55 S	1.35 S	2812.49
15	HFP 716	1.85 S	2.80 S	3.75 S	1.40 S	2216.66
C.D. at 5 %		0.44	0.42	0.50	0.52	508.93
General Mean		1.91	2.18	2.89	1.48	-------
S.D.		0.67	1.03	1.24	0.64	-------
Cut off value = Mean – S.D.		1.24	1.15	1.65	0.84	-------

R=Resistant and S = Susceptible

against leafhopper (*Empoasca kerri*), with less than 1.15 adults/nymphs per three compound leaves. The other genotypes, KPMR 400(ch), DF-1,HFP 715, HUDP 954, HFP 716, LFP 477, IPFD 1-10(ch), HFP-4, RFP 2009-4, IPFD 99-13(ch), Pant P 161, IPFD 10-12, IPF 99-25(ch) and Pant P 167 showed more than 1.15 adults/nymphs per three compound leaves and therefore, marked susceptible to this pest. In case of white fly (*Bemisia tabaci*), the genotype Pant P 167, IPFD 10-13 and IPFD 10-12 were found resistant exhibited more than 1.65 whitefly adults/nymphs per three compound leaves and marked as susceptible to this pest. Only genotype, IPFD 10-13 was found resistant to thrips (*Caliothrips indicus*) as it registered less than 0.84 adults/nymphs per three compound leaves, whereas, genotypes, KPMR 400(ch), DF-1,HFP 715, HUDP 954, HFP 716, LFP 477, IPFD 1-10(ch), HFP-4, RFP 2009-4, IPFD 99-13(ch), Pant P 161, IPFD 10-12, IPF 99-25(ch) and Pant P 167 had more than 0.84 adults/nymphs per three compound leaves and graded as susceptible against thrips.

The mean yield of marketable field pea seeds of genotypes differed significantly. Perusal of results further revealed that the yield of field pea seeds was maximum (3416.66 kg ha^{-1}) in genotype IPFD 10-13 (Table 1) followed by genotypes Pant P 167 (3229.16 kg ha^{-1}), IPFD 10-12 (2937.50 kg ha^{-1}) and IPF 99-25(ch) (2916.66 kg ha^{-1}) and proved highly promising. The lowest seed yield was recorded in the genotype, DF-1 (1333.33 kg ha^{-1}). The remaining genotypes *viz*., HFP 715, HFP 716, LFP 477, IPFD 1-10(ch), HFP-4, RFP 2009-4, IPFD 99-13(ch) and Pant P 161 produced the pea seed in the range of 2135.41 to 2906.24 ha^{-1}. The genotype IPFD 10-13 registered the highest grain yield and proved resistant against all the sucking pests. The genotypes, Pant P 167, IPFD 10-12 and IPF 99-25(ch) were also found promising as far as the grain yield is concerned. There is not much information available especially on varietal screening of field pea against sucking pests. However, Singh and Mishra (1977) studied twelve varieties of *P. sativum*, sown in October at Pantnagar, India in 1975-76, and found susceptible to thrips infestation. Early Badger, Bonneville, Arkel, Newline Perfection and Asauji showed comparative resistance to thrips, whereas, Alaska was the most susceptible variety to thrips, which means this pest preferred varieties with broader green leaves.

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Effect of cow milk on sucking pests and insect predators on rose

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ABSTRACT

Cow milk was evaluated for toxicity bioassays against three pests of rose, i.e., aphids (*Macrosiphum roseiformis*), thrips (*Scirtothrips dorsalis*) and two spotted spider mites (*Tetranychus urticae*) and its influence on two predatory insects ladybird beetles (*Coccinella septempunctata*) and minute pirate bugs (*Orius laevigatus*). In addition, anti and pro effects of the milk on behavioural responses of all experimental insects/mites were determined by using choice-no-choice method. Results revealed that milk has a potential to be used as a insect / mite control agent on roses, as it gave remarkable control of all the tested sucking pests of rose and found completely safe towards two general insect predators. In addition, repellent effect of milk was also noticed on these pests.

Key words: Cow milk, thrips, aphids, spider mites, control, insecticide, predator.

Cow's milk has many bioactive compounds, proteins, carbohydrates, fatty acids, minerals and other nutrients, which facilitate healthy growth and development. Besides health benefits, milk is a good medium for bacterial culture. This property made it to be used in control of number of insect problems (Young, 1982). In ancient times, farmers used cow's milk as a medium for saprophytic bacteria and virus inhibitor (Nene, 1999). Virkshayurveda and Chavundaraya which deals with agriculture and botany, described the use of milk, which changed the flower colour and enhanced the fruit taste (Shenoy *et al*. 2000). There is a scarcity of information with respect to field application of milk for pest control. However, other cow products, such as: *panchgavya* (Natarajan, 2002; Vivekanandan 1999a,b), cow urine (Gupta and Yadav, 2010), cow dung (Sadawarte and Sarode, 1997; Boomathi *et al*. 2006) and cow butter milk (Gupta and Rai, 2006) had success stories in insect pest control. Synthetic insecticides are used frequently for the control of various sucking pests on ornamentals and in greenhouses. Reports elucidated the side effects of these chemicals on biocontrol agents (Smith and Krischik, 1999; Rebek and Sadof, 2003) and other pest related problems like, development of resistance in pests to different group of insecticides (Schreiber *et al*. 1990; Zhao *et al*. 1995) and outbreaks of secondary pests (Sclar *et al*. 1998; Gupta and Krischik, 2007). Recent pest management approaches are focusing more towards natural and safer control measures especially on ornamentals and green houses, where a lot of dependency prevailed on synthetic pesticides. Cow's milk, if as a curative measure could get incorporated in this system, would be a safe approach. In current research, cow milk was evaluated with toxicity bioassays against three pests of rose (aphids, thrips & spider mites) and for influence on two predatory insects (lady bird beetles & minute pirate bugs).

MATERIALS AND METHODS

Experimental material: Cow milk was brought from V.P.O Chunni Kalan, Fatehgarh Sahib, Punjab, India. Three concentrations were made and tested against test insects. One hundred ml of cow (whole) milk was taken as X and further two serial dilutions (0.5X & 0.25X) were made with distilled water. Fresh milk was used for further experiments.

Insects/ mite: Natural populations of rose aphids (*Macrosiphum roseiformis*), thrips (*Scirtothrips dorsalis*) and two spotted spider mites (*Tetranychus urticae*) were collected from rose garden of Panjab University, Chandigarh, India, as and when available and needed for the experimentation. In addition, generalist predators of these pests, ladybird beetles, *Coccinella septempunctata* (LBB) and minute pirate bugs, *Orius laevigatus* (MPB), were selected for the study. LBB were collected from different locations near Chandigarh, from mustard and wheat fields. These beetles were kept in plastic containers covered with muslin cloth and fed with thin slices of apple and diluted honey solution till they were used for bioassays and behavioral assays. MPB were procured from Bio Bee India Pvt Ltd., New Delhi, India (http://biobee.in/products-and-services/solutions/bioorius/).

Toxicity bioassays : Bioassays were conducted to evaluate the toxic effect of milk on pests and predators selected for study. In cse of aphids, thrips and spider mites toxicity bioassays, compound rose leaflets were collected and washed thoroughly with water. These were treated with 3 different

concentrations (X, 0.5X & 0.25X) of milk. After air drying, these treated leaflets were kept in petridish (90 x15mm) and 7-10 aphids, thrips and spider mites were released in each petridish. Leaflets, untreated but washed with water served as control. Data on number of insects/mites survived were recorded after 24 and 48 hrs after release. The same procedures were followed in case of LBB and MPB but here 4-5 adults were released in each petridish. In addition, immature stages of aphids were given to these predators as feed in each petridish and provided *ad-libitum*. Here also observations were recorded on survival of predators at 24 and 48hrs after release. Three replicates for each concentration were made and three biological repeats were done at different dates (n=3x3). Data were analysed by ANOVA and means were compared using Tukey's HSD test and analysed for homogeneity using Welch's tests (JMP SAS Institute, 2005).

Food choice test: Behavioural response (food choice) of aphids, thrips and spider mites was studied by giving them two choices (untreated & treated rose leaves with whole milk). Rose leaves were cut to square discs (4x4 cm) and four leaves were kept in a petridish (140x20mm) lined with a moistened filter paper (Whatman filter paper 125mm). Treated and untreated leaf discs were arranged alternately around the circumference of the petridish. These were placed in the petridish at diagonal position. In this way two choices were given to test organisms (treated or untreated). Six thrips or 10 aphids or 6 spider mites were released at the center of the petridish. Observations on number of aphids or thrips or spider mites, present on treated or untreated rose leaf discs were recorded at 30, 90 and 180 min after the release. Goodness of fit (χ^2) analysis using PROC FREQ to determine, if the choice responses deviated significantly from random choice (1:1, 50%) was done (JMP SAS Institute, 2005).

RESULTS AND DISCUSSION

Aphids: Milk as whole, i.e., the higher concentrations (0.5X & X) showed significantly reduced number of aphids at 24 hours. The percentage mortality was 51 and 67 per cent and found significantly different from control (12%). Similarly, at 48 hours, both the higher concentrations (X & 0.5X) showed reduced number of aphids and the percentage mortality was 88 and 70 per cent (Table 1). These results showed that milk had the potential to control aphids, when applied as whole. Behaviour response of aphids via choice–no choice test revealed that average percentage of aphids reached to cow's milk treated leaves at 30 and 90 min of observations were non-significantly different from untreated control, whereas at 180 minute 40 per cent aphids reached to untreated leaves (Fig. 1), which had significantly more value than treated

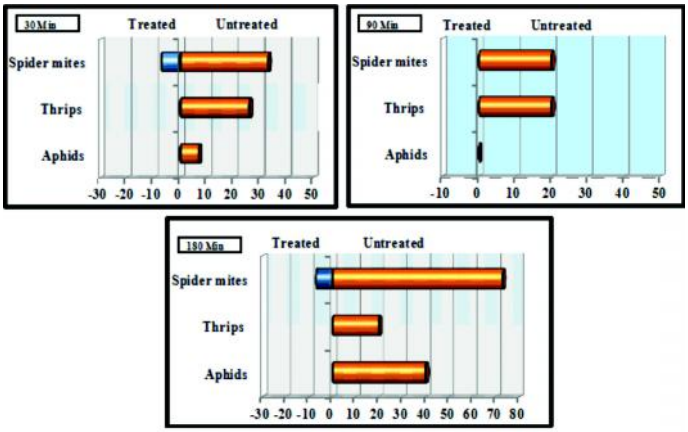

Fig. 1. Average percentage of rose pests reached to specific choices cow milk treated and untreated leaves (X concentration) at different time intervals.

Table 1. Per cent mortality of aphids, thrips and spider mites after 24 and 48 hrs on cow milk (3 concentrations) treated rose leaves.

Cow milk concentration	Mortality (%) after hrs					
	Aphid		Thrip		Spider	
	24	48	24	48	24	48
X (whole)	66.7±2.9a	87.8±4.0a	82.2±6.3a	100.0±0.0a	83.3±4.1a	94.4±3.6a
0.5X	51.1±5.3a	70.0±6.5ab	68.9±6.8a	88.9±4.8a	66.7±8.3a	80.5±6.9ab
0.25X	33.3±5.0b	50.0±6.9b	71.1±7.5a	84.4±5.6a	63.9±7.3a	75.0±4.1b
Control	12.5±3.9c	25.0±4.2c	28.3±6.2b	35.0±5.6b	4.1±2.8b	6.2±3.2c
F (df), P treatment	30.3 (3,38), <0.0001	26.9 (3,38), <0.0001	13.9 (3,38), <0.0001	27.4 (3,38), <0.0001	41.2 (3,38), <0.0001	84.1 (3,38), <0.0001
F (df), P treatment (Welch)	40.9 (3,18.5), <0.0001	38.1 (3,18.3), <0.0001	13.2 (3,18.9), <0.0001	-	87.9 (3,16.8), <0.0001	116.5 (3,18.2), <0.0001

leaves (χ^2 =8.32, Prob>ChiSq=0.0039). Choice- no-choice results indicates that when two choices (milk treated or untreated rose leaves) were given to aphids and these were left for some time with the choices, initially they did not make any choice up to 90 minutes but later at 180 minutes, about 40 per cent reached the untreated rose leaves.

Thrips: Milk at all the concentrations tested against thrips caused high mortality at 24 and 48 hours after application. At 24 hours, it caused 71, 69 and 82 per cent mortality at 0.25, 0.5 and X concentrations, which was significantly different from control (28%). The mortality after 48 hours of treatment with milk was 84, 88 and 100 per cent at 0.25X, 0.5X and X concentrations (Table 1). In choice-no-choice experiment average percentage of thrips reached on cow's milk treated rose leaves at 30, 90, 180 minutes was non-significantly different from those reached to untreated leaves**.** These results indicates that in presence of milk treated leaves along with untreated leaves thrips were unable to make any choice. This may be because of deterrent effect of milk and for that reason only, the mortality of thrips found very high as they were unable to perform normal actions (choice of food) in presence of milk.

Spider mites: All the tested concentrations of milk caused high mortality of mites at 24 and 48 hours after application. At 24 hours, it caused 64, 67 and 83 per cent mortality at 0.25, 0.5 and X concentrations and differed significantly from control (4%). The mortality after 48 hours of treatment was 75, 81 and 94 per cent at these concentrations. The results proved that milk was highly effective against spider mites (Table 1). In preference-non-preference test average percentage of spider mites on cow milk treated rose leaves at 180 minutes was 6.7 per cent as compared to 73.3 per cent on untreated leaves (χ^2=8.32, Prob>ChiSq=0.0039**)**. Choice-no-choice results indicates that when two choices (milk treated or untreated rose leaves) were given to mites at 30 and 90 minutes only 33 and 20 per cent, reached to untreated leaves, whereas at 180 minutes, 73 per cent spider mites were present on untreated leaves. This preference for untreated leaves indicates the high repellency towards milk by spider mites (Fig. 1).

Predators: Milk at all the concentrations had no influence on lady beetles, when observed at 24 and 48 hours after application. Survival of lady bird beetle was cent per cent at all the concentrations tested even after 48 hours of treatment (Fig. 2A). Similar results were obtained when milk treated leaves were given to minute pirate bugs (Fig. 2B). The results revealed that milk was almost safe for these predators and could be compatible for use along with other methods in pest control practices for rose.

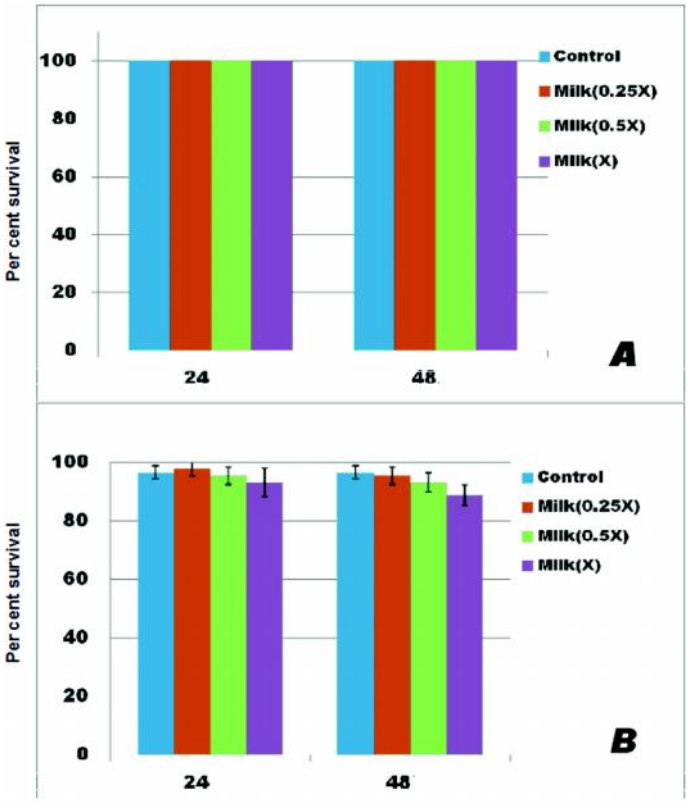

Fig. 2. After treatment in hrs percentage survival of Lady bird beetle (A) and minute pirate bugs (B) on milk treated rose leaves at 24 and 48 hrs after treatment

Results of above experiments revealed that milk has a potential to be used as a insect / mite control agent on roses, as it gave remarkable control of all the sucking pests of rose tested complete safe towards two generalist insect predators. In addition, repellent and deterrent effect of milk was also noticed with these pests. As very less information available showing insecticidal effect of milk in agriculture, results can not be compared with earlier findings. Although, Young (1982) documented that infestation of loopers that attack cabbage, cauliflower etc., can be controlled with the application of milk on plants as milk is a good medium for bacterial culture and these bacteria can paralyse the larvae's intestinal tract and brings death in 2 to 4 days. Besides milk, other products from cow had significant evidences of controlling insect pests. *Panchgavya*- a combination of five products (milk, ghee urine, curd & dung) reported effective in Jasmine, when sprayed at 3.0 per cent, two times during the crop season, doubled the fruit yield besides increasing the resistance to pest and diseases (Vivekanandan, 1999a). *Panchgavya* (1.0%) spray reduced the flower drop, increased fruit size, retained freahness and enhance taste in peach trees and also prevented fruit drops from green worms attack

(Vivekanandan, 1999b). A plethora of literature is available depicting role of cow urine against various insect pests (Nankinga *et al*. 1999; Ukey and Sarode, 2003) and plant diseases (Surender Kumar and Sehgal, 1998). Cow urine is recommended as an insecticide by mixing it with soil and applying on plants at much diluted concentrations (Anonymous, 2005). Field trials were conducted in *kharif* season for evaluating cow urine efficacy against stem borers and cost benefit in soybean production in comparison to conventional insecticide (chlorpyrifos) and biopesticide (Dipel). Highest cost benefit ratio (1: 18.9) was obtained from 5 per cent cow urine (Gupta and Yadav, 2006). Gupta and Yadav (2010) had shown the efficacy of cow urine against different lepidopterous pests of soybean. Different concentrations of cow urine with one conventional, pesticide were sprayed three times during crop season and results revealed that different concentrations of cow urine significantly reduced the number of *Spilosoma obliqua* and *Spodoptera litura* larvae in all plots. Higher concentration of cow urine caused significant reduction in whitefly, *B. tabaci* at seven days after first spray. Sadwarte and Sarode (1997) reported that the combination of cow dung and cow urine with half dose of insecticides was observed to have moderate impact on *H. armigera* on pigeonpea, while NSKE + half dose of insecticide was most effective treatment, but sole application of cow dung and cow urine were found ineffective. The efficacy of neem (*Azadirachta indica*) kernel extract in cow urine (NSKE 30 ml l^{-1}), neem oil (1.0%), dimethoate (0.045%), NSKE + dimethoate (0.03%), NSKE (3.0%) + dimethoate (0.03%), neem oil (1.0%) + dimethoate (0.03%) and neem kernel extract in cow butter milk (NCBM 20 ml l^{-1}) against *L. erysimi* on *Brassica juncea* has been noticed. The highest benefit cost ratio (30.1) was obtained with 2 % NCBM (Gupta and Rai, 2006).

It emanates from the study that the milk has potential to be considered as a highly effective product, which could use in sustainable agriculture as it does not have any toxic effect for the insect predators. In addition, milk showed high toxicity towards spider mites and thrips by reducing a significant percentage on treated rose leaves. It was moderately toxic to aphids and could be recommended only at higher concentration, i.e., milk as whole. Overall milk has a good possibility for use in control of sucking pest complex of rose in greenhouse IPM with totally safe effect towards its predators.

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Seasonal incidence and prediction model of grapevine mealy bug (*Maconellicoccus hirsutus* Green)

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ABSTRACT

Study on seasonal incidence of grapevine mealy bug revealed the reduction in its population at every pruning (September and April) but reached at its peak during full vegetative growth (2nd - 12th MSW), i.e., fruiting season. The incidence of mealy bug was observed throughout the season. The incidence of parasitoids was seen throughout the season except 12th, 14th and 16th meterological week (MSW) on mealy bugs. However, predators were found absent during fruiting season, i.e., 50th to 12th meteorological standard week (MSW). The weather parameters *viz*., maximum temperature and bright sunshine hours showed significant and positive correlation, but minimum temperature, morning and afternoon relative humidity and rainfall correlated negatively with mealy bug incidence. The model ($LW_1 = 68.03 - 0.6X_3$) developed can be used to estimate population development of mealy bugs one week early, so that one can initiate management practices to reduce the population build up.

Key words: *Maconellicoccus hirsutus*, grapevine, prediction model, correlations, mealy bug.

Grape (*Vitis vinifera* L.) is one of the most important commercial fruit crops of sub-tropical, tropical and temperate regions of the world. The prevailing sub-tropical and tropical climatic condition of India is well suited for higher sucrose level and berry yield. In India, the major grape growing states are Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, Punjab, Madhya Pradesh and Haryana. Over 85 species of insect pests are known to occur on grapes in India (Butani, 1979). About 26 pests infesting grapevine in northern Karnataka are reported by Balikai and Kotikal (2003). Out of these, two insects, i.e., flea beetle (*Sceledonta strigicollis* Mots.) and mealy bug (*Maconellicoccus hirsutus* Green) were recorded as major pests. In recent years, *M. hirsutus* has become very severe on grapevine. This pest is hard to kill (Lower, 1968) because of its waxy coating. Generally the pest builds up at any time with the result of interaction between pest and weather. The correlation studies, carried out using pest and weather parameters data may be of great help to predict the pest population in advance. This prediction model will be helpful in adopting control measures in time to suppress pest before it cause economic damage. Therefore, the study was conducted for two years to know the seasonal incidence of grape mealy bug and to analyse the prevailing weather as well as the weather during the previous (antecedent) three weeks (one/two/three lead weeks) and results reported.

MATERIALS AND METHODS

Well established grape vineyard located at the Horticultural Research Station, Tidagundi, Bijapur (Karnataka) was selected for studying the seasonal incidence of *M. hirsutus* and its natural enemies. The study was conducted on cv. Thompson Seedless planted at a spacing of 3 x 1 m for 2 years (2009-10 & 2010-11). The crop was pruned in April and October every year and all other recommended cultural practices were followed during the period of study. Observations were recorded on 10 plants selected at random in each vineyard on 10 randomly selected shoots during the vegetative phase and 10 randomly selected bunches during the fruiting phase. After counting, the infested shoots/berries were brought to the laboratory and placed over the pumpkin in wooden cages for the emergence of parasitoids. In case of predators, its number on each vine was counted and mean number of natural enemies present per vine worked out.

In order to study the influence of abiotic factors (meteorological parameters) and to develop the prediction model for mealy bug population, data on maximum and minimum temperatures, relative humidity (morning & evening), sunshine hours and rainfall were collected from the All India Co-ordinated Research Project on Agrometeorology, Bijapur. The correlations were worked out between mealy bug population and weather parameters that existed during the week of observations and one, two and three weeks lead time considering two season's data in order to develop valid prediction models. The post-monsoon and winter season (38th to 50th & 50th to 12th standard week) mealy bug population and weather parameters were used for better validation of the prediction model. To validate the prediction

model, previous two year data on mealy bug population and weather parameters were considered from the findings reported earlier by Katke (2008).

RESULTS AND DISCUSSION

Seasonal incidence of grapevine mealy bug

The observations on seasonal incidence of mealy bug over two seasons revealed its presence throughout the year (Table 1). During the study period, 10.6 egg masses and 15.9 colonies per vine were observed during 28th MSW (Meteorological Standard Week). Two peaks of mealy bugs (egg masses & colonies) were observed during 36th and 12th MSW (9.4, 25.1 & 19.4, 37.3). However, the drastic reduction in the population of both egg masses and colonies was observed during 44th and 14th MSW due to the effect of September and April prunings. The population of predators was observed during 28th to 48th MSW and again from 14th to 26th MSW with a peak of 3.8 during 24th MSW (Table 1). The parasitoids found present throughout the season on mealy bugs except 12th to 16th MSW. The population of parasitoids increased from 28th MSW and reached to its peak during 34th MSW. Afterwards the population of parasitoids started decreasing upto 16th MSW and again it increased (Table 1). Results similar to present work has been reported by earlier workers (Azam, 1983; Manjunath, 1985; Babu and Azam, 1987). During the second fortnight of September to first fortnight of October, the female adult population decreased largely due to pruning operation. The mealy bug again became active during January and increased as the grape clusters developed and was abundant by March, when the fruits were at ripening stage. Similarly, it has been earlier reported that the population of the mealy bug, *M. hirsutus* was heavy from January to May and low from June to December in the vineyards of South India and in general, the activity of the natural enemies coincided with that of the mealy bugs (Mani, 1989). It has also been reported from Pune, Maharashtra that the mealy bug population was maximum from middle of February to May and middle of September to middle of November (Anonymous, 1992), which is showing similarity to present findings. Balikai (1999) reported the presence of mealy bug throughout the year at Tikota village of Bijapur district in Karnataka, which is similar to our results. The mealy bug population started to increase from January and reached to its peak during February-March before harvesting. After harvesting, the mealy bug population

Table 1. Seasonal incidence of grapevine mealy bug and its natural enemies in Bijapur area of Karnataka, India during 2009-10 and 2010-11

Meteorological standard week (MSW)	Month and date	No. of egg masses (vine^{-1})			No. of mealy bug colonies (vine^{-1})			Number of natural enemies (vine^{-1})					
								Predator			Parasitoid		
		2009-10	2010-11	Mean	2009-10	2010-11	Mean	2009-10	2010-11	Mean	2009-10	2010-11	Mean
28	Jul 09-15	7.3	13.8	10.6	13.3	18.5	15.9	3.4	3.1	3.3	8.3	3.4	5.9
30	Jul 23-29	6.8	9.3	8.1	13.8	17.8	15.8	2.3	2.4	2.4	10.3	1.8	6.1
32	Aug 06-12	7.8	8.3	8.1	16.3	12.6	14.5	4.3	2.8	3.6	6.8	5.6	6.2
34	Aug 20-26	8.2	9.2	8.7	18.4	14.3	16.4	2.8	3.4	3.1	9.3	3.2	6.3
36	Sep 03-09	8.9	9.8	9.4	23.2	15.6	19.4	3.4	2.1	2.8	5.4	3.3	4.4
38	Sep 17-23	4.8	4.8	4.8	10.3	14.8	12.6	2.4	1.3	1.9	2.7	2.1	2.4
40	Oct 01-07	3.8	3.6	3.7	8.8	9.8	9.3	2.6	0.3	1.5	3.3	1.3	2.3
42	Oct 15-21	5.2	4.3	4.8	9.3	7.8	8.6	1.8	0.4	1.1	4.8	0	2.4
44	Oct 29 – 04	6.8	5.3	6.1	11.2	6.3	8.8	0.6	0.6	0.6	2.5	0.2	1.4
46	Nov 12-18	8.8	5.8	7.3	10.3	10.5	10.4	0.8	0.2	0.5	2.2	0	1.1
48	Nov 26-02	19.8	8.3	14.1	13.8	13.6	13.7	1.2	0	0.6	3.8	0.8	2.3
50	Dec 10-16	12.5	9.4	11.0	21.3	14.3	17.8	0	0	0.0	1.2	1.8	1.5
52	Dec 24-31	13.8	12.3	13.1	18.5	18.4	18.5	0	0	0.0	2.3	0.8	1.6
2	Jan 08-14	19	18.6	18.8	24.3	21	22.7	0	0	0.0	1.3	1.3	1.3
4	Jan 22-28	23.6	23.3	23.5	28.2	28.4	28.3	0	0	0.0	0.2	0.2	0.2
6	Feb 05-11	24.8	28.2	26.5	27.4	33.5	30.5	0	0	0.0	0.8	0.9	0.9
8	Feb 19-25	23.8	23.2	23.5	34.6	34.6	34.6	0	0	0.0	1.8	0.8	1.3
10	Mar 05-11	21.2	17.8	19.5	32.3	34.4	33.4	0	0	0.0	0.3	0	0.2
12	Mar 19-25	23.8	26.3	25.1	38.3	36.3	37.3	0	0	0.0	0	0	0.0
14	Apr 02-08	3.6	5.2	4.4	11.2	14.8	13.0	0	0.7	0.4	0	0	0.0
16	Apr 16-22	4.2	7.7	6.0	11.3	10.7	11.0	1.3	1.1	1.2	0	0	0.0
18	Apr 30-06	3.2	8.9	6.1	8.3	11.9	10.1	0.8	0	0.4	1.8	4.3	3.1
20	May 14-20	5.1	13.2	9.2	6.3	10.8	8.6	3.2	2.1	2.7	4.2	5.6	4.9
22	May 28-03	10.7	12.8	6.8	7.4	14.7	11.1	2.6	1.8	2.2	6.8	3.7	5.3
24	Jun 11-17	10.5	15.8	13.2	8.3	16.6	12.5	4.3	3.2	3.8	5.2	6.8	6.0
26	Jun 25-01	11.8	17.8	14.8	10.7	17.2	14.0	3.5	2.9	3.2	4.1	5.8	5.0

remained low from May to December. It is reported by Koli (2003) that the grape mealy bug was active during September to March in Rahuri, Maharashtra, which corroborate to present findings. Similarly, Katke *et al.* (2009) observed the occurrence of mealy bugs throughout the year with two peaks, i.e., during 10th and 36th MSW.

