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Quantification of Greenhouse Gas Emission from Agroforestry Systems in Semi-arid Alfisols of India during Rainy Season

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Abstract: Studies on measuring CO_2, CH_4 and N_2O fluxes from five agroforestry systems *viz.,* teak, jatropha, pongamia, simaruba and leucaena were conducted at CRIDA, Hyderabad during June-August, 2013 in semi-arid alfisols. The fluxes were measured at weekly interval using closed static chamber technique and gas chromatography method. The highest mean soil CO_2 emission observed in jatropha (5644.11 kg $ha^{-1}yr^{-1}$), teak (4422.90 kg $ha^{-1}yr^{-1}$) and simaruba (4673.58 kg $ha^{-1}yr^{-1}$), whereas, lower values were recorded in pongamia (4575.28 kg $ha^{-1}yr^{-1}$) followed by leucaena (2556.94 kg $ha^{-1}yr^{-1}$). Observations regarding mean uptake in methane showed that in jatropha (8.57 kg $ha^{-1}yr^{-1}$) and Simaruba (7.37 kg $ha^{-1}yr^{-1}$) recorded higher values than pongamia (4.02 kg $ha^{-1}yr^{-1}$) and Teak (3.40 kg $ha^{-1}yr^{-1}$). The leucaena system (3.50 kg $ha^{-1}yr^{-1}$) was net emitter of methane as compared with other systems. Highest N_2O fluxes during measurement period were observed in simaruba (140.62 kg $ha^{-1}yr^{-1}$), leucaena (123.96 kg $ha^{-1}yr^{-1}$) and pongamia (76.26 kg $ha^{-1}yr^{-1}$). In present study, temperature was most limiting factors than soil moisture among all the agroforestry systems and produced better fit polynomial models with fluxes of gases. This study gives an idea of successive potential values of GHGs in agroforestry systems to compare with carbon sequestration abilities of these systems.

***Key Words*:** Agroforestry systems, Closed static chamber, Gas chromatography, GHGs flux, Soil temperature, Soil moisture

Global climate change is one of the most important issues of contemporary environmental safety. Climate change caused by rising levels of carbon dioxide (CO_2) and other greenhouse gases (CH_4 & N_2O) is recognized as a serious environmental issue of the twenty-first century. A scientific consensus has evolved that the emissions of greenhouse gases from anthropogenic activities had played a key role in elevating the global temperatures and affecting livelihood of people. Emission of greenhouse gases (GHGs) has become a matter of great concern because of the future projections of the global warming and related effects on biological life (Yadava, 2010). GHG emissions data are already needed for such varied purposes as guiding national planning for low-emissions development, generating and trading carbon credits, certifying sustainable agriculture practices, informing consumers choices with regard to reducing their carbon footprints, assessing product supply chains, and supporting farmers in adopting less carbon-intensive farming practices (Olander *et al.,* 2013), so country can manage emission by adopting successive steps.

Carbon dioxide emissions resulting from soil respiration and vegetation being 10-15 times greater than emissions of CO_2 from fossil fuels are the principal sources from which this gas enters in the atmosphere (Raich and Schlesinger, 1992). This takes in to account the production of CO_2 by the respiration of plant roots, microorganisms and the transport of gases in the soil from atmosphere. Methane is formed in soils by the microbial breakdown of organic compounds in strictly anaerobic conditions and at very low redox potential, in which soil contributes by 40 per cent of the total emission (Smith *et al.,* 2003). Two microbial processes, produces and consumes methane by methanogenesis and methyanotrops, respectively. Nitrous oxide is the third and most dangerous gas produced in soil mainly in the course of two contrasting microbial processes: nitrification (ammonium to nitrite and then to nitrate) and denitrification (nitrite to N_2O and ultimately to molecular nitrogen). Nitrification is an aerobic process but when the supply of O_2 is limited by diffusional constraints then nitrifying bacteria can use nitriteas, an electron acceptor and reduce it to NO and N_2O (Bollman and Conrad,1998).

Better information on GHG emissions and mitigation potential of the agroforestry systems is necessary to manage these emissions and identify responses that are consistent with food security, environmental safety and economic development priorities of individual countries. Agroforestry practices are said to be characterized by four "I" words which state that intentional, intensive, integrated, and interactive (Gold and Garrett, 2009). This complexness of agroforestry systems renders them significant sources of GHG emissions due to management practices such as tillage, burning, manuring, chemical fertilization, and frequent disturbance that can lead to emission of CO_2, CH_4, and N_2O from soils and vegetation to the atmosphere. Establishment and management of agroforestry systems incompatible with prevailing edaphic and climatic conditions can accelerate soil GHG emissions. Non-sustainable agroforestry systems are quickly degraded,

and woody and herbaceous crops can become significant GHG sources (Dixon *et al.,* 1995; Verchot *et al.,* 2008; Hergouaich *et al.,* 2012 and Dube *et al.,* 2013). Ruminant-based silvopastoral systems and rice paddy agri-silvicultural systems are well documented sources of CH_4, which significantly contribute to the global CH_4 budget. Presently most of the scientists emphasized on carbon sequestration potential of agroforestry but there are limited work related to GHG emission from agroforestry. However, extensive research is required to quantify GHG emission from agroforestry systems.