Predatory population was high during July to October, which shows similarity to the results of Misra (1999). Das *et al.* (1948) observed heavy build-up of the *F. virgata* during July-August on jute, while on garden land fruit crops during winter and early spring in Dacca. The natural enemy population, mainly the grubs of *Cryptolaemus montrouzieri* Mulsant were observed during 26th to 52nd MSW, even though the population in general was very low. The grub population started increasing from 28th MSW and reached at its peak during 38th MSW and thereafter declined and vanished from the garden by 2nd MSW (Katke *et al.* 2009). The results of the present investigations are more or less in agreement with the above reports.

week increased by fifteen per cent compared to the lead periods of two and one. The present results corroborate with the findings of earlier workers (Mani, 1986; Koli, 2003; Katke *et al.* 2009), who observed positive and significant correlation of the grape mealy bug population with maximum temperature and negative correlation with the relative humidity and non-significant negative correlation with rainfall. Shreedharan *et al.* (1989) reported that the population of mealy bug, *P. citri* in Mandarin orange correlated positively with the temperature and negatively with relative humidity, while it showed no clear correlation with total rainfall. According to Katke *et al.* (2009), it correlated negatively and significantly with minimum temperature at one, two, three and four weeks lead time. Similarly, it also correlated negatively and significantly with morning and afternoon relative humidities and rainfall. As per the entomological reports from Rahuri, a significant and positive correlation with maximum and minimum temperatures and significant negative correlation with morning relative humidity was observed in pomegranate mealy bugs

Table 2. Correlation between weather parameters with mealy bug colonies (38th - 12th standard week) at Bijapur, Karnataka, India during 2009- 2011.

Parameter	X_1	X_2	X_3	X_4	X_5	X_6
LT3	0.432*	-0.303	-0.549**	-0.683**	0.629**	-0.401*
LT2	0.726**	-0.151	-0.811**	-0.680**	0.573**	-0.412*
LT1	0.661**	0.019	-0.654**	-0.746**	0.644**	-0.327
LT0	0.802**	0.224	-0.830**	-0.607**	0.449*	-0.313

** Significant at the 0.01 level

* Significant at the 0.05 level

Correlation with weather parameters

The mealy bug population showed significantly positive correlation with maximum temperature and bright sun shine hours during the week of observation, one, two and three weeks lead time, whereas it was negatively correlated with morning and afternoon relative humidities (Table 2). Rainfall had negative correlation during all the lead time. However, no correlation existed between the incidence of mealy bug and minimum temperature during all the lead weeks but negatively and non-significantly correlated at two and three weeks lead time. It was noticed from the Table 3 that relative humidity was the main controlling variable for mealy bug. Even though the R^2 at three weeks lead time was less (R^2 = 27), afternoon relative humidity was the only variable that could be considered to estimate mealy bug incidence three weeks later. At two (R^2 = 64) and one (R^2 = 60) week lead time morning relative humidity was important to predict mealy bug incidence. The reliability of estimation of mealy bug incidence in the current

Table 3. Regression models developed to forecast incidence of mealy bugs colonies (38th - 12th MSW) with meteorological variables at different lead weeks (2009-2011) at Bijapur, Karnataka, India

Lead time	Regression equation	R^2
LT3	$36.34 - 0.35X_4$	27
	$42.71 - 0.49X_4$	60
LT2	$76.53 - 1.15X_2 - 0.46X_3$	64
	$-13.09 + 1.15X_1 - 0.09X_6$	30
LT1	$68.03 - 0.6X_3$	60
	$40.7 - 0.47X_4$	51
	$43.69-0.53X_4$	75
LT0	$65.32 - 0.57X_3$	66
	$-38.52 + 1.91X_1 - 0.06X_6$	52

LT0- Current week lead time; LT1- Lead time one week; LT2- Lead time two weeks; LT3- Lead time three weeks; X_1- Max. temp.; X_2 – Min. temp.; X_3 - RH1 morning ; X_4 -RH2 afternoon ; X_5 – Bright Sunshine hrs and X_6– Rainfall.

(Anonymous, 1995). The results of the present study are almost in line with the above workers, when correlations were worked out for mealy bug during its peek incidence period (38th - 52nd MSW).

The forecasting model developed at current lead time using the observation made on mealy bug population and weather parameters from 38 to 12th MSW of 2009 to 2011 was validated by substituting the mealy bug population and weather parameters of 2005-06 and 2006-07 data into the developed model. The population of mealy bug in the observed was lower than estimate at 38th MSW, but later on the population in the observed was slowly increased with that the error in the model decreased (at the time of fruit development/maturity, i.e., 52nd - 12th MSW) during both the years of observations (2005-06 & 2006-07). During the peak infestation of the mealy bug, it was observed that the difference between the observed population and estimated was either equal or lower and thus reduced error in the model noticed (Table 4). Using the same model the lead time one and two the mealy bug population was predicted. The trend was same in the population of mealy bug as it was in the current week. It is noticed from Table 5 and 6 that the forecast models of lead weeks performed better in 2006 than in 2005. In both years as well as in pooled, it was noticed that the error with model LW1 ($R=68.03 - 0.6X_3$) gave best results. It was also noticed from error analysis using different methods on pooled data that the LW1 model gave minimum error. Hence, it could be inferred that the forecast of incidence of mealy bug can be made best using the forecast model LW1, as indicated by the validation of the models for independent data sets of 2005 and 2006.

The mealy bug population prediction model was developed for current lead week ($LT0 = 43.69-0.53X_4$), one lead week ($LT1 = 68.03 - 0.6X_3$) and two lead weeks ($LT2 = 76.53 - 1.15X_2 - 0.46X_3$). Keeping the afternoon relative humidity as independent factor, because of its high influence on the population development, it was observed that the forecasting model developed for LT1 showed less error in

Table 4. The forecasting of grapevine mealy bug infestation at different lead weeks with substituted data of 2005-06 and 2006-07.

Meteorological standard week (MSW)	Population of mealy bug (vine-1) (2005-06)				Population of mealy bugs (vine-1) (2006-07)			
	Observed (LT0)	Estimated			Observed (LT0)	Estimated		
		LT0	LT1	LT2		LT0	LT1	LT2
38	7.3	11.36	14.03	10.98	15.1	7.12	11.03	10.98
40	6.4	17.72	14.63	11.44	8.3	5.00	11.03	11.44
42	6.0	10.83	12.83	11.21	5.4	22.49	18.83	12.36
44	5.7	21.43	23.63	21.79	4.2	12.42	12.23	20.64
46	6.3	30.44	21.83	28.46	4.5	20.37	15.83	21.46
48	8.4	27.79	20.63	25.24	5.0	20.37	22.43	25.24
50	10.2	28.32	25.43	31.22	9.3	21.96	13.43	31.22
52	12.3	27.26	21.83	29.61	10.2	23.02	13.43	28.46
2	18.4	24.08	17.63	21.79	12.5	24.61	13.43	21.79
4	19.5	31.50	31.43	35.82	16.5	25.14	18.83	31.22
6	21.3	33.62	29.63	33.29	19.3	27.79	16.43	29.84
8	25.6	35.74	37.43	34.67	25.7	26.20	20.03	31.22
10	30.5	29.91	32.63	29.84	34.3	28.32	24.23	21.79
12	31.4	32.03	35.63	27.54	31.4	29.38	21.83	22.94

LT0- Current week lead time; LT1- Lead time one week; LT2- Lead time two weeks.

Table 5. Comparison of efficacies of pest (mealy bug)forecast models.

Lead time	Population error for entire season		
	2005	2006	Mean
LT2	9.5	8.8	9.1
LT1	7.3	1.2	4.3
LT0	11.4	7.8	9.7

Table 6. Error analysis of forecast models of mealy bug.

Lead time	Error analysis		
	Mean Error	Mean Absolute error	RMSE
LT2	9.1	10.0	9.8
LT1	4.3	7.0	9.7
LT0	9.7	9.7	11.2

the forecasting model than the LT2 on mealy bug population. Hence, it is inferred that the population of mealy bug observed on current lead week can be substituted in this model and how much population of mealy bug would come after one week can be predicted. It is clear from Fig. 1 that the forecasts with model LT1 gave best result. Except in the month of November (MSW 46 & 48, error 12.23 & 13.63), in all the other periods the error was less than 10. Lowest errors of less than 5 are noticed in January and February (MSW 2 - 8). The informaton in literature on forecasting model of mealy bugs is scanty. The forecasting model on grape vine mealy bug was developed for the first time in Karnataka, keeping weather parameter as independent factors.

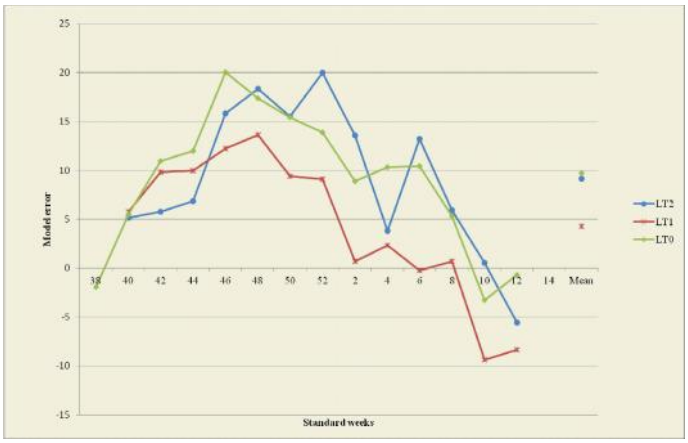

Fig. 1. Error analysis of forecast model of grape mealy bugs for different lead weeks

This forecasting model information would be very useful for the grape growing farmers, who could estimate the mealy bug population one week early and can take preventive measures for the management of mealy bug population. It was also noticed that the pest incidence increased considerably in the same period (MSW 52-12). Therefore, the models developed at LT1 can give best results when there is peak incidence of mealy bug. Further, as the model can provide forecast of incidence one week before actual incidence, it has got highly practical value for the management of the mealy bugs on grape vine.

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Field effecacy of newer molecules on sap feeders of green gram *Vigna radiata* (L.) Wilzeck

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ABSTRACT

A field experiment was conducted to study the effect of newer molecules on sucking pest complex of green gram *viz.*, white fly (*Bemisia tabaci*), thrips (*Megaleurothrips distalis*) and aphids (*Aphis craccivora*). All the three sap feeders (thrips, aphids & whitefly) were found attacking greengram crop from 2nd week of January and attainted their peak, i.e., 7, 6 and 26 (nos. plant^{-1}) at 60, 63 and 68 DAS. Amongst six newer molecules tested, thiomethoxam, emmamectin benzoate and cyazypyr were most promising against thrips (1.0-2.0 plant^{-1}) followed by spinosad and cartap hydrochloride (5.0-7.0 plant^{-1}) as against 18.30 plant^{-1} in untreated control. Aphids though appeared for a short period had a distinctly lower built up in cyazypyr (1.33 plants^{-1}) followed by emmamectin benzoate and thiamethoxam (3.00-3.33 plant^{-1}) as compared to 25.23 plant^{-1} in untreated control. All the new molecules had a marked variation against whitefly and most effective molecule was thiamethoxam (2.98 plant^{-1}) followed by cyazypyr (5.29 plant^{-1}), while it was 27.23 plant^{-1} in untreated control.

Key words : Sap feeders, new molecules, green gram, efficacy.

The greengram, *Vigna radiata* (L.) Wilzeck is an important pulse crop grown since ancient times and occupies third position with respect to area among the pulses in India. The sap feeders *viz.,* whitefly, thrips and aphids were major sucking pests of mung bean in Odisha causing considerable damage during dry warm weather. The sap feeders in general, cause damage by sucking the cell sap from the plant parts, thereby reducing the plant vigour and seed yield. In contrast whitefly cause damage to the plants in 3 ways, i.e., sucking cell sap from the foliage, developing sooty mould and the most important, act as a vector in transmission of yellow mosaic virus (YMV) from infected to healthy plants (Nene, 1971). The sucking pest complex were known to cause considerable damage to different pulse crops and can be effectively controlled by imidaclopid (Shah *et al.* 2007) and thiamethoxam, diafenthiuron and acetamiprid (Khattak *et al.* 2004). Therefore, the main aim of the study was to evaluate efficacy of different newer molecules to develop an integrated approach for the management of sap feeders to reduce yield losses in green gram.

MATERIALS AND METHODS

The study on pest complex of green gram was conducted in a replicated trial in the experimental field of Department of Entomology, Bhubaneswar during summer, 2012. Green gram variety "Nayagarh local" was line sown at 15cm apart from plant to plant and 20 cm between the rows. Five insecticides of different groups with novel mode of action viz., cartap hydrochloride, cyazypyr, emmamectin benzoate, spinosad, thiomethoxam and chlorpyriphos (standard check) were tested along with untreated control. Regular monitoring of the insect pest was done and insecticidal treatments were imposed 40 days after sowing (DAS) of the crop. Twenty plants from each treatment and replication were examined thoroughly on both the sides of trifoliate leaves and shoots for the presence of thrips, whitefly and aphids. Statistical analysis was done following Gomez and Gomez (1984).

RESULTS AND DISCUSSION

All the three sap feeders were found attacking greengram crop from 2nd week of January and attainted their peak (7, 6 & 26 plant^{-1}) at 60, 63 and 68 DAS. Amongst six test molecules, thiomethoxam, emmamectin benzoate and cyazypyr were found most promising against thrips (1.0-2.0 plant^{-1}) followed by spinosad and cartap hydrochloride (5.0-7.0 plant^{-1}) as compared to 18.30 plant^{-1} in untreated control. Aphids though appeared for a short period had a distinctly lower built up in cyazypyr (1.33 plant^{-1}) followed by emmamectin benzoate and thiamethoxam (3.00-3.33 plant^{-1}) as against 25.23 plant^{-1} in control (Table 1). Thiamethoxam was found best (2.98 plant^{-1}) against whitefly followed by cyazypyr (5.29 plant^{-1}). The white fly population was highest (27.23 plant^{-1}) in control (Table 1). All the tested molecules except chlorpyriphos yielded more than 5.0q ha^{-1} as against 4.42q ha^{-1} in control.

Table 1. Field efficacy of new molecules on sap feeder insect pests of mung bean in Odisha.

Chemical	Dose (kg a.i. ha^{-1})	Aphids (population 3 terminal leaves^{-1}) DAS		Reduction over control (%)	Thrip (population 3 terminal leaves^{-1}) DAS		Reduction over control (%)	White fly (population 3 terminal leaves^{-1}) DAS		Reduction over control (%)	Yield (q ha^{-1})
		3	10		3	10		3	10		
Cartap hydrochloride	0.50	15.38 (3.97)	12.66 (3.62)	50.01	13.49 (3.73)	7.00 (2.73)	61.81	15.29 (3.91)	13.84 (3.78)	49.17	5.08
Emmamectin benzoate	0.007	14.07 (3.81)	3.00 (1.86)	88.16	4.08 (2.11)	1.00 (1.22)	94.54	13.47 (3.67)	6.11 (2.56)	77.56	5.16
Spinosad	0.067	14.99 (3.93)	8.33 (2.96)	67.11	13.26 (3.69)	5.00 (2.34)	72.72	15.05 (3.88)	6.98 (2.73)	74.37	5.23
Thiomethoxam	0.031	14.28 (3.84)	3.33 (1.95)	886.85	8.14 (2.94)	2.00 (1.56)	89.09	9.42 (3.07)	2.96 (1.85)	89.13	5.02
Cyazypyr	0.08	13.00 (3.66)	1.33 (1.35)	94.75	6.31 (2.60)	1.33 (1.35)	92.74	11.97 (3.46)	5.29 (2.40)	80.57	5.10
Chlorpyriphos	0.50	15.56 (4.00)	15.00 (3.93)	40.78	15.42 (3.99)	12.00 (3.53)	34.53	15.60 (3.95)	14.72 (3.89)	45.94	4.96
Untreated control	_	22.94 (4.84)	25.33 (5.08)	-	17.48 (4.24)	18.33 (4.33)	-	26.83 (5.18)	27.23 (5.26)	-	4.42
CD at 5%		0.659	0.430	-	0.363	0.430	-	0.496	0.095	-	0.03

DAS = Days after sowing, figers in paranthesis are transformed values.

A good number of chemicals *viz*., cypermethrin, triazophos and dimethoate were reported effective against these pests in other parts of India (Srinivasa and Verma, 1997). The efficacy of thiometoxam and emmamectin benzoate were also studied by Dubey and Singh (2010) and Rao and Rao (2007), which also corroborate the present finding. It emanates from the study that among the novel group of molecules, emmamectin benzoate, thiomethoxam and cyazypyr were the effective insecticides against the sap feeders and can be recommended for management of these pests in green gram.

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Influence of plant morphological traits on the incidence of stem borers in different maize hybrids

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ABSTRACT

Among fifteen maize genotypes evaluated for their reaction to stem borers, the hybrids, Super 900M and Bioseed 9681 were found less susceptible to *Chilo partellus* and *Sesamia inferens,* while, NK 6240, NK 30 and Arjun were highly susceptible in terms of leaf feeding score and per cent infestation. Correlation of trichome density and leaf width with per cent infestation of stem borers was significantly positive. However, the correlation between other morphological characters and borer damage were non-significant.

Key words: *Chilo partellus, Sesamia inferens,* morphological trait, maize.

Maize (*Zea mays* L.) is the most versatile crop adapted to different agro-climatic conditions and an important staple food crop in Asia and Africa. It is grown for grain, fodder, raw material for processing industry and diversified products. Globally, India ranks 5th in area, 4th in production and 3rd in productivity (Pal *et al.* 2009). The multiple pest complex of maize crop poses serious limitations in the maize cultivation in different agro-climatic regions of India. Among different insect pests affecting maize crop, the stem borers, *Chilo partellus* (Swinhoe) and *Sesamia inferens* (Walker) are the most serious. The maize stem borers cause dead heart in seedling and early whorl stage, leading to total loss of the crop. The loss due to *C. partellus* varied from 26.7 to 80.4 per cent in different agro-climatic regions of India (Chatterji *et al.* 1969). Different maize genotypes exhibit varied reaction to the stem borer infestation (Mallapur *et al.* 2012). The morphological differences in maize hybrids deter insect feeding and oviposition, rendering them resistant or less susceptible. Keeping this in view, influence of various morphological traits of maize genotypes on the incidence of maize stem borers were studied and results reported.

MATERIALS AND METHODS

Fifteen selected maize genotypes, Arjun, Bio-9681, Super-900M, DMH 1001, DMH 1003, DMH-1007, DMH-1006, 25K65, NK-6240, NK 30, Pinnacle, Maharaja, K 244, P 3502 and S 6304 were sown in Randomized Block Design (RBD) over a plot size of 3m x 3m at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad, Karnataka, India. All the recommended packages of practices were followed for raising the crop except insect control measures. Data on number of plants showing leaf feeding symptoms, total number of plants and number of borer infested plants and leaf feeding score (1-9 scale) were recorded at 10 day intervals after 15 days of emergence. The 1-9 scale was based on number of pinholes per plant, i.e., 1-5 holes (1), 6-10 holes (3), 11-20 holes (5), 21-30 holes (7) and more than 30 holes (9). Observations were also recorded on morphological traits like number of nodes, cob height, leaf width, leaf colour and trichome density on 5 randomly selected plants in each plot. At the time of harvest, 5 plants with stem borer damage were observed for stem tunneling. Per cent infestation and length of stem tunneling were calculated by using following formula:

$$\text{Per cent infestation} = \frac{\text{No. of infested plants}}{\text{Total number of plants}} \times 100$$

$$\text{Per cent stem tunneling} = \frac{\text{Length of tunneling (cm)}}{\text{Total length of plant (cm)}} \times 100$$

RESULTS AND DISCUSSION

Infestation of *Chilo partellus*

The damage was maximum (30.00-34.00 %) by this pest in maize hybrids, NK 6240 followed by NK 30, Arjun, P 3502 and DMH-1007, whereas, it was minimum ((4.00 - 8.00 %) in Super 900M followed by Maharaja, Pinnacle and K 244 at 10, 20 and 30 DAE (Table 1). The leaf feeding score varied from 0.6 to 3.0 at 10 to 30 DAE in different maize genotypes. However, the minimum leaf feeding injury was at 10 DAE in Super 900M (0.6) while, it was maximum (3.0) at 30 DAE in NK 6240 (Table 1).

Infestation of *Sesamia inferens*

The infestation incidence of *S. inferens* was relatively more (Table 2) in NK 6240 and NK-30 (14.00-22.00%) followed by DMH-1006 (12.00-20.00%), DMH-1007 (12.00-18.00%) and Arjun (10.00-22.0%) as compared to other hybrids. The pest infestation was least in Super 900M (2.00-6.00%) at 10, 20 and 30 DAE. Leaf feeding score varied from 0.2 to 2.2 at 10, 20 and 30 DAE in different maize genotypes (Table 2). The minimum leaf feeding injury (0.2) was noticed at 10 DAE in Super 900M (Table 2).

Dead heart and stem tunneling

The dead heart incidence ranged from 0.00 to 10.00 per cent at 15, 30 and 45 DAE in different maize genotypes. Dead heart was not noticed in the hybrids Super 900M, Bioseed 9681, Pinnacle, Maharaja, DMH-1003, 25K65 and K 244, while it was more (Table 3) in NK 6240 (8.0-10.00%) followed by NK 30 (6.00-8.00%) and Arjun (2.00-6.00%). The stem tunneling was lowest in Super 900M (2.55%) and closely followed by Bioseed 9681 (3.94%), Maharaja (4.19%), Pinnacle (5.23%), P 3502 (5.84%), S 6304 (5.89%) and K 244 (6.34%).

Correlation with morphological traits and infestation

The data on morphological traits indicated that the leaves were pale green in colour at 10 DAE and after 20 and

Table 1. Infestation of *Chilo partellus* in different maize hybrids after 10 to 30 days of emergence

Maize hybrid	Infestation after DAE					
	10		20		30	
	Infestation (%)	Feeding score	Infestation (%)	Feeding score	Infestation (%)	Feeding score
Arjun	24.00 (29.33)^{def}	2.0	26.00 (30.64)^{def}	2.2	28.00 (31.89)^{efg}	2.6
Bioseed 9681	6.00 (13.98)^{a}	0.8	8.00 (16.43)^{a}	1.0	14.00 (21.92)^{b}	1.2
Super 900M	4.00 (11.54)^{a}	0.6	6.00 (13.98)a	0.8	8.00 (16.43)a	1.0
DMH-1001	20.00 (26.45)^{cd}	1.8	22.00 (27.95)^{cd}	2.4	26.00 (30.64)^{ef}	2.8
DMH-1003	20.00 (26.56)^{cd}	1.4	22.00 (27.95)^{cd}	2.0	28.00 (31.94)^{efg}	2.4
25K65	20.00 (26.56)^{cd}	1.2	24.00 (29.33)^{cde}	1.6	24.00 (29.33)^{de}	1.8
NK30	28.00 (31.94)^{ef}	2.4	30.00 (33.19)^{ef}	2.4	32.00 (34.45)^{gh}	2.8
NK6240	30.00 (33.19)^{f}	2.6	32.00 (34.45)f	2.8	34.00 (35.66)^{h}	3.0
Pinnacle	16.00 (23.58)^{bc}	1.0	18.00 (25.07)^{bc}	1.0	18.00 (25.07)^{bc}	1.4
Maharaja	12.00 (20.27)^{b}	1.2	14.00 (21.92)^{b}	1.4	18.00 (25.07)^{bc}	1.6
DMH-1007	22.00 (27.95)^{cde}	2.0	24.00 (29.33)^{cde}	2.2	30.00 (33.19)^{fgh}	2.6
DMH-1006	18.00 (25.07)^{cd}	1.8	24.00 (29.25)^{cde}	1.8	28.00 (31.94)^{efg}	2.2
K244	16.00 (23.58)^{bc}	1.2	18.00 (25.07)^{bc}	1.6	20.00 (26.56)^{cd}	1.8
P3502	18.00 (25.07)^{cd}	1.2	26.00 (30.64)^{def}	1.6	26.00 (30.64)^{ef}	1.8
S6304	18.00 (25.07)^{cd}	1.0	20.00 (26.56)^{bcd}	1.4	24.00 (29.33)^{de}	1.8
C.D.(0.05)	3.89		4.38		3.36	

Figures in parenthesis are arcsine transformed values, means followed by same alphabet differ non-significantly (0.05), DAE = days after emergence.

Table 2. Infestation of *Sesamia inferens* in different maize hybrids after 10 to 30 days of emergence

Maize hybrid	Infestation after DAE					
	10		20		30	
	Infestation (%)	Feeding score	Infestation (%)	Feeding score	Infestation (%)	Feeding score
Arjun	10.00 (18.35)^{cd}	1.2	14.00 (21.92)^{def}	2.0	22.00 (27.95)^{e}	2.0
Bioseed 9681	4.00 (11.54)^{ab}	0.6	6.00 (13.98)^{ab}	0.6	8.00 (16.43)^{ab}	0.8
Super 900M	2.00 (5.77)^{a}	0.2	4.00 (11.54)^{a}	0.4	6.00 (13.98)^{a}	0.6
DMH-1001	6.00 (13.98)^{bc}	1.2	8.00 (16.43)^{bc}	1.2	12.00 (20.27)^{bc}	1.6
DMH-1003	8.00 (16.43)^{bcd}	1.0	8.00 (16.43)^{bc}	1.0	16.00 (23.58)^{cde}	1.0
25K65	10.00 (18.35)^{cd}	1.2	14.00 (21.92)^{def}	1.4	16.00 (23.41)^{cde}	1.4
NK30	14.00 (21.92)^{d}	1.4	16.00 (23.58)^{ef}	1.4	20.00 (26.56)^{de}	1.8
NK6240	14.00 (21.92)^{d}	1.8	18.00 (25.07)^{f}	1.6	22.00 (27.95)^{e}	2.2
Pinnacle	4.00 (11.54)^{ab}	0.5	14.00 (21.92)^{def}	0.6	16.00 (23.58)^{cde}	0.4
Maharaja	4.00 (11.54)^{ab}	0.6	12.00 (20.27)^{cde}	0.6	14.00 (21.92)^{cd}	0.8
DMH-1007	12.00 (20.27)^{cd}	1.0	18.00 (25.07)^{f}	1.8	18.00 (25.07)^{de}	1.8
DMH-1006	12.00 (20.27)^{cd}	1.0	16.00 (23.58)^{ef}	1.8	20.00 (26.56)^{de}	1.6
K244	8.00 (16.43)^{bcd}	1.0	12.00 (20.27)^{cde}	1.0	14.00 (21.92)^{cd}	1.5
P3502	12.00 (20.27)^{cd}	0.8	12.00 (20.27)^{cde}	1.0	16.00 (23.58)^{cde}	0.8
S6304	8.00 (16.43)^{bcd}	1.0	10.00 (18.35)^{cd}	1.2	16.00 (23.58)^{cde}	1.4

Figures in parenthesis are arcsine transformed values, means followed by same alphabet differ non-significantly (0.05), DAE = days after emergence.

30 DAE, these leaves turned to green colour. The observations on number of nodes taken at different days revealed that there was no significant difference between mean number of nodes at 10, 20 and 30 DAE in different maize genotypes. Mean leaf width was significantly higher in NK 6240 (2.20-5.70cm) followed by NK 30 (2.10-5.10cm), whereas it was significantly lower in Super 900M (1.40-4.00cm) and Bioseed 9681 (1.40-4.20 cm) as compared to other genotypes (Table 4). The trichome density was significantly higher in Super 900M (61.17, 84.12 & 86.00 cm^2) followed by Bioseed 9681 (58.67, 81.12 & 84.00 cm^2) and was significantly lower in NK 6240 (41.42, 50.57 & 55.17 cm^2), which was at par with NK30 (41.42, 50.57 & 55.17 cm^2) at 10, 20, 30 DAE. Cob height was significantly higher in Super 900M (30.9cm) followed by Bioseed 9681 (30.7cm) whereas, it was lower in Arjun (23.2cm) followed by NK 6240 (24.3cm) at 60 DAE (Table 4).

The values of correlation coefficient of morphological characters with infestation revealed that there was significant negative correlation between mean trichome density and per cent infestation of *C. partellus* and *S. inferens* (- 0.845, - 0.922 & - 0.940 and - 0.684, - 0.802 & - 0.714) at 10, 20 and 30 DAE. Mean leaf width was positive but correlated non-significantly with pest infestation at 10 and 30 DAE but at 20 DAE, there was significant positive correlation between per cent infestation of stem borers and mean leaf width (0.913

Table 3. Dead heart incidence and stem tunneling due to stem borers in different maize hybrids after 15 to 45 days of emergence

Maize hybrid	Dead heart (%) after (DAE)			Stem tunneling (%)
	15	30	45	
Arjun	2.00	4.00	6.00	8.92
	(5.77)^{ab}	(8.21)^{ab}	(13.98)^{b}	(17.34)$^{c-f}$
Bioseed 9681	0.00	0.00	0.00	3.94
	(0.00)^{a}	(0.00)^{a}	(0.00)^{a}	(11.25)^{ab}
Super 900M	0.00	0.00	0.00	2.55
	(0.00)^{a}	(0.00)^{a}	(0.00)^{a}	(9.17)^{a}
DMH-1001	2.00	4.00	4.00	10.12
	(5.77)^{ab}	(11.54)^{ab}	(8.21)^{ab}	(18.35)^{def}
DMH-1003	0.00	0.00	0.00	8.02
	(0.00)^{a}	(0.00)^{a}	(0.00)^{a}	(16.39)$^{b-e}$
25K65	0.00	0.00	0.00	10.76
	(0.00)^{a}	(0.00)^{a}	(0.00)^{a}	(18.56)^{def}
NK30	6.00	8.00	8.00	12.12
	(13.98)^{b}	(13.98)^{b}	(16.43)^{bc}	(20.29)^{ef}
NK6240	8.00	8.00	10.00	14.64
	(16.43)^{b}	(16.43)^{b}	(18.35)^{c}	(22.47)^{f}
Pinnacle	0.00	0.00	0.00	5.23
	(0.00)^{a}	(0.00)^{a}	(0.00)^{a}	(12.97)$^{a-d}$
Maharaja	0.00	0.00	0.00	4.19
	(0.00)^{a}	(0.00)^{a}	(0.00)^{a}	(11.80)^{abc}
DMH-1007	2.00	2.00	4.00	9.33
	(5.77)^{ab}	(5.77)^{ab}	(8.21)^{ab}	(17.59)$^{c-f}$
DMH-1006	2.00	2.00	4.00	7.94
	(5.77)^{ab}	(5.77)^{ab}	(11.54)^{ab}	(16.16)$^{b-e}$
K244	0.00	0.00	0.00	6.34
	(0.00)^{a}	(0.00)^{a}	(0.0)^{a}	(14.12)$^{a-d}$
P3502	2.00	2.00	2.00	5.84
	(5.77)^{ab}	(5.77)^{ab}	(5.77)^{ab}	(13.96)$^{a-d}$
S6304	2.00	2.00	2.00	5.89
	(5.77)^{ab}	(5.77)^{ab}	(5.77)^{ab}	(13.92)$^{a-d}$
C.D.(0.05)	10.76	10.67	11.74	5.15

Figures in parenthesis are arcsine transformed values, means followed by same alphabet differ non-significantly (0.05), DAE = days after emergence.

& 0.790). The cob height was negatively correlated with pest infestation but differences were non-significant at 10, 20, 30 DAE (Table 5).

In preset investigation variation in different types of damage may be because of morphological characters in maize genotypes. Varied level of resistance in different maize hybrids may be because of varying morphological characters and genetic variation as reported earlier (Biradar *et al.* 2011; Arabjafari and Jalali, 2007). Similar opinions have also been given by Chavan *et al.* (2007) and Rao and Panwar (2001) on maize and Marulasiddesha *et al.* (2007) on sorghum. The present results are also in accordance with the findings of Mallapur *et al.* (2012), who reported that incidence of maize stem borers (*C. partellus* and *S. inferens*) was more in Prince-740, CMH, Kanaka-740, Proagro and Prabal maize hybrids, while their infestation was lower in hybrids Nithyashri, NMH-1137, Rajkumar and STT-40 at farmer's fields. Rao and Panwar (2001) reported that maize genogypes Kisan and Azam are the most resistant to stem borers on the basis of infestation and dead hearts, which is almost similar to present findings. Muhammad *et al.* (2009) reported that plant characters viz., stem diameter, cob length, leaf length, leaf width, leaf trichomes and 100 grains weight had negative and significant correlation with the infestation of *C. partellus*, which corroborates with present findings. Rao and Panwar

Table 4. Morphological traits of different maize hybrids after 10 to 30 days of emergence

Maize hybrid	Leaf colour			Mean number of node			Mean leaf width (cm)			Mean trichome density (cm^2)			Cob height (cm)
	10 DAE	20 DAE	30 DAE	10 DAE	20 DAE	30 DAE	10 DAE	20 DAE	30 DAE	10 DAE	20 DAE	30 DAE	60 DAE
Arjun	PG	G	G	2.40	4.10	6.10	2.00^{abc}	3.40^{ab}	5.10^{ab}	50.76^{g}	66.32^{hi}	71.50^{f}	23.2^{d}
Bioseed-9681	PG	G	G	2.40	4.30	5.60	1.40^{d}	2.50^{d}	4.20^{d}	58.67^{b}	81.12^{b}	84.00^{ab}	30.7^{a}
Super 900M	PG	G	G	2.60	4.50	5.70	1.40^{d}	2.40^{d}	4.00^{d}	61.17^{a}	84.12^{a}	86.00^{a}	30.9^{a}
DMH-1001	PG	G	G	2.20	4.50	5.80	1.80^{abcd}	2.60^{d}	4.20^{d}	57.30^{c}	78.55^{c}	82.67^{bc}	24.9^{cd}
DMH-1003	PG	G	G	2.50	4.50	6.20	1.60^{cd}	2.70^{cd}	4.30^{cd}	55.75^{d}	76.63^{d}	78.83^{d}	25.5^{cd}
25K65	PG	G	G	2.40	4.50	5.90	1.60^{cd}	2.70^{cd}	4.20^{d}	53.83^{e}	74.67^{e}	80.5^{cd}	25.6^{cd}
NK30	PG	G	G	2.50	4.20	5.90	2.10^{ab}	3.60^{a}	5.70^{a}	41.42^{m}	50.57^{k}	55.17^{k}	25.0^{cd}
NK6240	PG	G	G	2.50	4.20	6.00	2.20^{a}	3.70^{a}	5.70^{a}	41.42^{m}	50.57^{k}	55.17^{k}	24.3^{cd}
Pinnacle	PG	G	G	2.50	4.30	6.30	1.40^{d}	3.10^{bc}	4.30^{cd}	47.08^{j}	54.92^{j}	61.25^{i}	29.0^{a}
Maharaja	PG	G	G	2.50	4.00	6.10	1.40^{d}	3.00^{bc}	4.30^{cd}	49.00^{h}	69.53^{f}	76.33^{e}	28.8^{ab}
DMH-1007	PG	G	G	2.40	4.30	6.30	1.70^{bcd}	3.10^{bc}	4.90^{bc}	48.00^{i}	65.23^{i}	58.83^{j}	25.9^{c}
DMH-1006	PG	G	G	2.40	4.40	6.10	1.50^{d}	2.90^{bcd}	4.60^{bcd}	52.33^{f}	68.15^{g}	66.00^{h}	26.1^{c}
K244	PG	G	G	2.40	4.30	5.90	1.50^{d}	2.80^{cd}	4.30^{cd}	45.92^{k}	69.97^{f}	68.83^{g}	25.7^{cd}
P3502	PG	G	G	2.40	4.30	5.70	1.50^{d}	2.70^{cd}	4.30^{cd}	45.17^{k}	74.10^{e}	74.33^{e}	26.6^{bc}
S6304	PG	G	G	2.40	4.40	6.20	1.50^{d}	2.90^{cd}	4.40^{cd}	44.25^{l}	67.13^{gh}	63.67^{h}	25.1^{cd}
C.D.(0.05)	-	-	-	NS	NS	NS	0.40	0.58	0.60	0.82	1.26	2.36	2.27

PG = pale green , G = green, DAE= days after emergence.

Table 5. Correlation of morphological traits of maize hybrids with infestation of stem borers at different periods of crop growth

Morphological trait/borer	Mean per cent infestation at DAE		
	10	20	30
Chilo partellus			
Mean trichome density	- 0.845**	- 0.922**	- 0.940**
Mean leaf width	0.294	0.898**	0.790**
Cob height	- 0.470	- 0.513	- 0.488
Sesamia inferens			
Mean trichome density	- 0.684**	- 0.802**	- 0.714**
Mean leaf width	0.377	0.913**	0.485
Cob height	- 0.445	- 0.486	- 0.337

** Significant correlation at 0.01 level, DAE= Days after emergence.

(2001) also opined that more trichome density and less leaf width were main factors contributing resistance in to maize towards borers.

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Influence of groundnut based intercropping system on *Spodoptera litura* (Fab.)

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ABSTRACT

Field experiments were undertaken to find out the influence of groundnut based intercropping system on *Spodoptera litura* (Fab.) at Main Agricultural Research Station, Dharwad. Results revealed the highest number of egg mass (0.93 mrl^{-1}) 45 days after sowing (DAS), whereas larval population was highest at 60 DAS (3.77 larvae mrl^{-1}). The damage was more (27.0-31.27 %) during 60 to 90 DAS. Among the seven intercropping systems tested, lowest egg mass, larval population and leaf damage by *S. litura* was in groundnut+foxtail millet intercropping system, which was followed by groundnut+pearl millet, groundnut+sorghum and groundnut+sunflower intercropping. Groundnut+lucerne, groundnut+chilli and groundnut+cowpea intercropping system recorded moderate egg mass, larval population and leaf damage. The egg mass, larval population and leaf damage were highest in sole groundnut crop.

Key words: Groundnut, intercropping, *Spodoptera litura,* egg mass, larva, leaf damage.

The cultivated groundnut (*Arachis hypogaea* L.) is an important oilseed crop of tropical and subtropical region of the world. More than 50 insects are reported to occur on groundnut in India and among them tobacco leaf eating caterpillar has been emerged as most destructive and widely distributed pest in India including Karnataka. It is a polyphagous pest and reported on more than 120 host plants. It is next to *Helicoverpa armigera* in terms of economic importance at national level. The population of this defoliator in groundnut ecosystem has been found to increase in number and intensity both in rainy and post rainy seasons, especially in fields, where insecticides have been applied (RangaRao and Shanower, 1989). Due to destruction of natural control system, the pests created a serious threat to agricultural industry crops because of development of resistance towards commonly used insecticides. Populations of many pests including *S. litura* have developed resistance to many commercially available pesticides (Ramakrishnan *et al*. 1984; Ramegowda, 1999). A greatly increased knowledge of ecology and population dynamics of insect pests and their natural enemies in different agro-ecosystem is highly relevant in order to manipulate their systems effectively. Intercropping can affect the micro-climate of the agro-ecosystem and ultimately create an unfavourable environment for pests (Wilken, 1972; Singh, 1976). With this in background a field trial was conducted to study the impact of intercrops on *S. litura* incidence in groundnut crop ecosystem and results presented in the artile.

MATERIALS AND METHODS

The experiment was conducted at Main Agricultural Research Station, UAS, Dharwad during *Kharif,* 2013 under Randomized Complete Block Design (RCBD). There were 7 treatmets and each replicated thrice. The main crop (groundnut cv. GPBD-4) and intercrops (pearl millet, sorghum, cowpea, lucerne, foxtail millet, chilli & sunflower) were sown in a ratio of 3:1. Plant to plant and row to row distance of 10 x 30 cm was maintained in case of main crop, whereas intercrops were sown at the distance of 10-15 x 30 cm. The data on *S.litura* egg mass mrl^{-1} (per meter row length), larvae mrl^{-1} and leaf damage (%) were recorded on 5 randomly selected plants in each plot of groundnut at 15 days interval starting from 15 days after sowing (DAS) up to 15 days prior to harvest. The data obtained were subjected to square root and arcsine transformation depending on the nature of the data before statistical analysis.

RESULTS AND DISCUSSION

Effect on egg mass

The insect pest, *Spodoptera litura* (Fab.) egg mass was not observed at 15 days after sowing (DAS), but found present from 30 to 75 DAS in different groundnut based intercropping systems. There was no egg mass in groundnut + foxtail millet and groundnut + pearl millet intercropping systems at 30 DAS (Table 1). The other intercropping system such as groundnut + sunflower (0.13 egg mass mrl^{-1}),

groundnut + lucerne (0.20 egg mass mrl^{-1}) and groundnut+chilli (0.33 egg mass mrl^{-1}) recorded comparatively lower number of egg mass and were at par with groundnut + foxtail millet intercropping.The egg mass at 45 DAS was significantly lowest (0.20 egg mass mrl^{-1}) in groundnut + foxtail millet intercropping, which was at par with groundnut + pearl millet (0.33 egg mass mrl^{-1}), groundnut + sorghum (0.40 egg mass mrl^{-1}) and groundnut + sunflower (0.40 egg mass mrl^{-1}) and differed significantly from other treatments. The treatments, groundnut + lucerne (0.67 egg mass mrl^{-1}) and groundnut + chilli (0.73 egg mass mrl^{-1}) recorded comparatively higher *S. litura* egg mass and were at par with each other. However, groundnut + cowpea and sole groundnut were recorded significantly higher egg mass (0.80 & 0.93 mrl^{-1}) and were at par with each other (Table 1). Almost a similar trend of egg mass load was observed across the intercropping treatments at 60 DAS. Groundnut + foxtail millet (0.07 mrl^{-1}) harboured significantly lowest egg mass and was at par with groundnut + pearl millet (0.13 mrl^{-1}), groundnut+ sorghum (0.27 mrl^{-1}), groundnut+sunflower (0.33 mrl^{-1}) and groundnut+lucerne (0.40 mrl^{-1}), sole crop (0.73 mrl^{-1}), groundnut + cowpea (0.60 mrl^{-1}) and in groundnut + chilli (0.53 mrl^{-1}). There was no egg mass of *S. litura* at 75 and 90 DAS in groundnut + foxtail millet, groundnut + pearl millet, groundnut+ sorghum and groundnut + sunflower intercropping systems (Table.1).

Among the different intercrops, groundnut + foxtail millet intercropping system supported least number of *Spodoptera* egg mass throughout the season, which was always non-significant with groundnut + pearl millet intercropping system followed by groundnut + sorghum, groundnut + sunflower, groundnut + lucerne, groundnut + chilli and groundnut + cowpea. However, during all the observation point of time sole crop recorded significantly highest number of egg mass. Probably, the canopy and chemical ecology of intercrops, especially the foxtail millet and pearl millet might not have preferred or less preferred by *S. litura* moth to lay eggs. The similar opinion expressed by Nath and Singh (1998). According to them difference in the insect pest load on groundnut under groundnut based intercropping may be due to differential preference of the insects for the companion crop. There is no earlier report which indicates the specific level of *Spodoptera* egg mass under different intercropping system. Similar observations were recorded by Kennedy *et al.* (1990), who found that the groundnut intercropped with pearl millet, cowpea and sorghum has reduced population of jassids, thrips and aphids and also lowered the population of *Spodoptera.* Similarly, the lowest population of defoliators in groundnut + sorghum (Agasimani *et al*. 1993) and groundnut+ foxtail millet (Rashmi, *et al.* 2011) intercropping system reported earlier.

Table.1. *Spodoptera litura* (Fab.) egg mass per meter row length (mrl^{-1}) in groundnut based intercropping systems

Groundnut and intercrop (3:1)	No. of egg mass (mrl^{-1}) DAS					
	15	30	45	60	75	90
Groundnut + pearl millet	0.00^{a}	0.00^{c}	0.33^{c}	0.13^{c}	0.00^{d}	0.00^{a}
	(0.71)	(0.71)	(0.89)	(0.79)	(0.71)	(0.71)
Groundnut + sorghum	0.00^{a}	0.07^{c}	0.40^{bc}	0.27^{bc}	0.00^{d}	0.00^{a}
	(0.71)	(0.75)	(0.94)	(0.87)	(0.71)	(0.71)
Groundnut + cowpea	0.00^{a}	0.40^{ab}	0.80^{a}	0.60^{ab}	0.20^{b}	0.00^{a}
	(0.71)	(0.95)	(1.14)	(1.05)	(0.84)	(0.71)
Groundnut + lucerne	0.00^{a}	0.20^{bc}	0.67^{ab}	0.40^{abc}	0.07^{cd}	0.00^{a}
	(0.71)	(0.83)	(1.08)	(0.94)	(0.75)	(0.71)
Groundnut + foxtail millet	0.00^{a}	0.00^{c}	0.20^{c}	0.07^{c}	0.00^{d}	0.00^{a}
	(0.71)	(0.71)	(0.83)	(0.75)	(0.71)	(0.71)
Groundnut + chilli	0.00^{a}	0.33^{abc}	0.73^{ab}	0.53^{ab}	0.13^{c}	0.00^{a}
	(0.71)	(0.90)	(1.11)	(1.02)	(0.79)	(0.71)
Groundnut + sunflower	0.00^{a}	0.13^{bc}	0.40^{bc}	0.33^{bc}	0.00^{d}	0.00^{a}
	(0.71)	(0.79)	(0.95)	(0.91)	(0.00)	(0.71)
Sole groundnut	0.00^{a}	0.67^{a}	0.93^{a}	0.73^{a}	0.33^{a}	0.00^{a}
	(0.71)	(1.07)	(1.20)	(1.11)	(0.91)	(0.71)
C.D. (5%)	0.00	0.17	0.22	0.18	0.08	0.00

DAS=Days after sowing, figures in the parenthesis are "x+0.5 transformed values, means followed by same letter in the column differ non-significantly.

Effect on larval population

There was no *S. litura* larval population at 15 and 90 DAS (Table 2). However, the larval population was noticed from 30 to 75 DAS on groundnut under different intercropping systems. The larval population was nil at 30 DAS in groundnut + foxtail millet and groundnut + pearl millet intercropping systems and were at par with groundnut + sorghum (0.07 mrl^{-1}), groundnut + sunflower (0.13 mrl^{-1}), groundnut + lucerne (0.17 mrl^{-1}), and groundnut + chilli (0.33 mrl^{-1}) but significantly superior to groundnut + cowpea (0.53 mrl^{-1}) and sole groundnut crop (0.97 mrl^{-1}). There was increasing trend in larval population from 30 to 45 DAS which reached to its peak at 60 DAS and declined thereafter. The larval population at 45 DAS was least in groundnut + foxtail millet (0.43 mrl^{-1}) and found at par with groundnut + pearl millet (0.93 mrl^{-1}) but differed significantly from remaining treatments. Significantly highest larval population was recorded in sole groundnut crop (2.97 mrl^{-1}). Population of *S. litura* was least (1.00 larvae mrl^{-1}) in groundnut + foxtail millet intercropping system, which was significantly superior to the other intercropping systems. Other treatments were non-significant with each other but differ significantly with sole groundnut crop (3.77 larva mrl^{-1}). The larval population of *S. litura* was reduced at 75 DAS but treatment effects showed trend similar to 60 DAS (Table.2).

There was no *S. litura* larval population at 15 and 90 DAS but its population increased from 30 DAS (0.00-0.97 mrl^{-1}) to 45 DAS (0.43-2.97 mrl^{-1}), reached its peak at 60 DAS (1-3.77 mrl^{-1}). The *Spodoptera* larval population was least in groundnut + foxtail millet intercropping, followed by groundnut + pearl millet, groundnut + sorghum, groundnut + sunflower and groundnut + lucerne. However, the larval population was highest in sole groundnut crop. The lower *S. litura* larval population recorded in groundnut based foxtail, pearl millet and sorghum intercropping system is in conformity with the report of Agasimani *et al*.(1993). Nath and Singh (1998) found the minimum incidence of *S. litura* on groundnut + pearl millet intercropping system, while Rashmi *et al.* (2011) recorded least population of defoliators in groundnut + foxtail millet intercropping system, which is in line of the present findings.The variation in the *S. litura* larval population on groundnut crop in different groundnut based intercropping may be due to differential preference of the insects for the companion crop of groundnut. The complex plant canopy of the intercrops sustains variety of fauna including the insect pests and the beneficial ones. But the intercrops do not encourage the pest fauna to build up their population above the level as generally found in monocropping system because of variation in plant stand. Further, the insect pests find difficulty to get proper nourishment, while it helps the polyphagous friendly fauna,

Table 2. *Spodoptera litura* (Fab.) larval population per meter row (mrl^{-1}) in groundnut based intercropping systems

Groundnut and intercrop (3:1)	No. of larvae (mrl^{-1}) DAS					
	15	30	45	60	75	90
Groundnut + pearl millet	0.00 ^{a}	0.00^{c}	0.93^{bc}	1.80^{c}	0.80^{bc}	0.00^{a}
	(0.71)	(0.71)	(1.20)	(1.51)	(1.14)	(0.71)
Groundnut + sorghum	0.00^{a}	0.07^{bc}	1.23^{b}	2.33^{bc}	0.94^{abc}	0.00 ^{a}
	(0.71)	(0.75)	(1.32)	(1.68)	(1.20)	(0.71)
Groundnut + cowpea	0.00^{a}	0.53^{ab}	1.37^{b}	2.73^{b}	1.27^{ab}	0.00 ^{a}
	(0.71)	(1.01)	(1.37)	(1.79)	(1.33)	(0.71)
Groundnut + lucerne	0.00^{a}	0.17^{bc}	1.50^{b}	2.47^{bc}	1.07^{abc}	0.00 ^{a}
	(0.71)	(0.81)	(1.41)	(1.72)	(1.25)	(0.71)
Groundnut + foxtail millet	0.00^{a}	0.00^{c}	0.43^{c}	1.00^{d}	0.73^{c}	0.00 ^{a}
	(0.71)	(0.71)	(0.96)	(1.19)	(1.11)	(0.71)
Groundnut + chilli	0.00^{a}	0.33^{abc}	1.57^{b}	2.53^{bc}	1.13^{abc}	0.00 ^{a}
	(0.71)	(0.91)	(1.44)	(1.74)	(1.28)	(0.71)
Groundnut + sunflower	0.00^{a}	0.13^{bc}	1.23^{b}	2.40^{bc}	1.00^{abc}	0.00 ^{a}
	(0.71)	(0.79)	(1.31)	(1.70)	(1.22)	(0.71)
Sole groundnut	0.00^{a}	0.97^{a}	2.97^{a}	3.77^{a}	1.40^{a}	0.00 ^{a}
	(0.71)	(1.20)	(1.84)	(2.07)	(1.38)	(0.71)
C.D. (5%)	0.00	0.22	0.29	0.28	0.13	0.00

DAS=Days after sowing, figures in the parenthesis are transformed values, means followed by same letter in the column differ non-significantly

which keep the pest population under check as opined by Nath and Singh (1998). The similar opinion of reduced *S.litura* incidence on main groundnut crop under different intercropping system has also been reported by RangoRao *et al.* (1995).

Effect on leaf damage

The nil defoliation in groundnut + foxtail millet, groundnut + pearl millet and groundnut + sorghum intercropping systems was recorded at 30 DAS (Table 3). The sole groundnut crop had the highest (16.40%) leaf damage and was significantly different from rest of the treatments. Similarly, groundnut + sunflower had lower (6.33%) defoliation and differed significantly with other treatments. The remaining treatments recorded moderate per cent leaf damage and were at par with each other. Significantly least defoliation (13.05%) was recorded in groundnut + foxtail millet intercropping system at 45 DAS and was at par with groundnut + pearl millet, groundnut + sunflower (15.03 %), groundnut + sorghum (16.00%), groundnut + lucerne (17.20%) and groundnut + chilli (18.01%). Treatment differences showed trend similar to 45 DAS at 60 DAS. The treatment effect was in the order of groundnut + foxtail millet (18.00%) < groundnut + pearl millet (20.20 %) < groundnut + sorghum (21.00%) < groundnut + sunflower (22.00%) < groundnut + lucerne (23.27%) < groundnut + chilli (24.07 %) < groundnut + cowpea (25.00%) < sole groundnut (27.00%). At 75 DAS too defoliation was least (20.00%) in groundnut + foxtail millet inter cropping system, which was found statistically at par with groundnut + pearl millet (21.07 %), groundnut + sorghum (22.00%) groundnut + sunflower (23.00%) . At 90 DAS also, the treatments found effective at 75 DAS showed the similar trend (Table 3).

Reduced egg laying led on groundnut under few particular intercropping system resulted into reduced larval load which might have resulted into least defoliation. Similar to present findings, Rashmi *et al.* (2011) also reported the lower per cent of leaf damage in groundnut + foxtail millet intercropping system. Reduced *Spodoptera* incidence on groundnut under groundnut + sunflower intercropping system was also reported by RangoRao *et al.* (1995), which supports the present findings. Lower *S. litura* damage in groundnut + sorghum intercropping compared to groundnut + sunflower and groundnut + chilli intercropping system is in line with the present observations (Patil, 1993). Nath and Singh (1998) recorded lower incidence of tobacco caterpillar in groundnut + pearl millet intercropping system, which is similar to the present results.

It can be inferred from the findings that groundnut + foxtail millet intercropping system followed by groundnut +

Table 3. Defoliation (leaf damage) of groundnut crop due to *Spodoptera litura* (Fab.) in intercropping systems

Groundnut and intercrop (3:1)	Defoliation (%) DAS					
	15	30	45	60	75	90
Groundnut + pearl millet	0.00^{a}	0.00^{d}	14.03^{bc}	20.20^{cd}	21.07^{bcd}	23.00^{bc}
	(0.00)	(0.00)	(21.99)	(26.72)	(27.30)	(28.61)
Groundnut + sorghum	0.00^{a}	0.00^{d}	15.03^{bc}	21.00^{cd}	22.00^{cd}	24.02^{bc}
	(0.00)	(0.00)	(23.49)	(27.28)	(27.93)	(29.30)
Groundnut + cowpea	0.00^{a}	10.20^{b}	18.95^{ab}	25.00^{ab}	27.00^{ab}	29.81^{ab}
	(0.00)	(18.60)	(25.74)	(29.99)	(31.26)	(33.04)
Groundnut + lucerne	0.00^{a}	7.47^{bc}	17.20^{bc}	23.27^{abcd}	25.00^{abc}	27.04^{abc}
	(0.00)	(15.79)	(24.46)	(28.84)	(29.97)	(31.31)
Groundnut + foxtail millet	0.00^{a}	0.00^{d}	13.05^{c}	18.00^{d}	20.00^{d}	22.03^{c}
	(0.00)	(0.71)	(21.15)	(25.12)	(26.55)	(27.97)
Groundnut + chilli	0.00^{a}	8.55^{bc}	18.01^{abc}	24.07$_{abc}$	26.07^{abcd}	28.04^{ab}
	(0.00)	(16.95)	(25.02)	(29.28)	(30.62)	(31.95)
Groundnut + sunflower	0.00^{a}	6.33^{c}	16.00^{bc}	22.00b^{cd}	23.00^{bcd}	25.12^{abc}
	(0.00)	(14.42)	(22.77)	(27.93)	(28.56)	(30.06)
Sole groundnut	0.00^{a}	16.40^{a}	23.31^{a}	27.00^{a}	30.33^{a}	31.27^{a}
	(0.00)	(23.86)	(28.83)	(31.32)	(33.40)	(33.98)
C.D. (5%)	0.00	2.83	3.80	3.52	5.53	3.15

DAS=Days after sowing, figures in the parenthesis are arc sign transformed values, means followed by same letter in the column differ non-significantly.

pearl millet had the least population of *S. litura* and lower degree of leaf damage as compared to rest of the treatments, which can be exploited as one of the IPM tool for managing this major pests in groundnut ecosystem.

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Effect of abiotic factors on seasonal incidence of rice armyworm (*Mythimna separata*) Walker

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ABSTRACT

Field experiments were conducted at Oilseeds Research Farm, Kalyanpur, C. S. Azad University of Agriculture and Technology, Kanpur to find out effect of abiotic factors on incidence of rice armyworm during *Kharif* seasons 2004 and 2005. Maximum number of adult armyworm was recorded in 2nd fortnight of August and 1st fortnight of September, i.e., 22 and 29 adult moths week^{-1} during 2004 and 24 and 28 adult moths week^{-1} during 2005. At the early stages of crop the highest larval population of armyworm was recorded in the crop transplanted at 30th June. However, in advance stages, the crop transplanted at 30th July become more susceptible to the armyworm and reached at its highest in 2nd fortnight of September to 1st fortnight of October with an average of 3.89 and 4.35 larvae m^{-2} and 3.77 and 4.37 larvae m^{-2} during 2004 and 2005, respectively.

Key words: Armyworm, *Mythimna separata*, rice, abiotic factor.

Rice is the staple food of more than 60 per cent of the world's population. About 90 per cent of the total rice grown in world is produced and consumed in Asian region. However, more than 100 insect species are associated with the rice crop, which affects the production. Among these insect pests, the rice armyworm is a serious one. It is polyphagous in nature, but important on rice, remain active during night and hide among the culms during day time. It occurs regularly and attacks plant from seedling stage to maturity. The environmental factors including abiotic, play considerable role in reducing the incidence of this pest. The population fluctuation due to these factors may affect the time of application of pest management strategies against this pest. Therefore, investigations were undertaken to determine the effect of abiotics factor on seasonal incidence of armyworm in different varieties of rice at different date of transplanting.

MATERIALS AND METHODS

Nursery raising

The nursery plot was ploughed first by spade and then pulverized by using hand hoe. The field was divided in to three equal parts for three seeding dates. The gap of 1 meter was maintained between two beds to avoid mixing of seeds. Side by side the soaking of seeds in water was done for about 15 hours to hasten its germination. The seeds were sown by spreading uniformly in nursery bed and recommended package of practices were followed for raising the nursery.

Field preparation

Experimental field was ploughed 20-25 cm deep by mould board plough in summer to expose the eggs of harmful insect pests and rhizome of weeds. It was flooded with water a fortnight prior to transplanting. An earthen bund, about 30 cm high was made around the field before puddling. The field was puddled by three to four runs of puddler in standing water and afterwards half of nitrogen and total amount of phosphorous and potash, applied uniformly on surface at the time of last puddling in the top 10-15 cm in soil. About four weeks old seedlings were transplanted in field @ 2-3 seedlings per hills at the distance 20 x 10 cm on different transplanting dates, i.e., 30th June, 15th July and 30th July. The rice varieties selected were Basmati 370, Kranti and Pant Dhan 4. Observation were recorded at weekly intervals on *M. separata* larval populations in 1 m^2 area. The rice plants and the soil surface within the area were thoroughly observed to count number of larvae more precisely. The adults were counted by visuals observations collected from light traps in night (6.0 PM - 6.0 AM). All the data were analysed statistically and correlated with meteorological parameters *viz.*, rainfall, relative humidity, temperature, wind speed and evaporation rate, collected from university observatory.