The proposed study is premised on the main objectives to focus on to quantify GHG emission from five agroforestry systems and to evaluate variation in the rate of GHG fluxes and its relationship with soil temperature and soil moisture in rainy season.

MATERIAL AND METHODS

Experimental site

This study was conducted in Hayathanagar Research Farm (HRF) of the Central Research Institute for Dryland Agriculture, Hyderabad. The HRF is located at $17^0$27'N latitude, $78^0$35' longitude with above mean sea level of 515m. The mean annual minimum and maximum temperature varies from 13.5° to 38.6°C and the mean annual rainfall is 755 mm. The experimental soil represented Alfisol soil order (Typic Haplustalf), with pH slightly acidic to neutral (6.4) and EC 0.085 dS m^{-1}. The soils were low in available nitrogen (145 kg ha^{-1}), medium in available phosphorus (13.0 kg P ha^{-1}) and available potassium (175 kg ha^{-1}). The five well developed agroforestry systems (Table 1) were selected for GHG emission study namely *Jatropha curcas* (rattanjot/jaflota), *Pongamia pinnata* (sukhchain), *Simaruba glauca* (simoruba), *Tectona grandis* (sagwan/teak) and *Leucaena leucocephala* (subabul). The study designed to quantify GHG emission from agroforestry systems during 15th June to 15th August, 2013 in rainy season.

Protocol for GHG determination

In the present study, the most widely used method of assessing surface-to-atmosphere GHG fluxes is the closed chamber (or enclosure) technique followed by Ali *et al.* (2006) and Hirano *et al.* (2009). CO_2, N_2O and CH_4 fluxes were measured with a static closed chamber technique (Verchot *et al.,* 1999; Hutchinson and Mosier, 1981 and Kumar *et al.,* 2012). Thus, the appropriate use of static closed chamber method requires an absolute minimum of three gas sub-samples to be taken during incubation and included in the calculation of each flux estimate. The box is prepared by using non-PVC material of 100 cm length, 50 cm height and 30 cm breadth. The adopted methodology is presented in following sections:

Chamber deployment

Anchor: Collars (Anchor) were inserted into the soil to a standardized depth of 8-10 cm to ensure the collection of trace gases in chamber without any diffusion. Anchors were placed in such a way that they adequately represent the system to be measured (placed in between the rows).

Gas Sampling: Gas samples of trace gases flux measurement were taken once a week during the rainy season (June–August) from closed chamber. The air inside the chamber was homogenized with a battery operated fan with an air displacement of 1.5 l min^{-1} during collection of gas samples from the field for proper mixing (homogenization) of gases inside the chamber. Gas samples were taken at 0, 15, 30, 45 and 60 min after chamber closure using 20 ml plastic syringes, and analyzed in the laboratory within 24 h (Zhang *et al.,* 2012). Gas samples were collected during mid-morning (9:00–10:00; 11.00-13.00 hrs local time) on each sampling date (Zhang *et al.,* 2012).

Gas Chromatography Analysis

The trace gases were analyzed by using Varian 450-GC based on gas chromatography principal. A Varian 450-GC based system was custom configured to analyze all three gases in one run in a matrix of atmospheric air containing water vapor. The gas analysis was done in Central laboratory of CRIDA, Hyderabad.

Calculation of flux

The fluxes of GHGs are calculated using the following equations (Pathak *et al.,* 2013).

The N_2O-N/CO_2-C fluxes from fields are expressed as µg m^{-2} h^{-1} using the following equation:

$$N_2O\text{-}N \text{ flux} = (?X \times EBV_{(STP)} \times 28 \times 10^3 \times 60) / (10^6 \times 22400 \times T \times A)$$

$$CO_2\text{-}C/CH_4\text{-}C \text{ flux} = (ÄX \times EBV_{(STP)} \times 12 \times 10^3 \times 60) / (10^6 \times 22400 \times T \times A)$$

Where, ?X = Difference in flux value between 60 min and 0 min (converted to ppb based on the standard N_2O/CO_2 values); $EBV_{(STP)}$ **=** Effective box volume at standard temperature and pressure; T = Flux time in min (15 or 30); A = Surface area occupied by the box in m^{-2} (length × breadth);

The Effective box volume (EBV) is calculated using the following equation:

$$EBV = Box\,[(H\text{-}h) \times L \times B] - V$$

Where, H = Box height (cm); h = Height of the water level in the groove of aluminum channel (cm); L = Box length (cm); B = Box breadth (cm); V = soil volume (mL) inside the box (above ground biomass only).