RESULTS AND DISCUSSION

The data on seasonal abundance of armyworm (Table 1) revealed that in both the years the pest was occur from the first week of August but their population was low in number

Table 1. Seasonal incidence of *Mythimna separata* larvae in different rice varieties as on 1 August, 2004 and 2005

Date	Armyworm (larval) population in rice varieties (m^{-2})							
	2004				2005			
	Basmati-370	Kranti	Pant Dhan -4	Mean	Basmati-370	Kranti	Pant Dhan -4	Mean
30th June	2.02	0.71	0.71	1.15	5.00	2.00	0.00	2.33
15th July	1.50	0.71	0.71	0.97	3.00	1.00	0.00	1.33
30th July	1.22	0.71	0.71	0.88	1.00	0.00	0.00	0.33
Mean	1.58	0.71	0.71	-	3.00	1.00	0.00	-
CD at 5%	Date	Varieties	Date x Varieties		Date	Varieties	Date x Varieties	
	0.27	0.27	0.47		1.28	1.28	2.21	

and slowly increased and reached its peak at the last week of September (Table 2) and first fortnight of October (Table 3). It is also clear from the data that at initial stages of the crop, the larval infestation of *M. separata* was maximum, i.e., 1.15 and 2.33 in 2004 and 2005, respectively, in the early transplanted crop (30th June). As the age advances, the late transplanted crop (30th July) become more susceptible for the infestation of armyworm larvae and maximum number of larval infestation (Table 2, 3) recorded. It is also visible from the data that none of the tested rice variety was found free from the pest infestation. Similar findings were also recorded by (Kulshreshtha *et al.* 1970, Sharma and Davi, 1983). The rice variety Basmati -370 was found most susceptible as compared to the Kranti and Pant Dhan – 4. The least infestation was recorded in the variety Pant Dhan–4 at all the stages of observations. The current findings are more or less in the line of the findings of Singh (1987). He also mentioned the impact of different periods and cultivar

Table 2. Seasonal incidence of *Mythimna separata* larvae in different rice varieties as on 26th September, 2004 and 2005

Date	Mean armyworm (larval) population in rice varieties (m^{-2})							
	2004				2005			
	Basmati-370	Kranti	Pant Dhan -4	Mean	Basmati-370	Kranti	Pant Dhan -4	Mean
30 June	4.14	2.75	2.74	3.21	3.67	2.34	1.97	2.66
15 July	4.42	3.54	3.40	3.78	4.18	3.39	3.24	3.60
30 July	4.64	3.67	3.35	3.89	4.42	3.64	3.24	3.77
Mean	4.40	3.32	3.16	-	4.09	3.12	2.82	-
CD at 5%	Date	Varieties	Date x Varieties		Date	Varieties	Date x Varieties	
	0.54	0.54	0.94		0.56	0.56	0.96	

Table 3. Seasonal incidence of *Mythimna separata* larvae in different rice varieties as on 10th October, 2004 and 2005

Date	Mean armyworm (larval) population in different rice varieties (m^{-2})							
	2004				2005			
	Basmati-370	Kranti	Pant Dhan -4	Mean	Basmati-370	Kranti	Pant Dhan -4	Mean
30 June	3.35	2.55	2.12	2.67	3.35	2.50	2.25	2.70
15 July	4.54	4.06	3.94	4.21	4.53	3.94	3.81	4.09
30 July	4.85	4.18	4.03	4.35	4.64	4.30	4.18	4.37
Mean	4.25	3.60	3.36	-	4.17	3.58	3.41	-
CD at 5%	Date	Varieties	Date x Varieties		Date	Varieties	Date x Varieties	
	0.25	0.25	0.42		0.58	0.58	1.01	

that significantly affect the larval population of *M. separata* larvae. Pandey and Tiwari (1998) reported that during *Kharif* season the pest was found active on rice crop in all the stages from September to November, during which 2-3 generation are passed. He also recorded the huge build-up of the larval population during the second fortnight of September and the first fortnight of October. Patel *et al.* (2012) reported two peaks of population level of *M. separata* in sorghum crop, first in the 1st week of September and second in last week of September and also reported that the armyworm population significantly and positively correlated with minimum temperature and morning relative humidity, indicating that when these climatic factors increased, the pest population increased significantly and vice-versa.

The data on adult moth of armyworm (Table 4) revealed that the adult population of *M. separata* fluctuated to a great deal not only from year to year, but also from week to week in different months. However, the general trends of population buildup are more or less same. It is obvious from the result that the emergence of the moths of *M. separata* begins with the onset of monsoon but their heavy population were noticed in the last week of August during both the years of studies. This may be one of the possible reasons that the outbreak of *M. separata* larvae occurred in the last week of September during the course of investigations. The simple correlation (Table 5) indicates that the rainfall, temperature (maximum & minimum) and evaporation rate had positive but non-significant effect on the adult population of armyworm moth, *M. separata,* while the effect of relative humidity and wind speed was inversely correlated with moth population and they had the negative but non-significant impact on population build up of this pest. Deol *et al.* (1987) reported that rainfall caused heavy infestation in rice crop. Vaishampayan and Veda (1980) correlated the population build-up of *H. armigera* larvae with atmospheric temperature and found that it was positively correlated with minimum temperature. Pande and Ganguli (1985) concluded that a number of insect pests thrive well due to prevalence of moderate to high temperature during most part of the year. The findings of Verma and Khurana (1971) show the negative correlation with the relative humidity against armyworm, *Pseudaletia separata*. Douthwaite (1978) recorded that higher wind speed adversely affect the moth population of *Spodoptera exempta*, while Rai and Khan (2002) found the

Table 4. Seasonal abundance of armyworm *Mythimna Separata* adults (moths) during different months of 2004 and 2005

Month	Standard week	Adults trapped week^{-1} 2004		Adults trapped week^{-1} 2005	
		Number	Mean	Number	Mean
July	27	7	1.00	8	1.142
	28	10	1.428	7	1.0
	29	8	1.142	6	0.857
	30	11	1.571	10	1.428
August	31	14	2.00	12	1.714
	32	14	2.00	11	1.571
	33	20	2.857	22	3.142
	34	22	3.142	24	3.428
September	35	29	4.142	28	4.00
	36	18	2.571	15	2.142
	37	13	1.857	14	2.00
	38	8	1.142	7	1.0
	39	7	1.00	6	0.857
October	40	4	0.571	3	0.428
	41	2	0.285	2	0.285
	42	3	0.428	4	0.571
	43	2	0.285	1	0.143
November	44	3	0.428	5	0.714
	45	2	0.285	1	0.143
	46	2	0.285	2	0.285
	47	2	0.285	2	0.285
December	48	7	1.00	9	1.086

Table 5. Correlation of *Mythimna separata* adult population with meterological factors during 2004 and 2005.

Weather factor	Correlation coefficient (r) (2004)	Correlation coefficient (r) (2005)
Rainfall (mm)	+0.1259	+0.01736
Maximum temperature(^{0}C)	+0.4083	+0.4258
Minimum temperature(^{0}C)	+0.4155	+0.5033
Relative humidity (%)	-0.4382	-0.3777
Wind speed (km hr^{-1})	-0.2961	-0.2621
Evaporation rate (mm day^{-1})	+0.1251	+0.4248

impact of evaporation rate against *N. virescence* in rice crop. It is obvious from the present results that the evaporation rate is positively correlated with moth trapping.

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Management of citrus rust mite, *Phyllocoptruta oleivora* (Ashmead) using new acaricidal molecules

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ABSTRACT

Studies on efficacy of new acaricides were carried out under laboratory and field conditions against citrus rust mite (*Phyllocoptruta oleivora*). The nine treatments of fungi along with acaricides evaluated under laboratory conditions, showed the highest mortality (96.30 & 94.70%) in fenazaquin 10EC (2 ml l^{-1}) followed by propergite 57EC (93.70 & 94.30 %) on leaves and fruits after nine days of treatment. The fungi, *Fusarium semitectum* and *Hirsutella thompsonii* showed 79.30 and 78.70 and 82.30 and 80.70 per cent reduction of mite population at 2.3 x 10^9 and 4.6 x 10^8 spores ml^{-1} on leaves and fruits, respectively. However, the least (73.70 & 70.79 %) mortality was recorded in the treatment wettable sulphur 80 WP (3g l^{-1}). In field conditions too, the highest mortality (90.89 & 90.79%) was obtained in fenazaquin 10EC (2 ml l^{-1}) on leaves and fruits after nine days of treatment. Propergite 57EC (1.5 ml l^{-1}) and diafenthiuron 50 WP (1.2 ml l^{-1}) were the next best (86.32 & 90.39 &87.79 & 83.28 %). The treatment, *F. semitectum* at 2.3 x 10^9 spores ml^{-1} showed 49.84 and 42.36 per cent mortality on leaves and fruits, being the least effective. *F. semitectum* + dicofol (0.02%) and *H. thompsonii* (4.6 x 10^8 spores ml^{-1}) recorded 54.04 and 43.70 and 50.43 and 49.21 per cent mortality.

Key words: Citrus, management, acaricides, *Phyllocoptruta oleivora.*

The Italian lemon, *Citrus limon* (L.) Burm.f. is a member of family Rutaceae. India is the leader in production of lemon, producing 2.1 million tons from 2.0 lakh ha area, which accounts 15 per cent of total world lemon production of 13 million tons and 5.7 per cent of total world lemon area of 35 lakh ha (Anonymous, 2011). The phytophagous mites reported so far on citrus from India includes, *Eutetranychus orientalis* (Klein.), *Panonychus citri* (Mc Gregor), *Schizotetranychus hindustanicus* (Hirst), *Tetranychus fijiensis* Hirst, *Tenuipalponychus citri* Channabasavanna and Lakkundi, *Brevipalpus deleoni* Pritchard and Baker, *B. californicus* (Banks), *B. phoenicis* (Geijakes), *Phyllocoptruta oleivora* (Ashmead), *Aceria sheldoni* (Ewig) and *Floracarus fleshneri* Keifer (Channabasavanna and Nageshchandra, 1977). The citrus rust mite, *Phyllocoptruta oleivora* (Ashmead) feed directly on various parts of the plant such as leaves, tender shoots, flowers, buds and fruits. The mite was first reported from Karnataka by Puttarudraiah and Channabasavnna (1959) and further studied by Channabasavanna (1966). The mite is known to be endemic in orchards and gradually spreading into larger areas. Our knowledge on control of this mite is scanty, hence the present investigation was carried out.

MATERIALS AND METHODS

Experiments were carried out at the College of Agriculture, Shimoga to test the efficacy of new acaricidal molecules along with *Fusarium semitectum* and *Hirsutella thompsonii* for the control of *Pyllocoptruta oleivora.* This experiment was conducted by using the nine mite infested lemon plants with nine treatments and three replications. Three mite infested leaves were selected from each tree at random and marked with staple pin. The treatments were randomized completely and plants were tagged and covered with polyethylene bag after spraying. The lethal concentrations of *F. semitectum* and *H. thompsonii* were worked out on active forms of mite *P. oleivora*. Spore concentrations of 2.3 x 10^4, 10^5, 10^6, 10^7, 10^8 and 10^9 (spores ml^{-1}) of *F. semitectum* and 4.6 x 10^4, 10^5, 10^6, 10^7, 10^8 and 10^9 (spores ml^{-1}) of *H. thompsonii* were evaluated on adult in laboratory condition and whichever gave high mortality were selected for further application. Hand sprayer was used for imposing the treatments. The spray solution was mixed with Tween – 20 (0.02 %) to ensure adherence. Observations were recorded on number of immature and adult mites one day prior and three, six and nine days after spray. Per cent mortality was calculated and were subjected to appropriate statistical analysis.

RESULTS AND DISCUSSION

Among the nine treatments evaluated under lab condition on both leaves and fruits, fenazaquin was

significantly superior over other treatments after six days of spraying and it maintained its efficacy up to nine days of application (Table 1). At 6th day after spray, per cent mortalities in *F. semitectum* at 2.3 x 10^9 spores ml^{-1} (60.30 & 59.70%), *F. semitectum* + dicofol at 2.5 ml l^{-1} (63.30 & 62.70 &) and *H. thompsonii* at 4.6 x 10^8 spores ml^{-1} (61.70 & 60.30%) were at par to each other but inferior to fenazaquin, propergite and diafenthuiron. Treatment *F. semitectum* + dicofol 1.25 ml l^{-1} was slightly more effective than *H. thompsonii* (4.6 x 10^8 spores ml^{-1}) alone. After nine days of application, trend changed and it was noticed that the treatment, 2.5 ml^{-1} dicofol (89.70 & 86.70%) was at par with *H. thompsonii* (82.30 & 80.70%), *F. semitectum* + dicofol 1.25 ml $^{-1}$ (86.70 & 84.30%) and *F. semitectum* (79.30 & 78.70%). However mortality decreased in water spray after nine days of application, which resulted in continuous increase in mite population. This may be due to fecundity and fast multiplication of mites on untreated trees.

Similar trend was noticed under field conditions too, where fenazaquin was significantly superior over all other treatments after 6th days of spraying and it maintained its efficacy up to nine days of application (Table 2). At 6th day after spray *F. semitectum* + dicofol 1.25 ml l^{-1} (40.35 & 27.78%) and *H. thompsonii* 4.1 x 10^{14} spores ml^{-1} (38.36 & 38.66%) were non-significant with each other and found inferior to fenazaquin, propergite and diafenthuiron. At 9th day after application trend changed and it was noticed that the treatment dicofol 2.5 ml^{-1} (64.41 & 44.17%) was at par with *H. thompsonii* (50.43 & 49.21%), *F. semitectum* + dicofol 1.25 ml^{-1} (54.04 & 43.70%) and *F. semitectum* (49.84 & 42.36%). Results similar to present studies are reported by Yadav Babu (2004), who reported 58.04 per cent mortality of mite *O. indicus* using *H. thompsonii* 6.2 x 10^{14} spores ml^{-1} under field conditions. Also the findings of present investigation are in the line of Rachana (2007), who found that the fungus *F. semitectum* 2.6 x 10^{14} spores ml^{-1} gave 43.45 per cent mortality of mite, *Tetranychus neocaledonicus* under field conditions.

Fenazaquin, propergite and diafenthiuron induced knock down action and continued to maintain it throughout the observation period. This effect may be due to the fact that chemical insecticides were quick in action, hence reduced the mite population considerably. Combination of fungus + sub lethal dose of insecticide suppressed the mite population compared to fungus alone. This is in conformity with the results of Mikunthan (2004). The principle behind the use of sub lethal dose of insecticide in combination with

Table 1. Effect of *Fusarium semitectum* and *Hirsutella thompsonii* along with new acaricidal molecules on the mortality of adult and immature forms of *Phyllocoptruta oleivora* (citrus mite on lemon) under laboratory conditions.

Chemical/mycopathogen	Mites pre-count (No.)	Cumulative mortality (%)					
		3 DAS		6 DAS		9 DAS	
		Leaf	Fruit	Leaf	Fruit	Leaf	Fruit
Fusarium semitectum (2.3 x10^9 spores ml^{-1})	15	46.70 (43.07)^{d}	45.30 (42.30)^{c}	60.30 (50.95)^{d}	59.70 (50.55)^{de}	79.30 (63.00)^{de}	78.70 (62.48)^{d}
Dicofol 18.5 EC (2.5 ml l^{-1})	15	50.70 (45.36)^{cd}	50.30 (45.17)^{b}	69.70 (56.57)^{c}	68.30 (55.75)^{c}	89.70 (71.52)^{bc}	86.70 (68.57)^{c}
F. semitectum + Dicofol 18.5 EC (1/2 dose)	15	49.30 (44.60)^{cd}	49.30 (44.60)^{b}	63.30 52.73)^{d}	62.70 (52.32)^{d}	86.70 (68.84)^{cd}	84.30 (66.69)^{c}
Hirsutella thompsonii (4.6 x 10^8 spores ml^{-1})	15	48.30 (44.02)^{cd}	46.70 (43.07)^{c}	61.70 (51.73)^{d}	60.30 (50.95)^{de}	82.30 (65.28)^{d}	80.70 (63.90)^{d}
Diafenthiuron 50 WP (1.2g l^{-1})	15	53.70 (47.09)^{bc}	50.30 (45.17)^{b}	72.30 (58.27)^{bc}	70.70 (57.18)^{dc}	91.30 (73.06)^{abc}	90.70 (72.26)^{b}
Propergite 57 EC (1.5 ml l^{-1})	15	56.30 (48.63)^{ac}	50.30 (45.17)^{b}	76.70 (61.10)^{ab}	74.30 (59.54)^{a}	93.70 (75.67)^{ab}	94.30 (76.24)^{a}
Fenazaquin 10 EC (2 ml l^{-1})	15	60.70 (51.14)^{a}	58.70 (49.97)^{a}	78.70 (62.62)^{a}	72.30 (58.26)^{ab}	96.30 (79.01)^{a}	94.70 (76.63)^{a}
Wettable sulphur 80 WP (3 g l^{-1})	15	40.70 (39.60)^{e}	39.70 (39.02)^{d}	58.30 (49.79)^{d}	57.70 (49.39)^{e}	73.70 (59.19)^{e}	70.70 (57.20)^{e}
Control (Water spray)	15	8.70 (17.11)^{f}	7.30 (15.65)^{e}	11.30 (19.66)^{e}	10.30 (18.72)^{f}	12.30 (20.54)^{f}	10.70 (18.97)^{f}
CD (p = 0.01)		4.40	1.99	4.93	2.58	8.20	3.70

DAS= Days after spraying, Figures in the parenthesis are arc sin transformed value.

Table 2. Effect of new acaricidal molecules along with *Fusarium semitectum* and *Hirsutella thompsonii* on the mortality of adult and immature forms of *Phyllocoptruta oleivora* on lemon under field conditions.

Chemical/mycopathogen	Pre-count of mites (leaf^{-1})	Pre-count of mites (fruit^{-1})	Cumulative mortality (%) after					
			3 DAS		6 DAS		9 DAS	
			Leaf	Fruit	Leaf	Fruit	Leaf	Fruit
Fusarium semitectum (2.3 x10^9 spores ml^{-1})	7.33	18.33	16.77 (23.99)^{de}	11.04 (19.38)^{de}	34.37 (35.76)^{d}	38.72 (38.28)^{cd}	49.84 (44.91)^{d}	42.36 (40.06)^{c}
Dicofol 18.5 EC (2.5 ml l^{-1})	7.99	16.66	31.16 (33.88)^{bc}	19.93 (26.50)^{cd}	45.14 (42.19)^{bc}	32.05 (34.47)^{d}	64.41 (53.37)^{c}	44.17 (41.64)^{c}
F. semitectum + Dicofol 18.5 EC (1/2 dose)	6.88	13.66	24.59 (29.67)^{cd}	14.26 (22.11)^{de}	40.35 (39.41)^{cd}	27.78 (31.74)^{de}	54.04 (47.33)^{cd}	43.70 (41.36)^{c}
Hirsutella thompsonii (4.6 x 10^8 spores ml^{-1})	11.10	19.00	23.28 (28.38)^{cd}	19.33 (25.90)^{cde}	38.36 (38.10)^{cd}	38.66 (38.42)^{cd}	50.43 (45.23)^{cd}	49.21 (44.53)^{c}
Diafenthiuron 50 WP (1.2g l^{-1})	11.77	20.33	42.35 (40.58)^{a}	26.72 (30.64)^{bc}	72.24 (58.31)^{a}	59.88 (50.75)^{b}	87.79 (69.66)^{ab}	83.28 (66.24)^{ab}
Propergite 57 EC (1.5 ml l^{-1})	12.21	20.33	34.55 (35.98)^{ab}	46.68 (43.04)^{a}	67.23 (55.06)^{a}	76.43 (61.46)^{a}	86.32 (68.28)^{ab}	90.39 (72.18)^{a}
Fenazaquin 10 EC (2 ml l^{-1})	11.22	21.00	38.57 (38.38)^{ab}	49.36 (44.57)^{a}	72.47 (58.37)^{a}	77.17 (61.61)^{a}	90.89 (72.45)^{a}	90.79 (72.50)^{a}
Wettable sulphur 80 WP (3 g l^{-1})	11.55	18.00	35.51 (36.55)^{ab}	33.40 (35.29)^{b}	53.21 (46.83)^{b}	50.09 (45.05)^{bc}	78.53 (62.44)^{b}	76.18 (60.92)^{b}
Control (Water spray)	10.44	19.66	12.92 (20.90)^{e}	10.37 (18.74)^{e}	23.70 (28.98)^{e}	20.17 (26.66)^{e}	28.53 (32.05)^{e}	22.40 (27.98)^{d}
CD (p = 0.05)			6.07	7.58	5.71	7.67	8.36	10.88

DAS= Days after spraying, Figures in the parenthesis are arc sin transformed value.

mycopathogen was to weaken the mites by the lower dose of the toxicant that ultimately favours the fungal infection. This weakening of the organisms by the chemicals enhanced the fungus ability to infect the insect under adverse conditions and subsequently its full establishment.

The results of present study indicates, though both the fungi found effective against all stages of mite *P. oleivora* but *H. thompsonii* found superior as compared to *F. semitectum*. Hence, between these two fungi, *H. thompsonii* can be exploited against the mite. However, *F. semitectum* being compatible with dicofol, its possible use could be explored in integrated management of mite on Italian lemon. In the absence of mite pathogens, the new molecules diafenthiuron, propergite and fenazaquin can be alternatively used to tackle the mite effectively.

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Survey and screening of different rose cultivars against rose aphid (*Macrosiphum rosae*)

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ABSTRACT

Survey and screening of different cultivars of roses for their resistance and susceptibility against rose aphid (*Macrosiphum rosae*) were undertaken in Srinagar and Baramulla and Floriculture Field Division of FMAP, SKUAST-K, Shalimar. Survey was carried out in two districts of Kashmir valley from March to December, 2007 on the incidence of rose aphid. The per cent incidence and number of aphids twig^{-1} were high in Srinagar district at all the five locations surveyed, while these were lower in Baramulla district at all the locations except Pattan. The pest activity was 10 months at district Srinagar and 9 months at district Baramulla. Screening of rose cultivars for their resistance against aphid *(M. rosae)* revealed that Grand Gala and Nobless harboured maximum mean aphid infestation index (MAII), i.e., 1.33 and 1.10, respectively, whereas Golden Gate and Naranga exhibited moderate mean (0.88 & 0.99). The minimum mean aphid infestation index was 0.55 in Konifittii.

Key words : Survey, cultivars, rose aphid, screening.

Rose is a perennial shrub/vine of the genus *Rosa* and family Rosaceae. Its species are probably the most widely recognised and universally favoured as ornamental flowering plants. In fact, the rose is the best known and most popular among all garden flowers. At present there are 400 rose species and more than 100 cultivars grown throughout the world (Anonymous, 2002). In the international trade, amongst the top three cut flowers namely, rose, chrysanthemum and carnation, rose ranks the first and fetching approximately 178.6 million dollars annually. The rose is affected by a number of insect pests. Among these pests, rose aphid *Macrosiphum rosae* is known as an important pest from the economic point of view of the crop. *M. rosae* is a minute, more or less globular, light green and fragile sucking pest and exhibits polymorphism in its life stages. This species on roses is seldom found singly. Its occurrence in cluster on tender shoots, buds and flowers and occasionally to lesser extent on the underside of the leaves, causes considerable yield loss and quality of flowers (Hole *et al.* 2007). The rose crop is subjected to both qualitative and quantitative losses due to attack of this pest. So far the authentic identification of pest complex of roses of Kashmir particularly aphid pest is lacking, hence it becomes necessary to carry out survey and screen different cultivars of roses for their resistance/ susceptibility against rose aphid.

MATERIALS AND METHODS

The investigation of the present study includes survey and monitoring of aphids and screening of rose cultivars for their resistance against the aphids. Random surveys were carried out for recording the prevalence and severity of the aphid pest infesting roses (*Rosa* sp.) in some localities of Srinagar and Baramulla districts. The localities were Harwan, Cheshmashahi, Nishat, Mirza Bagh and Hawal in Srinagar, whereas in district Baramulla, the locations selected for survey were Pando Park (Pattan), Sangramma, Gulnar Park (Baramulla), Sopora and Rafiabad. Five plants were randomly selected from each locality and 3 twigs (plant^{-1}) were examined for calculation of aphid infestation. The aphids were brushed off by using camel hair brush from the apical 5 cm of rose plants on a white paper sheet and counted to calculate aphid severity at different locations. The survey was carried out from March to December, 2007. Percentage of incidence of *Macrosiphum* spp. was computed by using the formula :

$$\text{Incidence} = \frac{n}{N} \times 100$$

Where, n = Number of twigs infested, and N = Total number of twigs examined.

The aphids were counted from 15 twigs including infested and non-infested ones. The twigs were considered infested even, if a single aphid was observed, to have basic data on aphid population twig^{-1} (severity). The monitoring was carried out at SKUAST-K, Shalimar Campus on ten (2-3 yrs old) rose plants. The plants were tagged and the observations were recorded at fortnight intervals starting from March till the end of November, 2007. *In situ* aphid

counting was done in case of low infestation. However, when infestation was high the apical 5 cm twig was trimmed carefully and put in tasel bag. After anaesthesing by chloroform, aphids were brushed with the help of camel hair brush on big white sheet of paper and counted. Each tagged plant was considered as replication for calculating the average number of aphids (twig^{-1}).

Screening of cultivars

Rose cultivars viz., Grand Gala, Golden Gate, Konifitti, Naranga and Nobless of pencil thickness of 1 year old hardwood or semi-hardwood cuttings (12-18 cm) of rootstock was planted in pots for screening against aphid pest. The cultivars after planting in pots were kept at ambient conditions following complete randomised design (CRD) with 3 replications. Plants were raised following recommended package of practices. Iincidence of aphid was recorded at fortnightly interval taking into account the upper 10 cm of a shoot of rose plant. Data on the number/incidence of aphids was taken from April to end of November, 2007. The rose plants were grouped into 6 categories (0 to 5 Grade) on the basis of aphid populations as follows:

0 = No aphid infestation or plant completely free from aphid.

1 = Leaves/shoots/inflorescence having upto 15 aphids, but not showing any sign of injury.

2 = Infestation moderately more than grade 1 (16-50 aphids). Aphid colonies scattered on leaves, shoots and buds/flowers. Small cutting and yellowing of leaves and flowers.

3 = Leaves, shoots and buds/flowers densely populated by aphids (51-100). Cutting and yellowing of leaves and bud/flowers.

4 = Very heavy population of aphids (> 100) on leaves and bud/flowers showing symptoms of dryness.

5 = Complete dryness of plants due to heavy infestation of aphids.

Mean aphid infestation index (MAII) was calculated by the number of plants falling under each grade and multiplied by the respective grade number. The total was then divided by the number of plants observed. Analysis of variance of the above indices was done after transforming the each value as $\sqrt{0.5+P}$, where P is the mean infestation index.

RESULTS AND DISCUSSION

Survey of aphid species

Results revealed that the aphid pest occurred during March at Harwan, Nishat and Cheshmashahi, district Sringar having its mean number twig^{-1} 0.40, 0.26 and 0.60 (Table 1, Fig. 1) and incidence of 13.33, 6.66 and 13.33 (Table 2, Fig. 2), while at Hawal and Mirzabagh, it appeared in April with mean number (twig^{-1}) and incidence of 6.13 and 5.47 and 33.33 and 26.66 per cent. The pest population reached to its 1st peak at all the locations during May with the mean aphid number of 32.06, 25.06, 34.00, 18.47 and 13.53 (twig^{-1}) and incidence of 93.33, 80.00, 100, 60.00 and 53.33 per cent. There after a rapid reduction in aphid number and its incidence has been observed at all the localities till July. However, the aphid population starts building up from August and reached to its 2nd peak in September with mean aphid number of 22.00, 20.80, 26.00, 16.40 and 9.80 (twig^{-1}) and incidence of 66.66, 60.00, 80.00, 46.66 and 40.00 per cent (Table 1, 2). The aphid population (number twig^{-1}) and

Table 1. Infestation of rose aphid (*Macrosiphum rosae*) at five locations of district Srinagar, J&K from March to December, 2007.

Month	Hawal*	Nishat*	Cheshmashahi*	Hawal*	Mirzabagh*	Mean for district Srinagar
March	0.40	0.26	0.60	0.00	0.00	0.25
April	6.00	5.86	7.60	6.13	5.47	6.21
May	32.06	25.06	34.00	18.47	13.53	24.62
June	9.26	5.93	7.93	0.40	0.13	4.73
July	1.13	0.53	0.93	0.20	0.00	0.55
August	7.46	5.46	12.33	1.66	4.93	6.36
September	22.00	20.80	26.00	16.40	9.80	19.00
October	10.73	8.53	9.33	9.00	1.20	7.75
November	1.00	1.40	2.53	0.73	0.26	1.18
December	0.40	0.20	0.80	0.00	0.00	0.28

*Aphid population per twig

Table 2. Incidence of *Macrosiphum rosae* (rose aphid) at five locations of district Srinagar, J&K during 2007.

Month	Rose aphid incidence (%)					Mean (%)
	Hawal	Nishat	Cheshmashahi	Hawal	Mirzabagh	
March	13.33	6.66	13.33	0.00	0.00	6.66
April	33.33	26.66	40.00	33.33	26.66	31.99
May	93.33	80.00	100.00	60.00	53.33	77.33
June	53.33	40.00	53.33	13.33	6.66	33.33
July	20.00	13.33	20.00	6.66	0.00	11.99
August	40.00	26.66	46.66	20.00	26.66	31.99
September	66.66	60.00	80.00	46.66	40.00	58.66
October	46.66	33.33	40.00	33.33	13.33	33.33
November	13.33	20.00	26.66	13.33	6.66	15.99
December	6.66	6.66	13.33	0.00	0.00	5.33

incidence showed reduction in October and November. Its population was observed at Harwan, Nishat and Cheshmashahi in December but it disappeared completely from Hawal and Mirzabagh.

In case of district Baramulla, the pest appeared in March at Sopore and Pattan with mean aphid number (twig^{-1}) of 0.26 and 0.33 and incidence of 6.66 and 6.66 per cent (Table 3, 4), whereas at Sangramma, Rafiabad and Gulnarpark, it appeared in April with mean number (twig^{-1}) of 0.53, 0.33, 0.20 and incidence of 13.33, 6.66 and 6.66 per cent, respectively. The pest occurrence showed a steady increase and reached to its 1st peak in May with mean aphid number of 21.13, 13.73, 13.00, 6.13, 24.53 (twig^{-1}) and incidence of 66.66, 53.33, 53.33, 40.00 and 73.33 per cent at different locations. Interestingly, the pest population showed rapid reduction till July and it completely disappeared at Rafiabad and Gulnarpark in July, 2007. However, the pest population buildup increased during August and reached to its 2nd peak in September having mean aphid number (twig^{-1}) of 7.20, 4.87, 1.07, 1.20 and 10.93 and incidence of 46.66, 26.66, 20.00, 26.66 and 53.33 per cent, at Sopora, Sangramma, Rafiabad, Gulnarpark and Pattan (Table 3, 4). Thereafter, the pest population showed reduction in number during October and November at Sopora, Sangramma and Pattan localities, while it was completely disappeared in November from Rafiabad and Gulnarpark. Aphid was not observed at any location selected in Baramulla district during December.

The studies are in conformity with the findings of Mohammed and Mallah (1987) that the pest appeared in spring season in mid-May and mid-February at Lublin, Poland and Mosul-Iraq, respectively. Bhagat and Ahmad (1995) also observed huge colonies of aphid on *Rosa* sp. at Batote (Jammu). Rani and Mohan (1997) reported that cool and cloudy weather during October to February favoured the build up of aphid, *M. rosae*, as blackish green clustering around growing shoots of the plants are observed in

Table 3. Infestation of rose aphid (*Macrosiphum rosae*) at five locations of district Baramulla, J&K from March to December, 2007.

Month	Sopora*	Sangramma*	Rafiabad*	Gulnarpark*	Pattan *	Mean for district Baramulla
March	0.26	0.00	0.00	0.00	0.33	0.11
April	1.07	0.53	0.33	0.20	3.00	1.02
May	21.13	13.73	13.00	6.13	24.53	15.70
June	2.80	15.33	0.80	0.13	6.53	5.11
July	0.53	0.13	0.00	0.00	0.86	0.30
August	2.53	1.20	0.13	0.60	4.53	1.79
September	7.20	4.87	1.07	1.20	10.93	5.05
October	2.87	0.26	0.20	0.40	3.40	1.42
November	0.53	0.20	0.00	0.00	0.93	0.33
December	0.00	0.00	0.00	0.00	0.00	0.00

*Aphid population per twig

Bangalore. However, Atwal and Dhingra (1971) observed in Punjab that the pest appeared in November, and it appeared in 3rd week of January (Hole *et al.* 1998) at Pune, Mahrashtra.

Screening of rose cultivars

Results on screening of rose cultivars against *M. rosae* revealed that comparatively Grand Gala and Nobless harboured the highest aphid infestation with MAII of 1.33 and 1.10. Thus, considered as highly susceptible cultivar, while cv. Golden Gate and Naranga exhibited moderate aphid infestation with MAII of 0.99 and 0.88 (moderately susceptible). However, Konifittii with minimum MAII 0.55 considered relatively least susceptible cultivar (Table 5, Fig. 3).

It is clear from the studies that none of the cultivar was free from aphid infestation. However, variable aphid numbers were recorded in different varieties throughout the season. Similar results were obtained by David *et al.* (1958), who reported that all garden and wild roses get infested by this pest. The analysis of the data to compute the mean aphid infestation index (MAII) revealed that comparatively rose varieties Grand Gala and Nobless had the highest MAII, Konifittii minimum and Golden Gate and Naranga moderate. These findings are in agreement with the observations of Akhtar and Khaliq (2003), who reported that none of *Rosa* sp. was free from aphid infestation. Rani and Sridhar (2003)

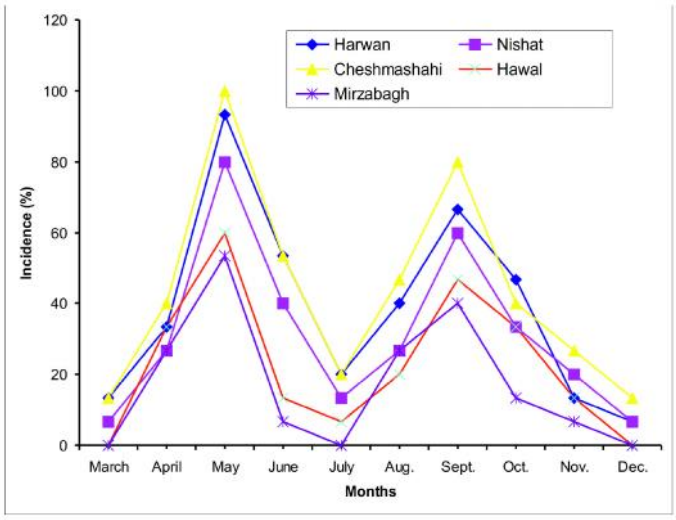

Fig. 1 : Monthly incidence of *Macrosiphum rosae* at five localities in district Srinagar during 2007

Table 4. Incidence of *Macrosiphum rosae* (rose aphid) at five locations of district Baramulla during 2007

Month	Aphid incidence (%)					Mean
	Sopora	Sangramma	Rafiabad	Gulnarpark	Pattan	(%)
March	6.66	0.00	0.00	0.00	6.66	2.66
April	20.00	13.33	6.66	6.66	26.66	14.66
May	66.66	53.33	53.33	40.00	73.33	57.33
June	26.66	20.00	13.33	6.66	40.00	21.33
July	13.33	6.66	0.00	0.00	20.00	7.99
August	26.66	20.00	6.66	13.33	33.33	19.99
September	46.66	26.66	20.00	26.66	53.33	34.66
October	26.66	13.33	6.66	13.33	33.33	18.66
November	13.33	6.66	0.00	0.00	20.00	7.99
December	0.00	0.00	0.00	0.00	0.00	0.00

Table 5. Mean aphid infestation index (MAII) of five cultivars of *Rosa* sp. at Shalimar Campus, SKUAST, J&K.

Cultivar/variety	Cv1	Cv2	Cv3	Total	MAII *
Grand Gala	1.66	1.00	1.33	3.99	1.33
	(1.46)	(1.22)	(1.350)		
Golden Gate	0.66	1.33	0.66	2.65	0.88
	(1.07)	(1.35)	(1.07)		
Konifittii	0.66	0.33	0.66	1.65	0.55
	(1.07)	(0.91)	(1.07)		
Naranga	1.00	0.66	1.33	2.99	0.99
	(1.22)	(1.07)	(1.35)		
Nobless	1.33	1.33	0.66	3.32	1.10
	(1.35)	(1.35)	(1.07)		

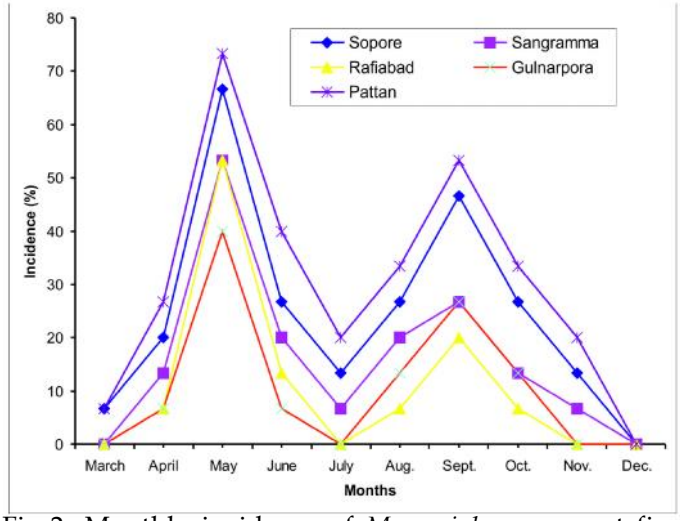

Fig. 2. Monthly incidence of *Macrosiphum rosae* at five localities in district Baramulla during 2007

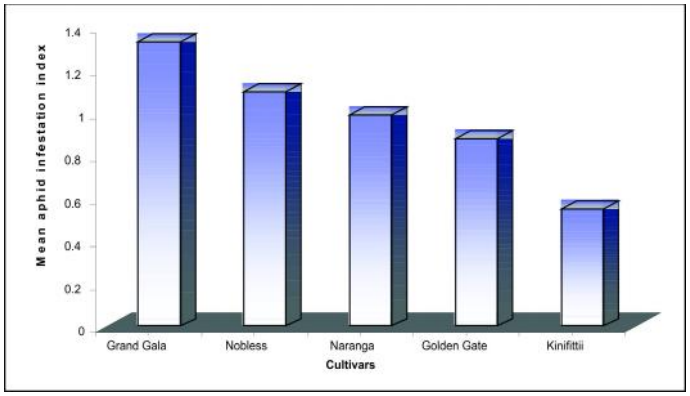

Fig. 2. ScreeningResponse of different rose cultivars against *Macrosiphum rosae* with response in mean aphid infestation index (MAII).

reported that varieties Versilia, First Red and Grand Gala were more susceptible to thrips, whereas other varieties exhibited moderate response. They further reported that relatively more number of thrips was settled on red and orange coloured flowers as compared to yellow coloured ones. The colour of rose flowers may be a source of attraction to aphid as well. Infact, varied susceptibility of different *Rosa* spp. to aphid may be attributed due to the morphological characters (flower colour, thorns, etc.) and chemical interaction especially the presence of catechin (1,2 benzenediol) content in the sap, which is a feeding deterrent as pointed out by Rani and Sridhar (2003) and Miles (1985).

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Comparative development of rice weevil, *Sitophilus oryzae* (L.) in stored split legumes

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ABSTRACT

Rice weevil mainly attacks whole grains such as wheat, corn, barley and rice and have been found actively breeding in such foods. Its host range, now extended to split legumes. In the present experiment in the laboratory, it has been found that the rice weevil completed its life cycle successfully in three split legumes. Field bean and Bengal gram proved best hosts, where the weevil showed highest fecundity (484.40 & 464.50), fertility (287.60 & 288.40), progency production (1292.50 & 1230.00), adult longevity (51.25 & 94.00, 51.75 & 97.75 days, male and females) and short developmental period (32.25±0.83 & 34.00±0.71 days). However, the fecundity (347.60 eggs), fertility (189.30 larvae), developmental period (37.50±1.12 days), longevity (49.75 days), progeny production (1127.50 beetles), adult length (2.90 mm) male and female and body weights (3.01 & 3.09 mg) were lower in stored split green gram. The result indicates future pest status of *S.oryzae* on split legumes.

Key words: Rice weevil, development, split legumes.

The rice weevil, *Sitophilus oryzae* (L.) (Curculionidae: Coleoptera) is one of the most serious stored grain pests world wide. This pest is originated in India and now it has a cosmopolitan distribution. The rice weevil attacks wheat, corn, oats, rye, barley, sorghum, buckwheat, dried beans, cashew nuts and cereal products especially macaroni. It is one such major pest, causing about 10.0 to 65.0 per cent damage in stored seed. Under prolonged storage the damage peaks has been reported up to 80.0 per cent (Park *et al*. 2004). Historically, *S. oryzae* has been associated with stored cereals (Cotton 1920; Chu and Wang, 1975) but some recent reports (Coombs *et al*. 1977; Halloway and Smith, 1986; Pemberton and de Rodriguez, 1981) indicated their ability to feed on some legumes. This aspect can be considered as major host expansion by the same strains or population of *Sitophilus oryzae,* hence the present work conducted.

MATERIALS AND METHODS

Study has been conducted to understand the development of *Sitophilus oryzae* using different split legumes (green gram, Bengal gram & field bean) at Department of Agricultural Entomology, Agriculture College, Shimoga, India during 2011-2012. Sorghum (whole grain) was used as check for comparing the development between split legumes and whole grains of sorghum. Adults of *Sitophilus oryzae* were maintained on mixed split legumes containing green gram, Bengal gram and field bean in plastic jars and their lids covered with muslin cloth.

Fecundity and fertility

A single same day old 10 males and females were released into a container having ten split legumes. A total of 10 replications were maintained for each host separately. Number of eggs laid on each host was counted visually and by treating with acid fuchsin. The observation on number of eggs laid was counted once in 2 days. The 10 split legume hosts were subjected to acid fuchsin staining and number of egg plugs on individual split legumes were counted. The frequency distribution of egg plugs was recorded. Further, 10 fresh split legumes were provided for egg laying. The procedure was carried out till the death of female. Separate batches of 10 split legumes were maintained for egg laying in order to record the fertility from 10 pairs of male and female. The split legumes were split open using knife after 5 days (general egg period 3-4 days) and observed for presence of larva in order to check the successful hatching of egg. The data on number of eggs laid and fertility in different split legumes and sorghum was compared using ANOVA.

Developmental duration

Experiment was conducted by releasing 10 pairs of *S. oryzae* adults into a plastic jar containing sorghum and individual split legumes. After confirming egg in the split legumes, they were kept and observed till the adult emergence. Total and mean egg to adult period was recorded host wise. Sex ratio, length of adults, length and width of elytra were compared across hosts. Further, the emerged

adults were maintained host wise till death in order to record the adult longevity. A separate group of 10 males and females were maintained in food deficient condition to know longevity of adults without food.

Progeny production

The study was conducted using 100g of split legumes and sorghum kept in plastic jars. Ten marked males and females were allowed to feed and breed in the jar. Four replications were maintained for each host. Number of emerged adults after 90 days was compared across hosts using ANOVA. Weight of male and female and their sex ratio was also recorded across hosts.

RESULTS AND DISCUSSION

Fecundity and Fertility

The observations on fecundity (Table 1) of *S.oryzae* on sorghum and different split legumes revealed that the highest fecundity was noticed in sorghum (630.80 eggs), while it was lowest in green gram (347.60 eggs). Bengal gram and field bean recorded the fecundity of 464.50 and 484.40 eggs. This variation may be due to adaptive evolution of weevils to legumes. The reasons for variation in fecundity across legumes needs further investigation in terms of softness, protein content etc., which may have influence on egg laying behaviour of adults. Optimality models generally predict that large number of eggs will be laid in high quality hosts because they can support more progeny (Godfray *et al*. 1991). In the present study Bengal gram and field bean recorded the highest fecundity as compared to green gram. This may be because of the large size of split legume. Additional choice experiments are needed to determine how the behavioural mechanisms impact the distribution of eggs among multiple split legumes.

The highest fertility of *S.* oryzae (Table 1) was recorded in sorghum (417.90 larvae), it was lowest in green gram (189.30 larvae). Bengal gram and field bean recorded a moderate fertility of 288.40 and 287.60 larvae. The fecundity and fertility in the present study was also affected by the fat content of the split legumes. Bengal gram, field bean and green gram contain total fat of 1.95, 0.7 and 0.4 g per 100 g of seeds (Anonymous, 2014). The fecundity and fertility was high in Bengal gram and field bean in comparison to green gram, which may be because of more total fat than green gram.

Table 1. Fecundity and fertility of *Sitophilus oryzae* on different split legumes

Cereal/split legume	Mean progeny production (after 90 day)
Sorghum	2117.50[a]
Green gram	1127.50[d]
Bengal gram	1230.00[b]
Field bean	1292.50[bc]
CD (%)	94.790

Developmental period

The developmental period (Table 2) of *S.oryzae* on sorghum was the lowest (28.75±1.3 days) followed by field bean (34.00±0.71 days) and Bengal gram (32.25±0.83 days). The highest developmental period (37.50±1.12 days) was in green gram, where weevil takes more day to complete its life cycle. The present results are in confirmity with Lathrop (1914), Newman (1927) and Wenholz (1927) but differed with Lefever (1953) and Nakayama (1931) who recorded life cycle of 54 and 90 days, respectively.

Table 2. Developmental period of *Sitophilus oryzae* (egg to adult) in sorghum and split legume grains

Cereal/legume	Range (days)	Mean±Sd
Sorghum	27-30	28.75±1.30
Green gram	36-39	37.50±1.12
Bengal gram	33-35	34.00±0.71
Field bean	31-33	32.25±0.83

Adult longevity

Adult longevity in male and female weevils was high (Table 3) in sorghum (59.7 & 97.0 days) followed by Bengal gram (51.75 & 97.75 days) and field bean (51.25 & 94 days). In green gram male and female recorded the lowest adult longevity (49.75 & 84.75 days). This deviation might be due to change of host.

Progeny production

In the present study, sorghum produced the highest number (Table 4) of progeny (2117.50 weevils) followed by field bean (1292.50 weevils) and Bengal gram (1230.00 weevils). The lowest progeny production was noticed in green gram (1127.50 weevils). In case of split legumes seed size influenced the progeny production of *S. oryzae*. However, the size of legumes can not be compared with sorghum, with respect to progeny production. This is because sorghum being the traditional host of *S. oryzae*, hence higher production is expected.

Sex ratio

The female and male sex ratio (Table 5) in sorghum (1:1.54), green gram (1:1.60), Bengal gram (1:1.52) and field

Table 3. Adult longevity of *Sitophilus oryzae* in sorghum and different split legume grains

S. oryzae	Sorghum		Green gram		Bengal gram		Field bean	
	Mean (day)	Range (day)	Mean (days)	Range (day)	Mean (day)	Range (day)	Mean (day)	Range (day)
Male								
With food	59.70	58-62	49.75	48-52	51.75	49-55	51.25	48-55
Without food	5.75	4-8	2.50	1-4	3.00	2-4	2.50	1-4
Female								
With food	97.00	89-105	84.75	79-92	97.75	93-103	94.00	89-100
Without food	9.75	8-12	5.50	4-7	6.50	5-8	5.25	5-8

Table 4. Progeny production by *Sitophilus oryzae* in sorghum and different split legume grains

Cereal/split legume	Mean progeny production (after 90 day)
Sorghum	2117.50[a]
Green gram	1127.50[d]
Bengal gram	1230.00[b]
Field bean	1292.50[bc]
CD (1%)	94.790

longer length.

Weevil weight

Females weighed heavier than males (Table 5) in sorghum (3.18 mg), green gram (3.09 mg), Bengal gram (3.29 mg) and field bean (3.30 mg). These results are in conformity with Dhanho (2002), where *S.zeamais* females reported heavier (3.17 mg) than males (3.06 mg), when reared on maize. Split legumes having larger size, i. e., bengal gram and field bean (1:1.54) was male dominating, indicating the predominance of males over females. These findings differed with Dhanho *et al.* (2002), who reported the female dominance of *S. zeamais* in maize with sex ratio of 86.07 males per 100 females.

Table 5. Weight, length and width of elytra and sex ratio of F_1 generation of *Sitophilus oryzae* fed on sorghum and different split legume grains

Cereal/split legume	Adult length (mm)	Elytra length (mm)	Elytra width (mm)	Weight (mg) of		Sex ratio (female: male)
				Male	Female	
Sorghum	2.85	0.11	0.06	3.03	3.18	1:1.54
Green gram	2.90	0.09	0.05	3.01	3.09	1:1.60
Bengal gram	3.17	0.13	0.07	3.10	3.29	1:1.52
Field bean	3.42	0.15	0.08	3.11	3.30	1:1.54

Length of adults

Among 4 hosts (Table 5), weevils fed on field bean measured longer adult (3.42 mm) followed by Bengal gram (3.11 mm), green gram (2.90 mm) and sorghum (2.85 mm). The adult length was also influenced by the seed size of the split legumes. The observations in respect to field bean and Bengal gram are in confirmation with the findings of Jadhav (2009), who reported average length of male (3.25 mm) and female (3.75 mm) of *S. oryzae* in pop sorghum. Richards (1947) has shown that grain size influences the size of the adult insect. In the present study the size of the adult produced, influenced by the size of split legumes, where Bengal gram and field bean with large size split grains, produced adult of bean produced heavier adults.

The findings of present study has an impact on the future pest status of *S.oryzae* on split legumes but it needs to be investigated further.

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Diversity and seasonality of ants associated with outdoor and indoor habitats of coastal Odisha

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ABSTRACT

The ant species composition and their seasonality were assessed in two different habitats selected from urban and sub-urban settings of coastal Odisha. A total of 18 species of ants have been documented during April to November, 2014 across habitats and seasons. In terms of species richness the sub-families, Myrmicinae, Formicinae and Ponerinae comprised of 7, 6 and 3 species, respectively. One species each was recorded under the sub-family Dolichoderinae and Pseudomyrmicinae. The species composition was found to be diverse in different seasons and overlapping between habitats. The seasonal occurrence of different ant species in different habitats are discussed.

Key words: Ant species, diversity, composition, seasonality, habitat, coastal Odisha.

Among the insects, ants are diverse, abundant, easily found and can be reliably sampled and monitored (Majer, 1983; Andersen, 1986; Delabie *et al*. 2006). They are also bio-indicators and efficient invaders of new habitats (Holway *et al*. 2002). Due to this, ants are increasingly used for biodiversity assessments and comparison of habitats and ecosystems (Andersen and Majer, 2004). Since, the data on the ants in natural and man made habitats are poorly documented (Gadagkar *et al*. 1993) and the coastal habitats are known to harbor rich biodiversity among the terrestrial ecosystems (Cunha and Nair, 2013), therefore attempts were made in the present investigation to document the ant species composition and their seasonality in outdoor and indoor habitats under the urban and sub-urban settings of coastal Odisha.

MATERIALS AND METHODS

Sampling of ants was done during April – May, July – August and October – November, 2014. Two undisturbed habitats were chosen for sampling, one at the campus of College of Forestry, OUAT, Bhubaneswar (Dist. Khurda), which represented the urban setting (designated as outdoor habitat) and the other being the residential premises in a village Nagapur (Dist. Puri), which represented the sub-urban setting (designated as indoor habitat). The methods employed for collection of the ant fauna from the first location include all out search (hand collection), bait and pitfall methods, while in the residential premises only the former two methods were adopted. About 25 plastic cups (6 cm in diameter and 7cm in length) half filled with water and few drops of liquid detergent were kept at five different locations @ five cups per location within the campus of College of Forestry, where different forest plants were raised and maintained since 15 years. Similarly, plastic tubes with sugar bait (candy) were placed at different locations at both the selected habitats (outdoor & indoor habitats). The ants collected during the above periods were preserved in alcohol (70%) and sorted out to subfamily and genus using the key provided by Bolton (1994). In few cases morpho species were identified by using reliable internet site, such as www.antweb.org. Identification of ants was done using Trinocular zoom stereoscopic microscope (Model: BD42-A).The ant specimens so collected were also sent to ant taxonomist for confirming the species. The identified ant species were listed and the number of ants in each genus / species was documented with respect to habitats as well as periods of observations so as to enumerate the species composition and species structure indices. Various ecological indices like Shannon- wiener's index, H (Shannon and Wiener, 1963), Simpson's index of diversity, SID (Simpson, 1949), evenness and Sorensen's similarity coefficient (QC) were worked out as per the following equations;

$$H = \sum_{i=1}^{s} - (P_i * \ln P_i)$$

Where, H= the Shannon species diversity index, S= no. of species encountered or species richness, Pi = proportion of the total sample belonging to i^{th} species, $\ln P_i$=natural logarithm with base e = 2.718281828..... and " = sum from species 1 to species S.

The index values (H) can range of 0 to ~4.6. A value near 0 would indicate that every species in the sample is the same, i.e., there is no diversity, while higher value of H would indicate more diverse communities and the numbers of individuals are evenly distributed between all the species.

Simpson's Index of diversity (SID)

The Simpson's Index (D) is a measure to assess the probability that two individuals randomly selected from a sample will belong to the same species or some category other than species. The above index was calculated using the following equation.

$$D = \frac{\Sigma\, n(n-1)}{N(N-1)}$$

Where, n = the total number of organisms of a particular species and N = the total number of organisms of all species

With this index, 0 represents infinite diversity and 1 no diversity. It means the bigger the value of D, the lower the diversity. In order to make the measure meaningful, D is often subtracted from 1 to give Simpson's Index of Diversity (1 - D). The value of this index also ranges between 0 and almost 1, the greater the value, the greater the sample diversity. A value approaching zero indicates low biodiversity. For a given richness (S), D increases as equitability increases and for a given equitability D increases as richness increases.

Evenness (E_H)

Using species richness (S) and the Shannon-Wiener index (H), the evenness was computed using the same log base as with H, as per the formula given by Pielou (1975);

$E_H = H / \ln (S)$

Where, H = the Shannon species diversity index, S = Number of species encountered or species richness and In = natural logarithm with base e = 2.718281828.....

The equitability assumes a value between 0 and 1 with 1 being complete evenness. Higher values of evenness indicate less variation between species in communities. In other words, there are similar proportions of all species, then evenness is one, but when the abundance are very dissimilar (rare & common species) then the value increases.

Sorensen's similarity coefficient

To measure the similarity between two community samples, coefficient of Sorensen was calculated after Chavhan and Pawar (2011) as per the following equation:

$$QC = \frac{2a}{2a + b + c}$$

Where, QC = Sorensen similarity coefficient, a = number of species in sample A and sample B (joint occurrences), b = number of species in sample B but not in sample A and c = number of species in sample A but not in sample B.

RESULTS AND DISCUSSION

Ants collected from outdoor and indoor habitats were mostly represented by five sub-families viz., Myrmicinae, Formicinae, Dolichoderinae, Ponerinae and Pseudomyrmicinae. The density of ants represented by these sub-families proportionately varied with the periods of observations and in descending order of their abundance, the sub-families were recorded as Myrmicinae (51.4%) > Dolichoderinae (25.1%) > Formicinae (16.6%) > Ponerinae (6.9%); Dolichoderinae (37.3%)> Formicinae (31.9%) > Myrmicinae (30.2%) and Myrmicinae (71.5%) > Formicinae (26.7%)> Ponerinae (1.4%) > Pseudomyrmicinae (0.1%), for the corresponding periods, respectively (Fig.1). Under coastal Odisha conditions, irrespective of habitats the Myrmicinae ants mostly predominated numerically during summer (April – May) and post rainy (October – November) season, while the Formicinae ants were found predominantly active during rainy (July – August) and post rainy (October–November) seasons and Dolichoderinae ants confined their activity to summer and rainy seasons (Fig.1). The ants of sub-family, Ponerinae and Pseudomyrmicinae were observed in low numbers either with low or restricted activities in different seasons.

Irrespective of seasons studied, the Myrmicinae ants were found almost in similar proportions (Fig.2) in both

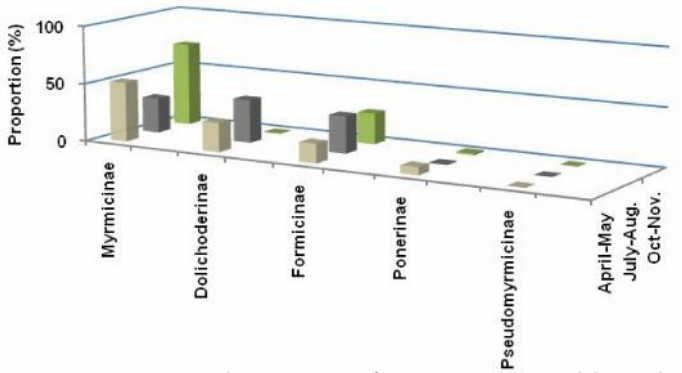

Fig.1. Proportional variation of ants represented by sub-families in different seasons irrespctive of habitats.

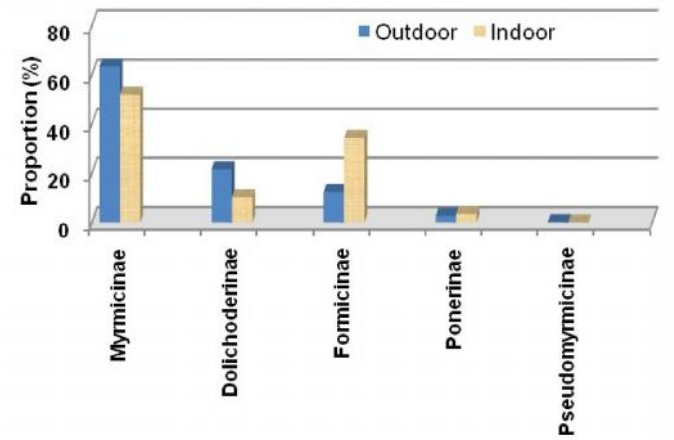

Fig. 2. Relative proportion of sub-families in outdoor and indoor habitats irrespective of seasons.

outdoor (63.4%) and indoor (52.0%) habitats. The population of ants belonging to sub-family Dolichoderinae were relatively high in outdoor habitats (21.6%) than in indoor (10.2%). Similarly, a major proportion of Formicinae ants were mostly sampled from indoor habitats (34.4%) than in outdoor (12.3%).

Ponerinae ants as residential population always prevailed in low proportion in both outdoor (2.7%) and indoor (3.4%) habitats, while negligble proportion of Pseudomyrmicinae ants (0.1%) was noticed only in outdoor habitats. In the west coast of Karnataka, Cunha *et al*. (2013) observed Myrmicinae (55%) as dominant sub-family followed by Formicinae (32%), Ponerinae (7%), Dolichoderinae and Pseudomyrmicinae (3% each).

Species diversity and evenness

The species diversity indices like Simspon's Index of diversity (SID) and Shannon-Wiener index (H) in respect of the habitats during different periods of observations are presented in Table 1. Relatively high diversity in species composition was noticed during April – May (SID = 0.84; H = 2.01) than during July – August (SID = 0.78; H=1.78) and October – November (SID=0.71; H=1.48). Similarly, irrespective of seasons the diversity indices showed similar species composition both in outdoor (SID = 0.76; H = 1.73) as well as in indoor (SID = 0.77; H = 1.82) habitats. The evenness (E_H) values in respect of seasons and habitats, when compared, it became apparent that different species were abundant and occurred almost in similar proportions in 72.0 to 78.0 per cent cases during April – May (E_H=0.78) and July – August (E_H=0.72) indicated that the species structure at both the locations was also found overlapping.

Species richness and composition

A total of 18 species of ants have been documented from the samples collected across habitats and seasons. In terms of species richness the sub-families viz., Myrmicinae, Formicinae and Ponerinae comprised of 7, 6 and 3 species, while one species each was recorded under the sub-family Dolichoderinae and Pseudomyrmicinae. The species richness in proportion to the total species recorded also evidenced predominance of the above sub-families in different seasons under coastal conditions of Odisha (Table 2).

Further, despite the fact that the proportion of species richness in both the habitats studied was almost similar, but the occurrence of ant species varied in these habitats with seasons. In April-May the proportion of ants represented by sub-family Myrmicinae was high (44.4%) in outdoor habitats and the species like *Monomorium* spp. and *Crematogaster* spp. occurred in high densities. The species diversity of Formicinae ants was observed to be high (36.4%) in indoor habitats and species like *Paratrechina* spp. and *Camponotus compressus* were mostly encountered. Within the residential premises (indoor habitats) at the village Nagapur, ant species like *Pachycondyla* spp., *Diacamma* spp. and *Leptogeny* spp. represented by sub-

Table 1. Species richness, diversity and evenness in ant community of outdoor and indoor habitats of coastal Odisha.

Period / habitat	Species richness	Diversity indices		Evenness (E_H)
		Simpson's index of diversity (SID)	Shannon diversity index (H)	
Periods irrespective of habitat				
April – May	13	0.84	-2.01	-0.78
July – August	12	0.78	-1.78	-0.72
October – November	15	0.71	-1.48	-0.55
Habitat irrespective of seasons				
Outdoor habitat	15	0.76	-1.73	-0.64
Indoor habitat	15	0.77	-1.82	-0.67

Table 2. Species richness in proportion to the total species (%) recorded in different periods and habitats under coastal Odisha.

Sub-Family	Proportion of species (%) recorded during periods / habitats							
	April-May		July-August		October-November		Overall	
	OD	ID	OD	ID	OD	ID	OD	ID
Myrmicinae	44.4	27.3	42.8	55.5	33.3	37.5	33.3	40.0
Formicinae	22.2	36.4	28.6	44.4	33.3	37.5	33.3	33.3
Ponerinae	22.2	27.3	14.3	0.0	16.7	25.0	20.0	20.0
Dolichoderine	11.1	9.1	14.3	0.0	8.3	0.0	6.7	6.7
Pseudomyrmicinae	0.0	0.0	0.0	0.0	8.3	0.0	6.7	0.0

OD = Outdoor, ID = Indoor

family Ponerinae constituted 27.3 per cent of the total species recorded during summer months. The former species was found to be most predominating, while occurrence of *Leptogeny* spp. was exceptional as this species mostly invades outdoor habitats.

Similarly, during the monsoon months (July – August) ants represented by sub-family Myrmicinae was found to be more diverse in both outdoor (42.8%) and indoor (55.5%) habitats. Among the Myrmicinae ants, *Monomorium* spp. was predominantly seen in both the habitats. On the contrary, the Formicinae ants mostly remained diverse under indoor conditions and species like *Pachycondyla* spp., *C. compressus* and *C. sericeus* being most common. The ant species like *Diacamma* spp. (sub-family: Ponerinae) and *Tapinoma* spp. (sub-family: Dolichoderinae) were noticed as most common in urban garden and each of these constituted about 14.3 per cent of the total species.

The Myrmicinae and Formicinae ant species were more diverse during post monsoon months (October – November) in both outdoor and indoor habitats. However, ant species like *Crematogaster* spp. (Myrmicinae) and *C. compressus* (Formicinae) were recorded in relatively high densities in outdoor habitats, while species like *M. pharaonis* (Myrmicinae), *Paratrechina* spp. (Formicinae), *C. compressus* (Formicinae) and *Diacamma* spp. (Ponerinae) occurred abundantly in indoor habitats. Ants represented by sub-family Pseudomyrmicinae was only noticed during post monsoon months and exclusively in outdoor habitats. Further, the Sorensen's Similarity Coefficient showed that the ant community were mostly overlapping, i.e., occurred in similar proportions during April – May (QC= 0.7) and October – November, (QC = 0.8) as compared to the monsoon months (QC = 0.5). The environmental differences between the two sampling periods owing to seasonal climatic conditions are also said to affect the temporal changes in ant assemblages (Barrow and Parr, 2008) and the abiotic factors are more important determinants of ant assemblage structure than competitive interactions (Narendra *et al.* 2010). Thus, each ant species might respond uniquely to changes in climate (Warren *et al.* 2011). The data mean over seasons also indicated that Myrmicinae, Formicinae and Ponerine ants were speciose in both the habitats (outdoor and indoor). The composition of ant species is unique to each habitat, and most likely governed by the vegetation, biota around it, soil characteristic and anthropogenic disturbances (Kumar and Mishra, 2008; Ramesh *et al.* 2010).

The present studies evidenced that various species prevailed differently depending upon the climatic conditions. The population of *Tapinoma melanocephalum* and *Solenopsis geminata* were appreciable in summer months, while *Paratrechina longicornis* and *Monomorium pharaonis* predominated during monsoon and post monsoon months. Bharti (2012) indicated that the Myrmicinae ants form the bulk of Indian ant diversity (45%) with *Pheidole* and *Crematogaster* having the most species, while the subfamily Formicinae is the second largest ant group (25% of species) with *Camponotus* and *Polyrhachis* constituting the majority of the diversity. The Ponerinae ants like *Diacamma* spp. and *Pachycondyla* spp. were most common in coastal Odisha with the former species being observed invading both the habitats (urban garden & residential premises) during summer and confined to indoor habitats during post-monsoon months. However, *Pachycondyla* spp. invaded both outdoor and indoor habitats during summer and post-monsoon months. The predominance of above two Ponerinae ant species in coastal habitats was in conformity with earlier findings of Patnaik *et al.* (2014), who reported that of the five species recorded at Bhubaneswar (Odisha), *Pachycondyla sulcata* and *Diacamma rugosm* constituted the major proportion.

The results indicated the prevalence of *Monomorium* spp., *T. melanocephalum, Crematogaster* spp. and *C. compressus* in undisturbed urban gardens and *T. melanocephalum, P.*

longicornis and *M. pharaonis* in residential premises need attention. Currently, four ant species, *Monomorium pharaonis, M. indicum, P. longicornis* and *T. melanocephalum* have emerged as weedy species in India with few more turning to be notorious as well (Bharti, 2012). Further, it is suggested that these ant species have remarkable adaptability to cope with environmental stress, thus leading to their rapid proliferation, which will be difficult to control with recently launched management practices. However, in order to conserve high species richness in urban areas, Uno *et al*. (2010) advised to maintain a variety of habitat types.

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Biological control of tomato wilt through soil application of bio-agent and organic ammendments

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ABSTRACT

Tomato (*Lycopersicon esculentum*) is the world's largest growing vegetable crop. Many diseases and disorders affect tomatoes during its growing season. *Fusarium oxysporum* f. sp. *lycopersici* (FOL) is a highly destructive pathogen in both green house and field conditions. There are options for the management of the disease viz., use of botanical, bio-agents, chemicals or genetic resistance. The present investigation was under taken to evaluate chemical, bioagents and botanicals viz. Bavistin (1g l^{-1} of water seedling dip), *Trichoderma viride* (25 kg ha^{-1}), Neem oil cake (250 kg ha^{-1}), NSKE (5%), combined treatment of *T. viride* + Neem oil cake, Bavistin + Neem oil cake and *T. viride* + FYM 1kg 100kg^{-1} FYM) for the management of wilt of tomato. Bavistin was found superior and followed by *T. viride* + FYM and *T. viride* alone. The treatments NSKE and Neem oil cake gave lowest performance. Bioagent *Trichoderma viride* + Neem oil cake or fungicide Bavistin + Neem oil cake were found equal in management of the disease.

Key words: Bioagent, wilt, *Trichoderma* spp., plant growth, tomato.

Tomato (*Lycopersicon esculentum*) is one of the important vegetable crops and known as protective food, both because of its special nutritive value and wide spread production. Tomato ranks third in priority after potato and onion in India but ranks second after potato in the world scenario. India ranks second in the area as well as in production of tomato. Tomato is a rich source of vitamins A and C, organic acid, essential amino acids and dietary fibers. It also contains minerals like iron, phosphorus and pigments like Lycopene and ß-carotene. As it is a short duration crop and gives higher return, it is considered an important crop from economic point of view. Tomato is mainly grown as *rabi* crop in the plains of India. However, in the hilly region it can be grown as a summer and rainy season crop. It is a successful crop in field as well as in green house conditions. Many diseases and disorders affect tomatoes, but wilt can be graded as most devastating disease. *Fusarium oxysporum* f. sp. *lycopersici* (FOL) is a highly distractive pathogen both in green house and field conditions. The disease is characterized by yellowing of leaves and finally wilting of plants (Asha *et al.* 2011). World-wide wilt is considered as one of the most economically important diseases (Alexander and Tucker, 1945; Cal *et al*. 2004). Disease is soil-borne in nature and produces two kinds of conidia, i.e., micro and macro-conidia. During unfavorable condition, pathogen survives in the form of chlamydospores. The perfect stage of pathogen is *Mychospherella* sp. Vascular wilt, by *Fusarium oxysporum* f. sp. *lycopersiciis*, is the main problem in the cultivation of tomato (Pareja *et al*. 2008) as the pathogen persists indefinitely in infected soil. As bioagents are dynamic in nature and multiplies itself in the soil, comparison was made with fungicide for it's efficacy against tomato wilt pathogen and results obtained are reported.

MATERIALS AND METHODS

A field experiment was conducted at the crop research farm, Allahabad School of Agriculture, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad during *Karif*, 2012-13 to find out the suitability of bioagent and botanicals for the management of wilt of tomato. The field selected for experiment was uniform, cultivable with typical sandy loam soil having good drainage facility. The experiment was laid out in Randomized Block Design with seven treatments in three replications. The treatments were Bavistin 1g l^{-1} of water as seedling dip (Musmade *et al*. 2009); *Trichoderma viride* 25kg ha^{-1}; Neem oil cake 250kg ha^{-1}; NSKE 5%; *Trichoderma viride* 25kg ha^{-1} + Neem oil cake 250kg ha^{-1}; Bavistin + Neem oil cake; *Trichoderma viride* + FYM 1kg 100 kg^{-1} and Control. Bavistin (carbendazim) manufactured by BASF India Limited was used as seedling dip method for 5-10 minutes (Musmade *et al*. 2009). Field with untreated soil served as control. The treatment *Trichoderma viride* @ 25kg ha^{-1} (Nikam *et al*. 2007) and *Trichoderma viride* + FYM (1000 kg ha^{-1}) @1.0kg q^{-1} of FYM (Barnwal *et al*. 2011) were applied as soil treatment. Neem oil cake was also applied as soil

Table 1. Effect of different bioagents, organic ammendments and combinations on the wilt incidence and growth of tomato.

Bioagent/organic amendment/chemicals	Disease incidence (%)	Plant height (cm)	Number of leaves	Number of branches
Bavistin (0.1%)	16.67	30.20	93.67	13.93
Trichoderma viride (25 kg ha^{-1})	25.00	24.87	79.83	11.53
Neem oil cake (250 kg ha^{-1})	33.33	24.33	74.80	10.73
NSKE (5%)	37.50	23.60	74.60	10.53
Trichoderma viride (25 kg ha^{1}) + Neem oil cake (250 kg ha^{-1})	29.17	24.73	75.00	11.07
Bavistin (0.1%) + Neem oil cake (250 kg ha^{-1})	29.17	24.73	78.40	11.27
FYM (1000 kg ha^{-1}) +*Trichoderma viride* (@1kg q^{-1} FYM)	20.83	26.00	83.40	11.80
Control (No treatment)	58.33	21.33	55.73	7.27
F-test	S	S	S	S
S. Ed.(±)	5.623	1.165	5.213	0.539
CD (P=0.05)	11.921	2.469	11.051	1.143

treatment (Barnwal *et al*. 2011). Uniform seedlings were raised in chemical free soil in the nursery beds of 1 x 0.5m, prepared with a height of 20 cm. Sowing of the seeds was done in straight lines with 2 cm spacing between successive seeds. Seeds ware planted at a depth of 0.5 cm to 1cm and covered with a thin layer of soil. The 20 to 25 days old seedlings were used for transplanting. The seedlings were transplanted in the main field in rows with spacing of 65 cm between rows and 45 cm between two successive plants. Irrigation was provided once in 7-10 days depending on the soil and weather conditions. Weed control was done by light hoeing during first four weeks in the field, which encourage the growth and also remove the weeds from the field. Data on growth parameters and wilt incidence were recorded after 90 days of treatment (DAT) and analysed statistically.

RESULTS AND DISCUSSION

The minimum incidence of the wilt (16.67%) was recorded in treatment Bavistin followed by the treatment FYM + *Trichoderma viride* (20.83%) and *Trichoderma viride* (25.00%). NSKE was least effective with disease incidence 37.50 per cent (Table 1). Similar finding was reported by Kamdi *et al*, 2012. Other treatments could control disease moderately, i.e., Bavistin + Neem oil cake (29.17%), *Trichoderma viride* + Neem oil cake (29.17%) and Neem oil cake (33.33%). Data presented in Table 1 also shows maximum plant height, more number of leaves and branches in Bavistin treated plot followed by the *Trichoderma viride* + FYM. Similar findings have been reported by Parsad *et al.* (2002). The result emanates that treatments not only check disease incidence but also help in the general growth of the plants.

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Impact of nutrition counselling on the nutritional status of the gestational diabetics

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ABSTRACT

Sixty patients suffering from gestational diabetes mellitus in the age group of 20-40 years were selected from Dayanand Medical College and Hospital and other local hospitals of Ludhiana. General information, family history and dietary pattern was recorded by interview schedule. In 2 groups, i.e., experimental (E) and control (C). Counselling was imparted for three months (group E) at 15 days interval about gestational diabetes, sign and symptoms, causes, risk factors, complications, management and dietary management. The anthropometric parameters were also measured. Results revealed that the mean daily intake of cereals (65.2 – 79g), pulses (65.9 - 73.9g), green leafy vegetables (60.3 - 90.7g), other vegetables (66.4 - 83.7g), fruits (50 - 97.7g) and milk and milk products (78.1 - 98.1ml) were increased significantly, while roots and tubers (82.2 - 30.7g), fats and oils (120.2 - 93.7g) and sugar and jaggery (110 – 50g) were decreased significantly in group E. The mean daily intake of energy (68.2 - 75.8kacl) and protein (64 - 73.8g) was increased significantly and total fat (167 – 117g) decreased in E. In case of this group, the mean daily intake of vitamins and minerals were also increased significantly. Similarly, anthropometric parameters were better after nutrition counselling. Thus, it can be inferred from the study that nutrition counselling significantly improved the nutritional status of the patients suffering from gestational diabetes mellitus.

Key word: Food, status, nutritional, anthropometric profile, gestational diabetic.

Gestational diabetes affects women during pregnancy. Pregnant women, who have not been diabetic before, but have high blood sugar levels during pregnancy are said to have gestational diabetes (GD). Normally, the disease affects women quite late in her pregnancy, around the 24th week. The disease does not show noticeable signs or symptoms. In some cases however, gestational diabetes may cause excessive thirst or increased urination. During pregnancy, body produces a number of hormones (chemicals), such as oestrogen, progesterone and human placental lactogen. These hormones make body insulin-resistant, which means cells respond less well to insulin and the level of glucose in blood remains high. The purpose of this hormonal effect is to allow the extra glucose and nutrients in blood to pass to the foetus so it can grow. In order to cope with the increased amount of glucose in blood, body should produce more insulin. However, some women can not produce enough insulin in pregnancy to transport the glucose into the cells, or their body cells are more resistant to insulin. Diabetes in pregnancy is associated with risks to the woman and developing fetus. A number of complications are also common in babies born to women with pre-existing diabetes (NICE, 2008). Pregnant and lactating women are recognized as vulnerable group from the health and nutritional point of view and requires additional nutritional supports. It is well known that the nutritional status of mother prior to and during pregnancy has a strong impact on the reproductive performance and on the health of both mother and the child. During adolescence, iron deficiency anemia not only reduce work productivity, also leads to complications of pregnancy. In the absence of adequate nutrition, the development of the foetus takes place at the expense of the mother. Nutrition is considered as one of the major factors in determining the future well-being of a child (Shobeiri and Begum, 2005; Vasanthamani and Devi, 2009; Kalpana and Habeeba, 2013). Keeping this in view the present study was undertaken with the specific objective of studying the impact of nutrition counselling on the food and nutrient adequacy of the gestational diabetics.

MATERIALS AND METHODS

A sample of 60 patients suffering from gestational diabetes in the age group of 40 to 60 years were selected from Dayanand Medical College and Hospital and other local hospitals of Ludhiana city and were equally divided into two groups viz., experimental (E) and control (C). Nutrition counselling was imparted to group E, while group C was not given any counselling. Dietary intake was recorded for three consecutive days by using "24 hour recall method" using standardized containers before and after nutrition counselling. The average daily nutrient intake was calculated using Michigan State University (MSU) Nutriguide Computer

Programme (Song *et al.* 1992). The nutrient intake was compared with recommended dietary allowances by ICMR (2010) and per cent adequacy of the various foods and nutrients were calculated before and after nutrition counselling. Anthropometric parameters, height, weight, mid upper arm circumference (MUAC), triceps skin fold thickness (TSFT) and waist hip ratio were recorded before and after nutrition counselling using standard methods of Jelliffe (1966). Based on the measurements, body mass index (BMI) was calculated. Nutrition counselling was imparted for the period of 3 months at every 15 days interval regarding gestational diabetes, its signs and symptoms, causes, risk factors, complications, management, dietary management and importance of exercise. Booklet containing all the above mentioned information along with food exchange lists and weekly sample menu were distributed among all the clients (experimental people). Special emphasis was given to make them aware of balanced diet, increased consumption of fibrous foods such as fruits with peels, vegetables, whole grains and pulses and increased physical activity.

RESULTS AND DISCUSSION

Study revealed that the 70 and 83.3 per cent of the subjects were in the age group of 20 to 30 years, while 30 and 16.7 per cent were in the age group of 31 to 40 years in group E and C respectively (Table 1). It was found that majority of subjects, i.e., 56.6 per cent belonged to Hindu religion, 36.7 to Sikh religion and only 6.7 per cent to Muslim religion in group E. However, in group C these were 43.3, 53.3 and 3.4 per cent. The 10 per cent of the subjects were studied up to high school in group E and none in group C, while the subjects belong to higher secondary, graduate post graduate in group E and C were 13.3 and 13.3, 36.7 and 36.7 and 40 and 50 per cent. Majority of subjects belonged to joint families (83.3 & 76.7%). Percentage of subjects belonged to nuclear families, were 16.7 and 23.3 per cent (Table 1). Further, it was observed that 16.7 and 23.3 per cent of the subjects belonged to families having 2 to 4 members, whereas 66.6 and 66.7 per cent were in the category of 4 to 8 members in group E and C, respectively. Rest of the subjects, i.e., 16.7 and 10 per cent had more than eight members in their families in the groups E and C.

Table 1. General information about experimental people (subjects)

Parameter	Group E (n=30)	Group C (n=30)
Age:		
20-30	21 (70)	25 (83.3)
31-40	9 (30)	5 (16.7)
Religion:		
Hindu	17 (56.6)	13 (43.3)
Sikh	11 (36.7)	16 (53.3)
Muslim	2 (6.7)	1(3.4)
Education:		
High school	3 (10)	-
Higher secondary	4 (13.3)	4 (13.3)
Graduate	11 (36.7)	11 (36.7)
Post graduate	12 (40)	15 (50)
Family type:		
Nuclear	5 (16.7)	7 (23.3)
Joint	25 (83.3)	23 (76.7)
Family size:		
2-4	5 (16.7)	7 (23.3)
4-8	20 (66.6)	20 (66.7)
>8	5 (16.7)	3 (10)

Figures in parenthesis are percentage, n = number of subjects in each group.

Diabetic information

Majority of the subjects, 93.3 and 90 per cent had family history of diabetes and only 6.7 and 10 per cent not had family history of diabetes in group E and C. Mothers of 42.9 and 37 per cent were found suffering from diabetes, whereas this percentage was nil and 14.81 in case of father in group E and C. Similarly, grandparents (21.4 & 25.9%), mother-in-law (14.3 & 11.1%), father-in-law (3.6 & nil) and grandparents-in-law (17.9 & 11.10%) were suffering from diabetes in groups E and C (Table 2). Findings revealed that

Table 2. Family history of diabetes of the subjects (experimental people).

Particular	Group E (n=30)	Group C (n=30)
Family history:		
Yes	28 (93.3)	27 (90)
No	2 (6.7)	3 (10)
If, yes then		
Mother	12 (42.9)	10 (37)
Father	-	4 (14.8)
Grand parents	6 (21.4)	7 (25.9)
Mother-in-law	4 (14.3)	3 (11.1)
Father-in-law	1 (3.6)	-
Grand parents-in-law	5 (17.9)	3 (11.1)
Disease diagnosed:		
5^{th} month	20 (66.7)	22 (73.3)
6^{th} month	10 (33.3)	8 (26.7)
Medicines:		
Yes	-	-
No	30 (100)	30 (100)

Figures in parenthesis are percentage, n = number of subjects in each group.

66.7 and 73.3 per cent of the subjects diagnosed disease in 5th month while 33.3 and 26.7 per cent in 6th month. All the patients were on diet control, i.e., cent per cent patient were not taking any medicine for gestational diabetes.

Food intake

The adequacy of cereals in group E and C was 65.2 and 68 g and 79 and 72.5 g before and after nutrition counselling. Majority of the subjects included broken wheat and whole wheat flour to their diets. Increase of whole cereal intake could be due to effect of nutrition education given to group E about the ill effects on the health by consumption of refined cereals. The adequacy of pulses of group E and C was 65.9 and 65.6 and 73.9 and 69.3 g before and after nutrition counselling (Table 3). The subjects were taught about the importance of protein and sprouting. The green leafy vegetables intake adequacy was only 60.3 and 61.9 and 90.7 and 65.3 g before and after nutrition counselling. The subjects were educated to increase intake of spinach and asparagus as they are good source of beta carotene and fiber. The low intake could be due to the lack of knowledge about the green leafy vegetables as a cheap and best source of vitamins, minerals and fiber. The intake adequacy in case of roots and tubers, vegetables in group E and C were 82.2 and 76.2 and 30.7 and 75.4 g, whereas these were 66.4 and 72.3 and 83.7 and 74.3 g before and after nutrition counselling (Table 3). During nutrition counselling sessions, the subjects were advised to increase the intake of other vegetables like pumpkin, turnip, bottle guard, ash guard and beans, which are high in fiber and results in more satiety. The fruit consumption by group E and C was 50 and 54.7 and 97.7 and 70 g before and after counselling. Subjects were taught about the importance of fruits, as these are good source of vitamins and minerals, necessary for good health. Milk was consumed in the form of tea, curd, buttermilk and paneer. Milk and milk products intake were 78.1 and 81.4 and 98.1 and 83.9 ml in group E and C before and after nutrition counselling.

The intake of fats and oils was 120.2 and 126.6 and 93.7 and 128.6 g before and after nutrition counselling in group E and C (Table 3). Similarly, the adequacy of sugar and jaggery was 110 and 85.4 and 50 and 76.4 g (Table 3). During nutrition counselling sessions, the subjects were taught to reduce the intake of sugar as it resulted in overweight, obesity, diabetes, hypertension etc. Subjects were also taught to avoid soft drinks and squashes because they contain huge amount of sugar.

Nutrients intake

The adequacy of energy was 68.21 and 68.91 and 75.77 and 71.11 kcal in group E and C before and after nutrition counselling, whereas the adequacy of protein was 64 and 65.3 and 73.8 and 65.3 g (Table 4). Before nutrition counselling the intake of protein was less as compared to ICMR (2010) in both the groups, possibly due to the vegetarian dietary habits of the subjects. Goyal (2003) reported a deficient protein intake (46.5 g) among adult Punjabi women. Deepti *et al.* (2006) also reported a low protein intake, i.e., 40.7 g among

Table 3. Adequacy of food intake of the subjects before and after nutrition counselling

Food group	Group E (n=30)		Group C (n=30)	
	Before	After	Before	After
Cereals (g)	65.2	79	68	72.5
Pulses (g)	65.9	73.9	65.6	69.3
Green leafy vegetables (g)	60.3	90.7	61.9	65.3
Roots and tubers (g)	82.2	30.7	76.2	75.4
Other vegetables (g)	66.4	83.7	72.3	74.3
Fruits (g)	50	97.7	54.7	70
Milk and milk products (ml)	78.1	98.1	81.4	83.9
Fats and oils (g)	120.2	93.7	126.6	128.6
Sugar and jaggery (g)	110	50	85.4	76.4

Table 4. Adequacy of nutrient intake of the subjects before and after nutrition counselling

	Group E (n=30)		Group C (n=30)	
Nutrient	Before	After	Before	After
Energy (kcal)	68.2	75.8	68.9	71.1
Protein (g)	64	73.8	65.3	67.7
Total fat (g)	167	117	168.7	151.8

Indian women. The per cent adequacy of fats decreased from 167 to 117 g in group E, while in group C, adequacy decreased from 168.7 to 151.8 g (Table 4). The subjects of group E and C were ignorant about the ill effects of more fat intake during gestational diabetes, but during counselling sessions, the subjects of group E reduced fat intake in their daily dietaries.

Vitamins intake

The adequacy of thiamine intake was 83.3 and 93.3 and 116.7 and 98.3 mg before and after nutrition counselling in group E and C, respectively, whereas riboflavin was 65.8 and 63.6 and 85.7 and 75 mg (Table 5). The niacin intake in group E and C was 61.85 and 58.14 and 71.36 and 64.42 mg before and after counselling. According to Bruso (2013) niacin deficiency is also a concern during pregnancy and it is relatively common. The adequacy of pyridoxine was 56 and 52 and 72 and 56 mg before and after counselling in group E and C, while in case of vitamin B12 it was 63.3 and 65 and 84.2 and 76.7 µg. The intake of â-carotene was 60.3 and 62.6 and 82.4 and 65.9 µg before and after counselling (Table 5). During nutrition counselling the subjects of group E were taught to increase intake of â-carotene, as it is rich in antioxidants and found in many fruits and vegetables and good for health. The folic acid intake was 34.9 and 36.4 and 45.1 and 38.3 µg. The increase in folic acid intake could be due to increased intake of cereals. All the patients were taking folic acid supplement, as prescribed by the doctor.

Mineral intake

The adequacy of intake of minerals are given in Table 6. The adequacy of calcium was 75 and 75.5 and 96.1 and 84.2 mg before and after counselling. The calcium intake was higher due to more consumption of milk and milk products. The adequacy of phosphorus was 73.8 and 74.2 and 95.2 and 84.2 mg. The high intake of phosphorus may be due to high intake of cereals, vegetables and milk and milk products. The adequacy of magnesium intake was 72.7 and 71.6 and 83.6 and 78.1 mg before and after nutrition counselling, while in case of iron it was 53.6 and 54.4 and 71.7 and 60 mg. Hwang *et al.* (2013) reported that iron is necessary for normal fetal growth and development and the physiological iron requirements during the second half of pregnancy, cannot be achieved by dietary iron only.

Anthropometric profile

The mean height of subjects was 157.7±3.3 and 158.2±3.1 cm in group E and C. Sohlberg *et al.* (2012) reported a short maternal stature and a high BMI increase risks of preeclampsia of all severities. Mean weight of subjects was 70.9±8.6 kg and 70.9 ±8.2 kg before nutrition counselling in group E and C, respectively (Table 7). The corresponding value after nutrition counselling were 75.9±9.3 kg, while in group C, it was 81.9±9.2. The results revealed that there was a gradual increase in body weight with the increase in pregnancy months. Mean body mass index of subjects

Table 5. Adequacy of vitamins intake of the subjects before and after nutrition counselling

Vitamin	Group E (n=30)		Group C (n=30)	
	Before	After	Before	After
Thiamine (mg)	83.3	116.7	93.3	98.3
Riboflavin (mg)	65.8	85.7	63.6	75.0
Niacin (mg)	61.9	71.4	58.1	64.4
Pyridoxin (mg)	56.0	72.0	52.0	56.0
Vitamin B12 (µg)	63.3	84.2	65	76.7
β- carotene (µg)	60.3	82.4	62.6	65.9
Vitamin E (mg)	50.0	80.0	51.2	61.2
Folic acid (µg)	34.9	45.1	36.4	38.3
Ascorbic acid (mg)	62.5	80.9	61.9	68.0

Table 6. Adequacy of minerals intake of the subjects before and after nutrition counselling

	Group E (n=30)		Group C (n=30)	
Mineral	Before	After	Before	After
Calcium (mg)	75.0	96.1	75.5	84.2
Phosphorous (mg)	73.8	95.2	74.2	84.2
Magnesium (mg)	72.7	83.6	71.6	78.1
Iron (mg)	53.6	71.7	54.4	60
Zinc (mg)	61.3	83.2	58.9	70.8

Table 7. Anthropometric parameters of the subjects before and after nutrition counselling

Variable	Group E (n=30)			Group C (n=30)		
	Before	After	Paired t-value	Before	After	Paired t-value
Height (cm)	157.7±3.3	157.7±3.3	-	158.2±3.1	158.2±3.1	-
Weight (kg)	70.9±8.6	75.9±9.3	1.72*	70.9±8.2	81.9±9.2	1.83 NS
BMI (kg m^{-2})	28.6±5.1	30.6±5.6	0.55**	28.7±4.7	31.9±4.7	0.75NS
MUAC (cm)	25.2±11.8	26.2±12.7	0.42**	25.5±12.8	29.5±12.7	0.89NS
TSFT (mm)	16.1±1.8	19.9±1.8	0.81**	19.6±1.7	20.6±1.9	0.97NS
WHR	1.3±0.1	1.9±0.1		0.8±0.1	1.2±0.1	0.15 NS

NS Non significant, *Significant at 1%, **Significant at 5%

increased from 28.6±5.1 to 30.6±5.6 kg m^{-2} in group E and 28.7±4.7 and 31.9±4.7 kg m^{-2} in group C after nutrition counselling. In the present study, the increase in body mass index after nutrition counselling in group E was due to increase in body weight in the last months of pregnancy. The mean values of MUAC was 25.2±11.8 and 25.5±12.8 cm before counselling in group E and C, while it was 26.2±12.7 and 29.5±12.7 cm in group E and C after counselling. The mean values of TSFT were 16.1±1.8 and 19.6±1.7 mm and 19.9±1.8 and 20.6±1.9 mm in group E and C before and after counselling (Table 7). The waist hip ratio before and after counselling was 1.3±0.1 and 0.8±0.1 and 1.9±0.1 and 1.2±0.1 in group E and C, respectively. Salem *et al.* (2011) reported women with increased WHRs were significantly more likely to give birth to macrosomic newborns.

The result of the present study suggest need to focus attention on nutrition counselling of gestational diabetics so as to facilitate the intake of increase amount of foods like whole cereals, pulses, sprouted pulses, fruits and vegetables and controlled intake of fried foods and sweets. Thus, it can be inferred from the study that the nutrition counselling can be an effective measure for brining favorable and significant changes in the nutritional status of gestational diabetics.

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Impact of supplementation of broccoli and nutrition counselling on dietary intake of non-insulin dependent diabetics

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ABSTRACT

Ninety non-insulin dependent diabetic male pateints in the age group of 40 to 60 years free from serious complications of diabetics were selected from the Ludhiana Mediways Hospital under the supervision of Diabetologist. Selection was based on their fasting and post prandial blood glucose level followed by blood pressure.The selected subjects were divided into three groups I, II and III, each group having thirty subjects each. The subjects of group I was given no treatment.The subjects of group II and III were given treatments. In the treatment, the subjects of group II and III were supplemented with 10 g of broccoli floret and leaf powder in form of *missi roti* for a period of 3 months along with nutrition counselling. Wheat and rice were the major cereals. Use of refined cereals was not common among subjects. It was observed that all the subjects consume cereal thrice a day in all groups. Group II (86.7%) and group III (56.7%) of the subjects were consuming green leafy vegetables once in a week. Pulses/legumes, roots and tubers, flesh foods, milk and milk products consumption pattern was decresed after nutrition intervention and fruits consumption was increased mostly once in a day in group II and III, as compared to group I.The mean daily food intake of cereals,pulses, milk and milk products, roots and tubers, meat/poultry, fats/oil, sugar/jaggery decreased significantly($p<0.01$) in the subjects of group II and III after the nutrition intervention. Mean daily intake of nutrients like carbohydrates, protein, fat, fiber, thiamine, riboflavin, niacin, calcium, phosphorus, magnesium decreased significantly ($p<0.01$) in the subjects of group II and III after the study and non- significantly ($p<0.01$) in the subjects of group I. A significant increase ($p<0.01$) was observed in vitamin C, iron and zinc intake by the subjects of group II and III.

Key words: Broccoli, supplementation, dietary intake, nutreints, vitamins, minerals.

Diabetes mellitus is one of the most common chronic diseases in nearly all countries, and continues to increase in numbers and significance, as changing lifestyles lead to reduced physical activity, and increased obesity. Estimates of the current and future burden of diabetes are important in order to allocate community and health resources and to emphasise the role of lifestyle and encourage measures to counteract trends for increasing prevalence. The complications related to diabetes pose a significant health care burden and a deterrent to overall quality of life. Cruciferous vegetables are an excellent dietary source of phytochemicals including glucosinolates and their by-products, phenolics and other antioxidants like vitamins C, K, etc., as well as dietary essential minerals (Jeffery *et al.* 2003; Finely *et al.* 2001). The breakdown products of the sulfur containing glucosinolates and isothiocyanates are the active principles in exhibiting the anticancer property at every stage (Vasanthi *et al.* 2009). Green leafy vegetables are a rich source of minerals. Fresh broccoli leaves are exceptionally rich source of vitamin, which is a powerful natural antioxidant and immune modulator. Patient counselling is an important task for achieving pharmaceutical care by providing medication related information orally or in written form to the patients or their representatives (Sigal *et al.* 2004). It should include an assessment of whether or not the information was received as intended and that the patient understands how to improve the therapeutic efficacy (Beardsley, 1997; Dooley *et al.* 1996). Several guidelines specify the points to be covered by the pharmacist while counselling the patients (Dooley *et al.* 1996; Adepu *et al.* 2007). Numerous clinical trials have established that lifestyle interventions can lower blood pressure or decrease the intake of antihypertensive medications (Mellen *et al.* 2004). Nutritional counselling forms an essential component in the management of diabetes. Broccoli is very low in calories, provides just 34 kcal per 100g. However, it is rich in dietary fiber, minerals, vitamins and anti-oxidants that have proven health benefits. Keeping in mind the beneficial effects of broccoli in the management of diabetes, this research problems is proposed to study effect of supplementation of broccoli floret and leaf powder and nutrition counselling on dietary intake pattern of non-insulin dependent diabetes.

MATERIALS AND METHODS

Material procurement and processing: The raw material, broccoli floret and leaves were procured from the vegetable farm of PAU, Ludhiana. These collected material thoroughly washed to remove unwanted material and dirt, cut in small pieces, blanched in boiling water for 10-15 sec and dried at room temperature for 1-2 hr by spreading on filter paper followed by drying in hot air oven at 40-50°C for 4-6 hrs. Dried floret and leaves were powdered.

Selection of subjects: Ninety non-insulin dependent diabetic male pateints in the age group of 40-60 yrs, free from serious complications of diabeties were selected from the Ludhiana Mediways Hospital under the Diabetologist. Selection was based on their fasting and post prandial blood glucose level followed by blood pressure.The selected subjects were divided into three groups, I, II and III, each group having thirty subjects.

Interviev schedule: An open ended preliminary interview schedule was drafted to elicit information pertaining to background, information regarding frequency of usage of various food stuffs, dietary intake, and physical activity etc. of the subjects. A multiple choice questionnaire was designed to test the knowledge regarding broccoli, diabetes and diet. Dietary intake of subjects was recorded for three consecutive days by 24 hours recall cum weightment method, using standarized containers, before and after the experimental period. The average daily nutrient intake of diet was calculated by using MSU nutriguide computer programme. (Song *et al.* 1992).

Feeding trials: The subjects of group I was given no treatment, while the subjects of group II and III were under treatments. In the treatment, the subjects of group II and III were supplemented with 10 g of broccoli floret and leaf powder in form of *missi roti* for a period of 3 months along with nutrition counselling.

Nutrition intervention: Along with supplementation, nutrition education was given for 3 months during supplementation at 15 days interval to the subjects of group II and III through individual and group contact. Subjects were imparted nutrition education regarding the disease, its symptoms, causes, complications and dietary modifications using appropriate charts, health benefits of broccoli, physical exercise and demonstrations by individual and group contact during the feeding trails.

Statistical analysis: The data on all the parameters was analysed statistically. The mean standard error,percentages, paired t-test and their statistical significance was ascertained using Statistical Package for Social Sciences (SPSS) version 16.0.

RESULTS AND DISCUSSION

Majority of the subjects belonged to sikh religion and had joint family size of 5-6 members (Table 1).The most common reason for diabetes among the selected subjects was obesity (Table 2). Obesity among the subjects was due to faulty eating habits, sedentary lifestyle and lack of physical exercise. The physical activity pattern of the subjects showed that majority of the subjects were not doing any kind of physical exercise. After nutrition intervention 73.3 and 76.7 per cent of the subjects in group II and III started some kind of physical exercise, while there was no change in group I (Table 3). Yaznik (2004) suggested that urban life style, including poor diet and sedentary habits promotes obesity,

Table 1. General information of the subjects selected for broccoli supplemented diet intake

Characteristic	Group I	Group II	Group III
Age (yrs)			
40-50	14(46.7)	17(56.7)	15(50.0)
50-60	16(53.3)	13(43.3)	15(50.0)
Religion			
Hindu	12(40.0)	16(53.3)	11(36.7)
Sikh	18(60.0)	14(46.7)	19(63.3)
Education			
Illiterate	1(3.3)	2(6.7)	2(6.7)
High School	22(73.3)	17(56.6)	21(70.0)
Higher Secondary	5(16.7)	3(10.0)	5(16.7)
Graduate	2(6.7)	8(26.7)	2(6.7)
Occupation			
Business	26(86.6)	20(66.7)	27(90.0)
Service	4(13.3)	10(33.3)	3(10.0)
Marital status			
Married	30(100.0)	30(100.0)	30(100.0)
Type of family			
Nuclear	10(33.3)	12(40.0)	8(26.7)
Joint	20(66.7)	18(60.0)	22(73.3)
Family size			
2-4	7(23.4)	10(33.4)	8(26.7)
5-6	18(60.0)	12(40.0)	20(66.7)
7-8	5(16.7)	8(26.7)	2(6.7)

Figures in parenthesis are percentage value

Table 2. Etiology of disease of the subjects selected for broccoli supplemented diet intake

Factors	Group I	Group II	Group III
Heredity	10(33.3)	12(40.0)	7(23.4)
Obesity	18(60.0)	15(50.0)	21(70.0)
Others	2(6.7)	3(10.0)	2(6.7)

Figures in parenthesis are percentage value

Table 3. Physical activity pattern of the subjects selected for broccoli supplemented diet intake

Life style	Group I		Group II		Group III	
	Before	After NI	Before	After NI	Before	After NI
Physical exercise:						
Yes	5(16.7)	6(20.0)	7(23.3)	22(73.3)	9(30.0)	23(76.7)
No	25(83.3)	24(80.0)	23(76.7)	8(26.7)	21(70.0)	7(23.3)
Type of exercise:						
Walking	4(13.3)	5(16.7)	5(16.7)	18(60.0)	7(16.7)	20(66.7)
Yoga	1(3.3)	1(3.3)	2(6.7)	2(6.7)	2(6.7)	3(10.0)
Sleeping pattern:						
Disturbed sleep (5-6 hrs)	18(60.0)	18(60.0)	19(63.3)	21(70.0)	20(66.7)	22(73.3)
Sound sleep (7-8 hrs)	12(40.0)	12(40.0)	11(36.7)	9(30.0)	10(33.3)	8(26.7)

Figures in parenthesis are percentage values, NI - nutrition intervention

insulin resistance and type II diabetes. Nearly 66 per cent of the subjects were going for walk daily, while 24 per cent were doing cycling and 10 per cent were doing yoga and walk. Both exercises have been reported to be beneficial for maintaining body weight and increases the quality of life (Stone *et al.* 2001). Two randomized trials each found that lifestyle interventions including 150 min week^{-1} of physical activity and diet-induced weight loss of 5–7 per cent reduced the risk of progression from impaired glucose tolerance (IGT) to type 2 diabetes by 58 per cent (Tuomilehto *et al.* 2001; Knowler *et al.* 2002). Therefore, there is firm and consistent evidence that programmes of increased physical activity and modest weight loss reduce the incidence of type 2 diabetes in individuals with IGT. Sixty per cent subject had income more than 30000 per month in group II and fifty per cent in group III. The per capita income was more than Rs. 7000 in case of 50 per cent subject of group II, while it was 46.7 per cent in case of group III (Table 4).

Table 4. Economic status of the subjects selected for broccoli supplemented diet intake

Economic status (Rs. month^{-1})	Group I	Group II	Group III
Family Income			
20000-25000	2(6.6)	2(6.6)	3(10.0)
25000-30000	12(40.0)	10(33.4)	12(40.0)
>30000	16(53.3)	18(60.0)	15(50.0)
Per capita income			
3000-5000	4(13.3)	6(20.0)	3(10.0)
5000-7000	9(30.0)	9(30.0)	13(43.3)
>7000	17(56.7)	15(50.0)	14(46.7)

Figures in parenthesis are percentage value

It was observed that all the subjects consume cereal thrice a day in all groups. Subjects of group II were consuming green leafy vegetables once in a week that was 86.7 per cent and and group III thrice in a week, i.e., 56.7 per cent after the study. Pulses/legumes, roots and tubers, flesh foods, milk and milk products consumption pattern was decresed after nutrition intervention and fruits consumption was increased mostly once in a day in group II and III, when compared to group I.The mean daily food intake of cereals, pulses, milk and milk products, roots and tubers, meat/ poultry, fats/oil, sugar/jaggery decreased significantly ($p<0.01$) in the subjects of group II and III after the nutrition intervention. The present study was in line with earlier report, where a significant decrease in cereal intake after three month of nutrition education noticed (Table 5). On the contrary, lower intake of cereals among NIDDM male and female were reported by Lee *et al.* (1998) and Vasanthamani and Savita (2001). The inadequate value of green leafy vegetables by NIDDM patients was reported by Vasanthamani and Savita 2001). Gupta (2003) has suggested less than 10 per cent intake of saturated fat for diabetics and ratio of monounsaturated to PUFA should be 1: 1 in diabetic diet. Shah and Garg (1996) reported that an increase in monounsaturated fatty acid has been suggested to improve both glycemic control and lipoprotein profile among patients with diabetes.

In the mean daily intake of nutrients, it was found that there was a significant decrease ($p<0.01$) in intake of energy by subjects of group II and III after nutrition intervention and a non-significant ($p<0.01$) decrease in the subjects of group I. Malek and Cakirogu (2013) revealed that the given education made a significant difference on the patients in receiving energy and the energy consumption in the first measurement was 2681, 80±1056, 11 kcal, while it

Table 5. Mean daily food intake of the subjects before and after nutrition intervention

Food group (g day^{-1})	Before (1)	After (2)	Change (%) (between 1 & 2)	Paired t-Value (between 1 & 2)	Suggested intake
Group I Control					
Cereals	307.10±0.11	306.17±0.20	0.3	0.81 NS	300*
Pulses	76.13±0.10	75.06±0.12	1.4	0.32 NS	70*
Green leafy vegetables	45.03±0.12	46.80±0.46	2.8	1.63 NS	200*
Other vegetables	56.23±0.96	57.26±0.13	1.8	0.91 NS	200*
Roots/Tubers	68.43±0.61	69.07±0.15	0.9	1.38 NS	100*
Fruits	53.83±0.13	54.96±0.18	2.0	2.30 NS	200*
Milk and Milk products	315.93±0.34	314.27±0.37	0.5	1.36 NS	400*
Meat/Poultry	48.23±1.70	47.16±1.90	2.2	1.86NS	30*
Fats/ Oils	36.06±0.28	35.03±0.35	2.8	2.47NS	25*
Sugar/Jaggery	35.50±0.31	34.30±0.20	3.3	2.12NS	NA
Group II (BFP+ NI)					
Cereals	310.13±0.97	284.23±1.46	8.1	10.37*	300*
Pulses	65.53±0.16	75.63±0.10	13.2	13.06*	70*
Green leafy vegetables	37.60±0.77	48.03±0.45	21.7	11.08*	200*
Other vegetables	74.86±1.77	110.80±0.75	32.0	19.72*	200*
Roots/Tubers	68.67±0.16	45.66±0.16	32.8	20.34*	100*
Fruits	62.03±1.01	77.93±0.28	20.3	11.14*	200*
Milk and Milk products	353.33±0.46	318.97±1.87	9.9	19.28*	400*
Meat/Poultry	48.10±1.87	45.03±1.36	6.3	12.56*	30*
Fats/ Oils	32.63±0.44	28.13±0.31	13.7	10.71*	25*
Sugar/Jaggery	34.03±0.18	28.20±0.70	17.1	7.8*	NA
Group III (BLP+NI)					
Cereals	308.77±1.34	274.97±1.20	10.9	19.18*	300*
Pulses	72.77±0.64	63.23±0.81	13.1	11.36*	70*
Green leafy vegetables	50.17±1.52	62.17±1.17	19.3	11.79*	200*
Other vegetables	91.27±1.10	126.73±1.52	28.0	17.79*	200*
Roots/Tubers	69.17±1.04	48.20±1.59	30.3	13.09*	100*
Fruits	66.60±0.80	82.30±1.03	19.1	11.36*	200*
Milk and Milk Products	351.60±1.41	333.90±1.32	5.0	9.26*	400*
Meat/Poultry	50.77±1.91	46.07±1.34	9.3	2.72*	30*
Fats/ Oils	38.16±0.36	32.67±0.35	14.4	10.30*	25*
Sugar/Jaggery	34.07±0.30	33.50±0.33	15.2	12.25*	NA

* Significant at 1%, NS – non-significant, BFP – broccoli floret powder, BLP- broccoli leaf powder, NI - nutrition intervention, NA - not applicable

decreased to 1508, 40±1508.40 kcal in the final measurement.There was a significant ($p<0.01$) reduction seen in the carbohydrates intake (Table 6) by the subjects in group II and III at the end of the study with maximum change of 5.2 per cent in subjects of group II followed by the subjects of group III (7.3%). DeCoste and Scott (2004) observed same with the diabetic patients, the complex carbohydrates that absorbed slowly are used, among the carbohydrates. Since the complex carbohydrates require more time for being absorbed, a slow and medium level increase is observed in glucose level of the blood. The diabetic patients are recommended to avoid from the simple carbohydrates and increase the complex carbohydrate intake. In a research, it was found that 86.7 per cent of the patients did not have

Table 6. Mean daily intake of nutrients of the subjects before and after nutrition intervention

Nutrient (g)	Before (1)	After (2)	% Change (between 1 & 2)	Paired t-Value (between 1 & 2)	Suggested intake
Group I (Control)					
Energy(Kcal)	1978.51±2.91	2001.30±2.59	1.1	1.97 NS	2000*
Carbohydrates	314.93±1.24	316.03±0.72	0.3	1.85 NS	328*
Protein	64.43±0.76	65.66±0.63	1.8	0.86 NS	64*
Total fat	51.23±0.63	52.76±0.55	2.8	1.34 NS	48*
Saturated fat	25.20±0.72	26.80±0.54	3.3	2.85*	20*
Unsaturated fat	26.03±0.59	25.90±0.57	0.4	1.84 NS	28*
Dietary fiber	51.23±0.81	50.03±0.80	2.3	3.42*	50*
Experimental					
Group II (BFP + NI)					
Energy(Kcal)	2326.59±4.30	2128.82±1.99	8.5	15.94*	2000*
Carbohydrates	342.53±1.13	324.63±0.63	5.2	13.03*	328*
Protein	74.36±0.50	66.56±0.50	10.4	13.77*	64*
Total fat	73.23±0.73	62.68±0.25	14.4	13.81*	48*
Saturated fat	41.56±0.67	37.76±0.47	10.0	5.14*	20*
Unsaturated fat	31.64±1.02	24.92±0.62	15.4	2.81*	28*
Dietary fiber	55.50±0.71	51.03±0.76	8.1	20.49*	50*
GroupIII(BLP +NI)					
Energy(Kcal)	2340.73±1.18	2119.9±3.55	9.4	17.55*	2000*
Carbohydrates	348.63±1.17	322.9±1.10	7.3	9.78*	328*
Protein	78.76±0.24	71.80±0.48	8.8	15.01*	64*
Total fat	70.13±0.20	60.10±0.42	14.3	6.85*	48*
Saturated fat	40.03±0.70	34.66±0.96	13.4	4.02*	20*
Unsaturated fat	30.13±0.96	25.59±0.71	15.0	3.65*	28*
Dietary fiber	57.07±0.99	52.27±0.95	8.4	12.02*	50*

* Significant at 1%, NS – non-significant, BFP – broccoli floret powder, BLP- broccoli leaf powder, NI - Nutrition intervention

knowledge about the food increasing the blood glucose level. It was found that there was 10.4 and 8.8 per cent reduction in the protein intake by the subjects in group II and III. The fat intake reduced by 14.4 and 14.3 in the subjects of group II and III. There was a significant decrease ($p<0.01$) in the fiber intake also in the subjects of group II and III. However, the intake value were still higher (Table 6, 7) than the suggested intake value in carbohydrates, protein, fat and fibre (Raguram *et al.* 2012). In this study, it was seen that there was a significant decrease in thiamine, riboflavin, niacin and folic acid vitamins after the study in the subjects of group II and III and a non-significant decrease in the subjects of group I. A significant increase was observed in vitamin C in the subjects of group II and III (Table 8). Mean daily intake of minerals like calcium, phosphorus, magnesium decreased significantly in the subjects of group II and III after the study and non- significantly in the group I. Significant increase was also observed in iron and zinc intake by the subjects of group II and III (Table 9).

It can be inferred from the study that diet consumed by male diabetic patients was adequate in cereals, milk, fats and oils and was marginally inadequate in pulses. However, intake of green leafy vegetables, fruits and other vegetables was inadequate leading to deficiency of vitamins and minerals like iron, zinc and vitamin B. Supplementation of broccoli floret and leaf powder along with nutrition counselling improved the nutritional food intake.

Table 7. Per cent contribution of carbohydrates, protein and fats to the total energy intake before and after nutrition

Nutrient (g)	Before	After	Raghuram *et al.* (2012)
Group I (Control)			
Energy(Kcal)	1978.51	2001.60	-
Carbohydrates	1259.72(63.1)	1264.12(63.1)	55-65
Protein	257.72(12.9)	262.61(13.1)	15-20
Total fat	461.07(23.4)	474.84(25.4)	20-25
Saturated fat	226.87(11.4)	241.2(12.04)	-
Unsaturated fat	234.27(11.8)	233.1(11.6)	-
Experimental			
Group II(BFP+NI)			
Energy(Kcal)	2326.59	2128.82	-
Carbohydrates	1370.12(58.7)	1298.52(60.9)	60-65
Protein	297.44(12.7)	266.2(12.4)	15-20
Total fat	659.07(28.4)	566.6(26.5)	20-25
Saturated fat	374.04 (16.0)	339.84(15.9)	-
Unsaturated fat	284.76(12.2)	224.28(10.5)	-
Group III(BLP+NI)			
Energy(Kcal)	2340.73	2119.98	-
Carbohydrates	1394.52(59.0)	1291.60(60.9)	60-65
Protein	315.04(13.4)	287.20(13.5)	15-20
Total fat	631.17(26.9)	540.90(25.5)	20-25
Saturated fat	360.27(15.3)	311.94(14.7)	-
Unsaturated fat	271.17(11.5)	230.31(10.8)	-

Figures in parenthesis are percentage, BFP – broccoli floret powder, BLP - Broccoli leaf powder, NI - Nutrition intervention

Table 8. Mean daily intake of vitamins of the subjects before and after broccoli intake and nutrition intervention

Vitamins (mg/«g day^{-1})	Before (1)	After (2)	Change (%) (between 1 & 2)	Paired t-Value (between 1 & 2)	Suggested intake
Group I (Control					
Thiamine	2.24±0.02	2.20±0.05	1.7	1.72 ^{NS}	1.2*
Riboflavin	1.82±0.05	1.77±0.07	2.7	0.82 ^{NS}	1.4*
Niacin	16.50±0.51	16.10±0.58	2.4	1.68 ^{NS}	16*
Folic acid (µg)	296.47±0.15	297.57±1.65	0.3	2.07 ^{NS}	200*
Vitamin C	36.73±0.71	37.06±0.69	0.8	1.0 ^{NS}	40*
Experimental GroupII (BFP+NI)					
Thiamine	2.19±0.02	1.71±0.09	21.9	6.47*	1.2*
Riboflavin	1.72±0.06	1.65±0.07	4.0	7.31*	1.4*
Niacin	17.66±0.48	16.70±0.52	5.4	1.46 ^{NS}	16*
Folic acid (µg)	250.67±0.66	230.60±0.85	8.0	10.50*	200*
Vitamin C	32.76±0.95	43.93±0.64	34.0	2.79*	40*
GroupIII (BLP+NI)					
Thiamine	2.23±0.09	1.74±0.05	21.9	4.29*	1.2*
Riboflavin	1.75±0.04	1.60±0.07	8.5	2.26*	1.4*
Niacin	18.36±0.61	17.33±0.45	5.6	1.60 ^{NS}	16*
Folic acid (µg)	288.53±0.95	269.80±0.94	6.4	15.18*	200*
Vitamin C	34.96±1.46	44.06±0.62	26.0	5.54*	40*

*Significant at 1%, NS – non-significant, BFP – broccoli floret powder, BLP- broccoli leaf powder, NI - Nutrition intervention

Table 9. Mean daily intake of minerals of the subjects before broccoli intake and nutrition intervention

Mineral (mg day^{-1})	Before (1)	After (2)	% Change (between 1 & 2)	Paired t-value (between 1 & 2)	Suggested intake (mg/day)
Group I Control					
Calcium	747.60±3.21	746.70±1.82	0.1	2.54*	600#
Phosphorus	1687.73±1.17	1670.20±3.83	1.0	2.82*	600#
Magnesium	451.03±1.15	447.30±1.86	0.8	6.84*	340#
Iron	18.10±0.52	17.90±0.54	1.1	1.79 NS	17#
Zinc	10.90±0.31	11.06±0.21	1.4	0.49 NS	12#
Experimental Group II (BFP+NI)					
Calcium	846.43±2.99	782.63±9.50	7.5	6.25*	600#
Phosphorus	1562.61±1.08	1420.4±2.38	9.1	15.33*	600#
Magnesium	559.27±1.01	509.03±1.05	8.9	14.54*	340#
Iron	22.00±0.65	26.36±0.81	19.8	4.51*	17#
Zinc	9.23±0.27	10.00±0.27	8.34	3.99*	12#
GroupIII (BLP+NI)					
Calcium	833.93±2.06	766.80±3.24	8.0	21.58*	600#
Phosphorus	1581.3±1.13	1442.8±2.32	8.7	12.26*	600#
Magnesium	488.40±1.04	450.13±1.02	7.8	14.15*	340#
Iron	20.56±0.14	24.10±0.38	17.2	9.53*	17#
Zinc	11.76±0.19	12.16±0.26	7.6	3.02*	12#

*Significant at 1%, NS – non-significant, BFP – broccoli floret powder BLP- broccoli leaf powder, NI - nutrition intervention

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Biochemical evaluation for nutritional characteristics of promising bhaderwahi rajmash (*Phaseolus vulgaris* L.) germplasms of Jammu and Kashmir

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ABSTRACT

An attempt was made to evaluate biochemical constituents of dry mature seeds of ten germplasm of Bhaderwahi Rajmash, which were collected from different altitudes/locations of Bhaderwah (J&K) during 2010-2011. Significant variations were observed in quality attributes viz. moisture, protein, crude fibre, starch, carbohydrates and ash ranging from 6.22 to 8.20, 14.78 to 24.66, 3.05 to 4.10, 40.18 to 49.61, 62.75 to 69.31 and 3.03 to 4.18 per cent, respectively. Genotypic rating indicated that germplasm collected from Chinta, Kansar, Thanalla, Nalthi and Manthla are superior germplasms, desired as multipurpose promising collections in further crop improvement programme.

Key words: Bhaderwahi rajmash, germplasm collection, nutritional parameters.

Pulses are the second most important food crops after cereals in India accounting for about one fifth of the total area under food grains and contribute to about one twelfth of the total food grain production. In India, from the total area of 1650 ha under pulses the production is 70000t (Anonymous, 2010). In Jammu and Kashmir, pulses are grown over an area of 0.27 lakh hectares with a production of 0.32 lakh MT. The total pulse area in J&K has witnessed a declining trend from 35570 ha in 1991-92 to 26750 ha in 2001-2002. The main cause of such decline has been the low yield of the existing varieties, non availability of high yielding varieties and its cultivation under low input system. Among the pulses, rajmash is one of the high potential pulse crops with a yielding potential of 18 to 20q ha^{-1}. Based on the archeological, historical, linguistic and botanical evidences, the origin and domestication of common bean (*Phaseolus vulgaris*) has been established in America (Gepts and Dpbouk, 1991). Dry common bean (*Phaseolus vulgaris* L) is a legume widely consumed throughout the world and it is recognised as the major source of dietary protein in many Latin-American and African countries (Papa *et al.* 2005). A large variability exists in common bean seeds, color and size are two important quality characteristics for the consumers. Seed size and weight depend on genetic variations, cultivar and environmental conditions. Rajmash, known by various names viz., French bean, rajma, field bean, kidney bean, pole bean etc. is a rich source of nutrients (Sangha *et al.* 1994). It is regarded as "Grain of Hope" as it is an important component of subsistence agriculture and feeds million people in tropics. It is a traditional temperate region crop. Its cultivation in India is mainly confined to northern hilly tracts of Jammu and Kashmir, Himachal Pradesh and Uttara Khand as a *kharif* crop and in some parts of Maharashtra, Andhra Pradesh, Western and Eastern Ghats and North eastern plain zone. It is a short duration non–traditional grain legume and one of the precious and highly relished pulse crops of North India and is considered as protein tablets. So an attempts are being made to augment pulse production technology so as to ensure availability of pulses, presently 40g $adult^{-1}$ day^{-1} to the tune of recommended 70g in the 21^{st} century. In this context rajmash (*Phaseolus vulgaris* L.) seems to hold promise especially in hill agriculture to meet out the challenges of under nutrition to much extent.

In Jammu & Kashmir, rajmash is widely grown in Doda (Bhaderwah, Gunadoh, Marmat), Udhampur (Ramnagar), Reasi (Gool, Sangladan), Kishtwar (Marwah and Dacchan), (Bani and Basoli) Kathua and some areas of Rajouri and Poonch districts in the temperate region of Jammu province. It is grown as sole crop as well as inter crop with maize in *kharif* in hills as well as in *rabi* season in plains. This crop owing to its ability to substantially tolerate to high attitude cold stress is viewed as potential source of protein and other nutrients for supplementary diet for hills in particular. Systematic information on biochemical charaterization of Bhaderwahi rajmash of Jammu and Kashmir is still scantly.

Bhadarwah is located at 32.98°N 75.72°E., it has an average elevation of 1,613 metres (5,295 feet), which is located on the foothills of middle Himalayas. The present study was therefore, undertaken to evaluate quality attributes of Bhaderwahi rajmash in order to identify nutritionally superior germplasms for their further multiple use in crop improvement.

MATERIALS AND METHODS

Seed samples of 10 rajmash local races/varieties/ germplasms were collected from different altitudes namely Kansar, Thannala, Gurakha, Chinta, Chirrala, Manthala, Nalthi, Halarian, Hamote and Bhalla in Bhaderwah area of Dist. Doda (J&K.) during the year 2010-2011. Dry mature seeds of rajmash germplasm were cleaned and freed of any extraneous substances and dried in an electric oven at 60 ± 5^0C. The oven dried samples were ground in a Willy mill to pass through 40-mesh sieve and stored in polythene bags. The samples were analysed for proximate principles namely moisture, crude protein, starch, total carbohydrates, crude fibre and ash.

The moisture content was measured by taking twenty grams of fresh seed and dried in an oven at 100-105°C for 3-4 hrs and cooled in desiccators. The process of heating and cooling was repeated till a constant weight was achieved (Gupta, 2007). The moisture content was calculated as following equation:

Moisture (%) =(initial weight - final weight) × 100/ weight of sample

To measure the protein content in rajmash, five grams of grinded sample was taken with 50 ml of 0.1 N NaOH and boiled for 30 min. The solution was cooled in room temperature and centrifuged at 1000 rpm. The supernatant was collected and total protein content was measured according to the method of (Lowry *et al.* 1951)**.**

The available carbohydrate content was determined by the following equation:

Carbohydrate (g 100g sample^{-1}) = 100 - [(moisture + fat + protein + ash + crude fibre) g 100g^{-1}] (Raghuramula, *et al*., 2003)

The crude fibre content was determined by taking ten grams of sample in a beaker with 200 ml of boiling 0.255 N H_2SO_4. The mixture was filtered through a muslin cloth and the residue washed with hot water till it was free from acid. The material was then transferred to the same beaker and added with 200 ml of boiling 0.313 N NaOH. It was then transferred to a gooch crucible, dried overnight at 105^0C and weighed (We) in an electric balance. The crucible was heated in a muffle furnace at 600^0C for 5-6 hours, cooled and weighed again (Wa). The difference in the weights (We - Wa) represents the weight of crude fibre.

Crude fibre (g 100g sample^{-1}) = [100 - (moisture + fat)] × (We-Wa)/Wt of sample (Gupta, 2007).

Starch was extracted in alcohol (80%) by following the procedure of A.O.A.C. (1970) and estimating the same in the test extract by following the phenol sulphuric acid method of (Dubois *et al.* 1956).

To measure total ash, one gram of the sample weighed in a crucible was placed on a clay pipe triangle and heated over a low flame till the whole material was completely charred, followed by heating in a muffle furnace for about 5-6 hours at 600°C. This was repeated till two same consecutive weights and the ash was almost white or greyish white in colour (Gupta, 2007). The entire data was analysed statistically by using analysis of variance as given by (Panse and Sukhatme, 1984).

RESULTS AND DISCUSSION

The data pertaining to the biochemical constituents of seeds of various germplasms of Bhaderwah area of Jammu and Kashmir are presented in Table 1. Significant variation in moisture content ranging from 6.22 to 8.20 per cent with its highest value in germplasm of Chinta (8.20%) followed by Kansar (7.25%) and Thanalla (7.23%) was noticed. The lowest value was found in Bhalla (6.22%). The variability among the mature seeds in regard to moisture content might be attributed to variable accumulation of photosynthates and other dietary constituents expressed in terms of gain in dry matter in the seeds (Gopalan *et al.* 1993).

The protein content of Bhaderwahi rajmash germplasm collections showed wide variability ranging from 24.66 to 14.78 per cent. The germplasm/collection of Chinta area showed highest value of protein (24.66%) followed by Kansar (23.25%) and Thanalla (22.52%). The lowest value of protein content was present in Bhalla (14.78%). Similar findings for protein content in rajmash germplasm have also been reported by (Samman, 1999). Germplasm from Thanalla gave the highest value for starch (49.61 %) followed by Chinta and Kansar (48.41% and 47.97%), while the germplasm from Gurakha showed minimum level of starch conc. (40.18%). The trend of variability on this aspect in the present study is in agreement with those reported by (Singh *et al.* 1996).

Status of dietary constituents such as carbohydrates in mature seeds of rajmash germplasm was observed to vary

Table 1. Proximate composition of dry mature seeds of Bhaderwahi Rajmash germplasm.

Location	Moisture (%)	Protein (%)	Starch (%)	Carbohydrate (%)	Crude fibre (%)	Ash (%)
Chinta	8.20	24.66	48.41	69.31	3.90	4.18
Kansar	7.25	23.25	47.97	68.97	4.10	4.12
Thanalla	7.23	22.52	49.61	68.53	3.82	3.92
Manthla	7.07	22.23	44.34	67.91	3.61	3.88
Dhara	6.96	21.36	43.11	67.32	3.31	3.82
Nalthi	6.95	20.91	43.06	66.90	3.28	3.80
Hanga	6.37	20.34	47.76	64.12	3.13	3.63
Hamote	6.50	20.60	41.84	62.75	3.16	3.69
Gurakha	6.28	19.74	40.18	66.53	3.11	3.57
Bhalla	6.22	14.78	45.61	67.42	3.05	3.03
CD (5%)	0.602	NS	0.820	0.595	0.066	0.327

significantly from maximum of 69.31 per cent in Chinta followed by Kansar and Thanalla (68.53 %) and lowest (62.75%) in Hamote collection, respectively. The maximum values with regard to crude fibre content were found in Kansar germplasm (4.10%) and Chinta (3.90%) and minimum from Bhalla area (3.05%). Researcher of different institute also reported similar findings in relation to crude fibre content of Rajmash in their study. Ash content varied significantly from 4.18 to 3.03 per cent. It is evident that ash content in germplasm collection from Chinta showed maximum value followed by Kansar 4.12 per cent and Thanalla 3.92 per cent. These findings were found more and less in agreement reported by other workers (Hsieh *et al*. 1992).

In the present findings the nutritional/biochemical composition of Bhaderwahi Rajmash, the collection from Chinta, Kansar, Thanalla, Manthlla and Nalthi showed superior concentration of protein, starch, carbohydrate, fibre as compared to Gurakha, Bhalla, Hamote etc. and can be used for further study for the improvement of crop. The range of variability in respect of nutritional quality attributes observed in the present investigation was due to cold and high temperature differences in the collection sites of germplasm of Bhaderwahi rajmash.

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Maturity indices in aonla (*Emblica officinalis* Gaertn.): Physical and biochemical attributes

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ABSTRACT

Fruits of different commercial cvs, NA-7, NA-10, Krishna and Chakaiya of aonla were evaluated to determine optimum maturity indices. The fruits were assessed for various physical, biochemical and chromacity attributes. In general, fruit weight, volume, pulp content and pulp-stone ratio increases, while specific gravity did not exhibit any specific trend to ascertain proper stage of harvest maturity. In addition, 'a' value (greenness) decreases, whereas yellowness index increases from initial to 5th stage of harvest maturity. Vitamin-C increased and tannic acid decreased continuously till final stage of harvest, but TSS increased only upto 3rd stage. Conclusively, it is inferred from the results that NA-10 and Krishna being early, attained optimum maturity after 95 days, while NA-7 and Chakaiya after 105 days of initial fruit growth, based on weight, yellowness index, glossy appearance, translucent skin with distinct stripes and maximum vitamin C content.

Key words: Aonla, chromacity value, maturity, physical, biochemical attributes, yellowness index.

Indian gooseberry or aonla (*Emblica officinalis* Gaertn.) is an important indigenous fruit crop of India. Botanically, fruit is a berry and its mesocarp, an edible portion. It is acrid, astringent, cooling, refrigerant, diuretic and has laxative value. The fruit is rich source of vitamin-C, pectin and tannin (Pathak *et al*. 2003). If, the fruits of aonla are not properly mature, tannic acid, vitamin-C and other constituents may not attain the optimum level and pose heavy post-harvest losses, including desiccation, browning of skin and prone to microbes, which resulted in poor shelf life with inferior quality. Maturity is influenced mainly by cultivars, climate, soil, cultural practices, canopy management and chemicals used. Scanty information are available on different aspects, i.e., shelf life (Nath *et al*. 1992; Singh *et al*. 2004; Singh *et al*.2005), plant growth regulators (Ram and Raja Rao, 1976; 1978; 1981) and vitamin C and tanin (Bajpai, 1969-71; Gupta *et al*. 2003) and limited information on maturity indices from semi arid and arid parts of India (Singh *et al*. 2004; Meghwal and Azam, 2004). However, maturity indices have also not been studied well in sub- tropical region. Thus, fixation of proper stage of harvest maturity is a prerequisite to obtain optimum size, quality with prolonged shelf life. Keeping these in view, the present work has been undertaken and results are reported.

MATERIALS AND METHODS

Individual fruits of different aonla cultivars, NA-7, NA-10, Krishna and Chakaiya were tagged at pea stage on 22nd September, to get fruits of uniform size and age. These fruits were harvested in the morning hours at five stages at an interval of 10 days, starting from 11th October. After harvesting, the fruits were washed, surface dried and divided into two sub-lots for physico-chemical analysis of fresh fruits. Average weight of ten fruits per replication of each cultivar in triplicate was recorded. Volume was measured by water displacement method and specific gravity was calculated by dividing the weight by volume of water displaced by fruits. The pulp and stone weighed separately, pulp-stone ratio and pulp per cent was calculated on the basis of fruit weight. The chromacity value, i.e., 'L', 'a', 'b' alongwith yellowness index (YI) were recorded using Color Flex Spectro Colorimeter (Hunter's lab, Reston, Virginia, USA) after standardization with standard white plates, L= 93.75, a= 0.91 and b= 0.33. The yellowness index (YI) was calculated as per formula YI= 71.53a + 178.82b / Lb (Singh *et al*. 2005). Aonla fruits were cut into small pieces and macerated to get homogeneous pulp for determination of its quality.. Total soluble solids were estimated with the help of hand refractometer (Erma, Japan 0-30%). Other attributes like acidity, vitamin C and tannic acid in fruit pulp were estimated as per method described by Ranganna (2000). The recorded data were subjected to statistical analysis by adopting complete randomized design (CRD) to test the level of significance (Panse and Sukhatme, 1976).

RESULTS AND DISCUSSION

Physical attributes

It is evident from the results that fruit growth in terms of weight increases consistently with advancement of growth

period (Table 1). The pattern of relative growth rate based on the initial weight of different cultivars of aonla and it increases from 1st to 2nd stage significantly at a faster rate in cv. Chakaiya followed by Krishna, NA-7 and NA-10. Subsequently, growth rate decreased gradually till the fruit reached at its final stage. Maximum fruit weight (26.11g) was attained by NA-10 followed by Krishna (25.16g) and NA-7 (24.10g). It was minimum 23.18g in Chakaiya. Initial accelerated increase in fruit weight may be due to more biogenesis of natural occurring growth substances like auxins, gibberellins, cytokinin and others (Ram and Raja Rao, 1976; 1978; 1981).

The trend of volume of the fruits is similar to the fruit weight (Table 1). It is obvious that volume of the fruit increased significantly till the last stage of harvest. Maximum volume was noted in NA-10 (24.53 ml) followed by Krishna (24.37 ml) and NA-7 (23.07ml), while it was minimum in Chakaiya (20.33ml). The volume of NA-10 and Krishna did not differ significantly.

Specific gravity of fruits varied due to maturity levels among different cultivars, which maintained always more than 1.0 (sinker) throughout growth period. However, it did not differ significantly with the stage of harvest. It is also observed (Table 1) that the specific gravity increased at the 2nd stage and further, it declined gradually with advancement of harvest maturity. The mean specific gravity was maximum (1.12) in Chakaiya due to larger size of stone followed by NA-10 (1.09), Krishna (1.08). It was minimum in NA-7 (1.06).

The pulp per cent increased in a linear order up to 4th

Table 1. Physical characters of different commercial aonla cvs at different stages of harvest.

Cultivars	Stage of harvest					Mean	CD at 5%
	1st	2nd	3rd	4th	5th		
Fruit weight (g):							
NA-7	18.03	20.01	22.28	23.12	24.10	21.51	cvs = 0.17
NA-10	20.91	22.89	24.87	26.10	26.11	26.11	stages= 0.19
Krishna	19.07	21.69	23.22	25.08	25.16	25.16	cvs x stages =0.38
Chakaiya	15.49	18.04	20.09	22.23	23.18	23.18	
Mean	18.49	20.66	22.61	24.13	24.64	-	
Fruit volume (ml):							
NA-7	16.73	19.00	20.83	22.33	23.07	20.39	cvs = 0.31
NA-10	19.07	20.17	22.67	24.50	24.53	22.19	stages = 0.35
Krishna	17.23	19.50	21.33	23.57	24.37	21.20	cvs x stages = 0.70
Chakaiya	14.87	16.27	18.17	19.33	20.33	17.79	
Mean	16.98	18.73	20.75	22.43	23.07	-	
Specific gravity:							
NA-7	1.08	1.05	1.07	1.04	1.04	1.06	cvs = 0.02
NA-10	1.10	1.14	1.10	1.07	1.06	1.09	stages = 0.02
Krishna	1.11	1.11	1.09	1.06	1.03	1.08	cvs x stages = 0.03
Chakaiya	1.07	1.11	1.11	1.15	1.14	1.12	
Mean	1.09	1.10	1.09	1.08	1.07	-	
Stone weight (g):							
NA-7	1.47	1.50	1.57	1.61	1.66	1.56	cvs = 0.02
NA-10	1.35	1.42	1.44	1.52	1.62	1.47	stages = 0.02
Krishna	1.54	1.63	1.66	1.71	1.75	1.66	cvs x stages = 0.05
Chakaiya	1.61	1.65	1.73	1.84	1.91	1.75	
Mean	1.49	1.55	1.60	1.70	1.74	-	
Pulp-stone ratio:							
NA-7	11.17	12.32	13.16	13.36	13.52	12.71	cvs = 0.17
NA-10	14.15	15.09	15.11	16.24	16.37	15.39	stages = 0.19
Krishna	11.36	12.28	13.02	13.36	13.61	12.73	cvs x stages = 0.39
Chakaiya	8.93	9.93	10.61	10.81	11.10	10.28	
Mean	11.40	12.40	12.98	13.44	13.65	-	

stage of fruit pulp growth. Among different cultivars of aonla, NA-10 exhibited maximum pulp content (24.58g) followed by Krishna (23.38g), NA-7 (22.44g) and minimum (21.24g) in Chakaiya after 5th stage of harvest maturity.

The stone weight also exhibited trend similar to fruit weight with advancement of harvest maturity (Table 1). Maximum average stone weight was noted in Chakaiya (1.75g) followed by Krishna (1.66g) and NA-7 (1.56g). The least stone weight (1.47g) was recorded in NA-10. It is interesting to note that relative contribution of stone weight showed a decreasing trend with advancement of growth period. Maximum pulp-stone ratio (16.37) was recorded in NA-10 and minimum (11.10) in Chakaiya. However; NA-7 and Krishna were at par with each other with regard to this character (Table 1).

Based on fruit and pulp weight, pulp-stone ratio was found highest in NA-10 and lowest in Chakaiya during fruit growth. The higher pulp per cent in NA-10, may be due to rapid accumulation of food material in pulp tissues with small stone size, governed by its genetic character. The variation in fruit weight and volume may be due to varied potency of cell division, enlargement and development of inter and intra cellular spaces in different cultivars of aonla. Results similar to present findings are reported earlier (Kalra 1988; Ghorai and Sethi, 1996; Mehta *et al*. 2002; Gupta *et al*. 2003; Singh *et al*. 2004) in aonla.

Chromacity value

The chromacity value in terms of 'L', 'a', 'b' and Yellowness Index (YI) also varied significantly due to cultivars and stages of harvest maturity. Among cultivars, maximum 'L' and 'b' values were recorded in NA-10 and minimum in Chakaiya. However, NA-7 and Krishna did not differ significantly as shown in Table 2. Fruit greenness in terms of 'a' value was maintained higher upto 3rd stage and further it decreased up to 5th stage. On an average, highest 'YI' value (72.73) was observed in Chakaiya and lowest (70.69) in Krishna (Table 2). Yellowness index increased consistently in linear order from 1st to 5th stage, which varied with cultivars and stages of fruit growth.

The decrease in greenness and simultaneously increase in YI values may be due to increased level of endogenous ethylene, which accelerates the chlorophyllase activity, resulted in disintegration of chlorophyll and consequent development of yellowness (carotenoids) at optimum stage of harvest. Reports similar to our results have also been cited by Singh *et al*. (2005). Ladaniya (2004) have also reported the same pattern in mature mosambi "sweet orange".

Biochemical parameters

Quality in terms of TSS, acidity, vitamin-C and tannin contents varied significantly due to cultivars and stages of harvest (Table 3). The TSS content increased invariably up

Table 2. Chromacity value of different commercial cultivars of aonla during fruit growth and maturity

Cultivars	Stage of harvest					Mean	CD at 5%
	1st	2nd	3rd	4th	5th		
'L' value:							
NA-7	48.58	45.87	43.86	45.61	44.21	45.62	cvs = 1.74
NA-10	51.44	47.40	46.33	46.29	44.69	47.23	stages = 1.94
Krishna	49.20	45.04	44.82	43.76	44.85	45.54	cvs x stages =3.88
Chakaiya	45.20	47.67	39.30	42.40	41.44	43.27	
Mean	48.67	46.50	43.60	44.52	43.80	-	
'b' value:							
NA-7	19.61	19.31	20.00	19.76	19.16	19.57	cvs = 16.44
NA-10	19.05	19.91	21.10	20.11	18.98	19.83	stages = 18.38
Krishna	18.55	18.26	18.59	20.17	19.15	19.02	cvs x stages = 36.75
Chakaiya	19.53	19.62	17.56	19.26	18.89	18.78	
Mean	18.93	19.37	19.31	19.83	19.13	-	
'YI' value:							
NA-7	68.83	71.70	72.13	74.84	75.47	72.59	cvs = 3.57
NA-10	62.70	71.07	72.58	75.23	76.78	71.67	stages = 3.99
Krishna	65.30	70.54	71.30	72.98	73.33	70.69	cvs x stages = 7.98
Chakaiya	69.24	69.90	70.06	71.99	72.48	72.73	
Mean	66.52	70.80	71.52	73.76	74.52	-	

Table 3. Biochemical attributes of different commercial aonla cultivars at different stages of harvest maturity.

Cultivars	Stage of harvest					Mean	CD at 5%
	1st	2nd	3rd	4th	5th		
TSS (%):							
NA-7	8.07	8.13	8.20	7.67	6.73	7.76	cvs = 0.10
NA-10	9.07	9.13	9.13	9.00	8.73	9.10	stages = 0.11
Krishna	10.0	10.07	10.13	8.27	8.13	9.45	cvs x stages = 0.23
Chakaiya	8.0	8.20	8.27	8.33	7.47	8.05	
Mean	8.79	8.88	8.93	8.32	7.77	-	
Acidity (%):							
NA-7	1.28	1.34	1.41	1.53	1.50	1.41	cvs = 0.008
NA-10	1.54	1.65	1.73	1.69	1.64	1.65	stages = 0.009
Krishna	1.34	1.40	1.52	1.58	1.53	1.47	cvs x stages = 0.018
Chakaiya	1.15	1.22	1.30	1.33	1.38	1.28	
Mean	1.33	1.40	1.49	1.53	1.51	-	
Vitamin-C (mg/100g):							
NA-7	121.40	165.99	210.89	255.99	302.02	211.26	cvs = 0.677
NA-10	149.27	214.52	279.41	344.03	408.99	279.24	stages = 0.757
Krishna	151.08	221.26	290.54	356.41	426.48	289.17	cvs x stages = 1.515
Chakaiya	146.17	202.34	257.66	313.54	368.77	257.70	
Mean	146.98	201.03	259.62	317.52	376.57		
Tannic acid (%):							
NA-7	6.18	5.06	4.28	3.21	2.38	4.22	cvs = 0.016
NA-10	5.13	4.40	3.03	2.62	1.76	3.39	stages = 0.018
Krishna	5.90	4.91	3.81	2.90	1.86	3.87	cvs x stages = 0.037
Chakaiya	6.30	5.10	4.83	3.78	2.53	4.51	
Mean	5.88	4.87	3.99	3.13	2.13	-	

to 3rd stage and decreased gradually till final harvest. On an average, highest TSS was noticed in Krishna (9.45%) followed by NA-10 (9.10%) and the lowest (7.76%) in NA-7. The decrease in TSS with advance stage of growth may be due to conversion of monosaccharides to polysaccharides (fiber development) and other ingredients. Similar findings have also been reported by earlier workers (Mehta *et al*. 2002; Gupta *et al*. 2003; Singh *et al*. 2004; Meghwal and Azam, 2004).

Acidity in terms of citric acid increased almost consistently till 4th stage and it declined later (Table 3). On an average, lower acidity was found in Chakaiya (1.28%) and highest (1.65%) in NA-10 followed by Krishna (1.47%) and NA-7 (1.41%). Variation in acidity in aonla fruits have also been reported earlier by (Kalra, 1988; Ghorai and Sethi, 1996; Mehta *et al*. 2002; Gupta *et al*. 2003; Meghwal and Azam, 2004). Initial increase in acidity might be due to higher synthesis of organic acids, it declined in advanced stages, which may be due to bioconversion of organic acids to sugars.

Vitamin C, a nutraceutical component of aonla also varied significantly by both cultivars and stages of harvest. Data indicated that vitamin-C content increased consistently in linear order with the advancement of harvest maturity (Table 3). Highest amount (426.48mg 100 g^{-1}) was noted in Krishna followed by 408.99mg, 368.80mg and 302.02 mg per 100g of edible portion in NA-10, Chakaiya and NA-7 at final harvest. Variation in vitamin C among cultivars has also been reported by others (Bajpai 1969-71; Kalra, 1988; Ghorai and Sethi 1996; Mehta *et al*. 2002; Gupta *et al*. 2003; Singh *et al*. 2004; Meghwal and Azam, 2004; Singh *et al*. 2005). The variation in vitamin-C content may be associated with inherited characters of aonla cultivars.

Tannic acid was found higher in early stages of fruit growth, which diminished with advanced maturity. Maximum tannin was determined in Chakaiya (4.51%) followed by NA-7, Krishna and NA-10 (4.22, 3.87 & 3.39%). The initial increase might be due to smaller size of fruits, which decreased consistently during advance stage, coupled with fast growth. The decreasing trend of tannin may also

be due to its dilution effect. Variations in tannic acid are in accordance with the findings of Ranjan *et al*. (1966), Ghorai and Sethi (1996) and Gupta *et al*. (2003).

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Journal of Eco-friendly Agriculture **10**(2): 212-214 : 2015 **SHORT COMMUNICATION**

Pesticide residues in unpolished, polished and parboiled rice in Bihar

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ABSTRACT

Studies were conducted to monitor the terminal residues in unpolished, poished and parboiled rice. Twenty rice samples were collected from different market of districts Muzaffarpur and Samastipur, Bihar during 2002. Each sample was tested in terms of unpolished, polished and parboiled form, for the presence of pesticide residues. HCH, DDT and endosulfan residues were found present in the rice samples. However, residues of all the pesticide were below their MRLs. Results also revealed that the parboiling of rice helps in reducing the contamination of pesticide residues to a great extent.

Key words : Pesticide residues, unpolished, polished, parboiled, rice, Bihar.

Rice *(Oryza sativa L.)* is a staple food of the Indian population and mainly consumed in the form of whole grain. Due to peculiar climatic conditions of the rice growing areas, such as high temperature coupled with high relative humidity, the crop is potentially prone to different insect pests. Many pesticides have been recommended on the crop but only a few have been tested for their residues in Bihar and results obtained are presented.

Rice samples (Approx 1.0 kg) were collected from markets of district Muzaffarpur and Samastipur and brought to the laboratory for pesticides residue analysis. A 15 g representative sample of grinded rice was extracted with 100 ml mixture of acetone and water (1:1, v/v) in a warring blended. The extract was transferred into a separating funnel, diluted with 150 ml aqueous solution of sodium chloride and the pesticides were partitioned into dichloromethane (2x100 ml). The dichloromethane layer was passed through anhydrous sodium sulphate. It was cleaned by passing through glass column (30 x 2 cm) packed with 10 g florisil, sandwiched between the layers of anhydrous sodium sulphate (2g). The cleaned extract was concentrated under reduced pressure and a desired final volume was make up in hexane for estimation of residues by GLC. The insecticide residues were analysed on a chemito 1000 gas liquid chromatograph equipped with 63Ni-electron capture detector (ECD) for organo-chlorines and synthetic pyrethroids and thermo ionic detector (TID) for organophosphates and a glass column (2 m x mm i.d.) packed with OV-101 (3%) on 80-100 mesh CHW (HP). The temperature (c) of column, injector and detector were 210, 220 and 270 for organochlorines and 260, 270 and 300 for synthetic pyrethroids and the flow rate of nitrogen carrier gas was 30 ml min^{-1}. For organophosphates, the temperature (c) were 200 (column), 250 (injector) and 260 (detector). The flow rate (ml min^{-1}) for nitrogen, hydrogen and air were 30, 4 and 65..

The recoveries of different pesticides from rice grain fortified at 0.5 and 1.0 mg kg^{-1} level was found in the range of 81-93 per cent. The results revealed that the main group of contaminant was the organochlorines. In unpolished rice residues of HCH ranged from 0.043 to 0.374 mg kg^{-1}. Similarly, residues of DDT ranged from 0.025 to 0.197 mg kg^{-1}. The residues of endosulfan ranged from 0.036 to 0.104 mg kg^{-1}. In polished rice residues of HCH ranged from 0.023 to 0.197, DDT from 0.010 to 0.093 and endosulfan from 0.018 to 0.067 mg kg^{-1}. In parboiled rice residues of HCH ranged from 0.015 to 0.160, DDT from 0.010 to 0.068 and endosulfan from 0.010 to 0.040 mg kg^{-1} (Table 1).

The results shows that in comparison to unpolished rice, pesticide residues in polished and parboiled rice were lower. HCH residues detected in all the twenty samples of rice (polished, unpolished & parboiled) and were in the range of 0.052-0.374 ppm. DDT residues (0.020-0.197 ppm) were detected in seventeen, while endosulfan (0.022-0.104 ppm) in fourteen samples (Table 2). Such studies were also conducted by Deka *et al.* (2004) and showed similar trend. All the insecticide residues were below their MRL values. The residues of organophosphates and synthetic pyrethroids were not found in analysed samples. The study clearly shows that the rice is safe from consumer's point of view, as residues of all the pesticide were below their MRLs.

Table 1. Residues(ppm) of organochlorine insecticides in rice collected from Muzaffarpur and Samastipur districts of Bihar

Sample No	α-HCH	β-HCH	γ-HCH	Σ-HCH	PP-DDE	PP-DDT	Σ -DDT	α - Endosulfan	β- Endosulfan	Σ- Endosulfan
Polished:										
1	0.033	0.054	0.061	0.148	0.015	0.045	0.060	ND	ND	ND
2	0.027	0.045	0.049	0.121	0.015	0.041	0.056	0.028	ND	0.028
3	0.043	ND	0.076	0.119	0.019	0.074	0.093	0.041	0.026	0.067
4	0.040	ND	0.072	0.112	0.026	0.052	0.078	0.046	0.018	0.064
5	0.023	0.120	0.054	0.197	0.010	0.034	0.044	0.022	ND	0.022
6	0.034	0.062	0.075	0.171	ND	0.020	0.020	0.050	ND	0.050
Unpolished:										
7	0.054	ND	0.166	0.220	0.094	0.056	0.150	ND	ND	ND
8	0.046	0.076	0.104	0.226	0.028	0.088	0.116	0.061	0.043	0.104
9	0.062	0.052	0.090	0.204	0.025	0.048	0.073	0.036	0.024	0.060
10	0.091	0.117	0.104	0.312	ND	0.119	0.119	0.092	ND	0.092
11	0.043	0.118	0.070	0.231	0.096	0.0101	0.197	0.060	0.040	0.100
12	0.053	0.225	0.096	0.374	ND	0.036	0.036	0.042	0.017	0.059
13	0.049	0.082	0.086	0.217	0.026	0.140	0.166	0.070	ND	0.070
14	0.050	0.098	0.077	0.225	ND	0.035	0.035	0.095	ND	0.095
Parboiled:										
15	0.015	0.051	0.037	0.103	0.011	ND	0.011	0.027	ND	0.027
16	ND	0.106	0.040	0.146	ND	ND	ND	ND	ND	ND
17	0.062	ND	0.098	0.160	0.022	0.046	0.068	ND	ND	ND
18	ND	ND	0.052	0.052	ND	ND	ND	ND	ND	ND
19	0.018	0.068	0.041	0.127	0.010	0.011	0.021	0.030	0.100	0.040
20	0.037	ND	0.113	0.150	ND	ND	ND	ND	ND	ND

ND= Not detected

Table 2. Monitoring of pesticides residue in rice samples collected from Muzaffarpur and Samastipr districts, Bihar

Sample type	Insecticide detected	Number of sample			Range of residues (ppm)
		Analysed	Contaminated	MRL	
Polished:					
	Σ-HCH	6	6 (100)*	Nil	0.112-0.197 (0.145)**
	Σ-DDT	6	6 (100)*	Nil	0.020-0.093 (0.058)**
	Σ -Endosulfan	6	5 (83.3)*	Nil	ND-0.067 (0.038)**
Unpolished:					
	Σ -HCH	8	8 (100)*	Nil	0.204-0.373 (0.251)**
	Σ -DDT	8	8 (100)*	Nil	0.035-0.197 (0.112)**
	Σ -Endosulfan	8	7 (87.5)*	Nil	ND-0.104 (0.072)
Parboiled:					
	Σ -HCH	6	6 (100)*	Nil	0.052-0.160 (0.123)**
	Σ -DDT	6	3 (50)*	Nil	ND-0.040 (0.011)**

* :Per cent contaminated, ** Mean

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