Soil Moisture and Temperature measurements

Soil moisture content (5-7 cm depth) and chamber temperature were measured using gravimetric method and thermometer, respectively during every gas sample collection. Soil temperature (5 cm) data recorded from Meteorological observatory at HRF.

Statistical analysis: The statistical analysis was performed using SPSS version 16.0 software. The relationships between GHG exchanges, soil temperature and soil moisture were examined using regression modeling techniques (second order polynomial regression/ quadratic equation). All comparison and correlation tests were carried out at the 0.05 level.

RESULTS AND DISCUSSION

Seasonality of soil CO_2 fluxes: The seasonality of soil CO_2 flux rates are presented in Fig. 1. Soil CO_2 flux rate varied considerably among the five agroforestry systems. During the study period, soil CO_2 flux varied from 45- 60 mg m^{-2} h^{-1} in Teak; 26.15-101.83 mg $m^{-2}h^{-1}$ in Jatropha; 19.03-147.10 mg $m^{-2}h^{-1}$ in Pongamia; 14.97-129.89 mg $m^{-2}h^{-1}$in Simaruba and 22.32-55.17 mg $m^{-2}h^{-1}$in Leucaena systems. The high variability in the measured CO_2 flux may be attributed to variability in soil properties in agroforestry systems. Carbon dioxide (CO_2) emissions resulting from respiration in soil and vegetation are the principal sources from which this gas enters the atmosphere, being 10–15 times greater than emissions of CO_2 from fossil fuels (Raich and Schlesinger, 1992). The result of this study is concomitant with the Haifang *et al.* (2011) in Eucalyptus plantation (132.6 mg $m^{-2}h^{-1}$); Acacia plantation (139 mg $m^{-2}h^{-1}$) and mixed plantation (94.0 mg $m^{-2}h^{-1}$).

Soil moisture and temperature are the most influencing factors for CO_2 fluxes from soil. In the present study, soil temperature varied from 24°C to 33°C and soil moisture from 1.2 % to 22.42%. In this study, regression analysis showed better relationship between soil temperature and soil CO_2 flux under agroforestry systems. The quadratic model produced a better fit for all the five systems (Fig. 2). The high correlation of soil temperature with CO_2 flux observed in Teak (R^2= 0.96) and Jatropha (R^2= 0.87) followed by Simaruba (R^2= 0.74), Leucaena (R^2= 0.87) and Pongamia (R^2= 0.87). Alvarez *et al.* (1995) indicates a relationship between soil temperature and soil CO_2 flux. Soil temperature was highly correlated with soil CO_2 ?ux, but soil moisture was not correlated with soil CO_2 ?ux. The poor relationship between soil moisture and soil CO_2 ?ux may be the result of relatively small seasonal range of soil moisture content. Teak (p= 0.04), Simaruba (p=0.068) and Leucaena (p=0.008) showed positive significant relationship with soil temperature at second order polynomial equation models. A positive relationship between CO_2 flux and soil temperature has been reported by many researchers (Acosta *et al.,* 2013 and Franzenluebbers *et al.,* 1995), although in warm, dry climates soil temperature effects are overruled by soil water content. Hence it has been proved that soil temperature is most limiting factor than moisture in the present study.

Seasonality of CH_4 fluxes : Weekly fluxes of methane observed in five agroforestry systems are shown in Fig 1. In this study, the uptake of methane by the soil was obtained in four systems *viz.* Teak, Jatropha, Simaruba and Pongamia. Highest mean uptake of methane was observed in Jatropha (8.57 kg $ha^{-1}yr^{-1}$) and Simaruba (7.37 kg $ha^{-1}yr^{-1}$) than Pongamia (4.02 kg $ha^{-1}yr^{-1}$) and Teak (3.40 kg $ha^{-1}yr^{-1}$). Most of the flux measurements showed that dry condition with high temperature and low moisture favors negative flux i.e. uptake of methane. The Leucaena system (3.50 kg $ha^{-1}yr^{-1}$) was net emitter of methane as compared with other systems. The ?uxes of CH_4 were generally low showing both uptake and emission. Methane measurements indicated a consistent net soil consumption of CH_4 in four systems. Negative fluxes represent uptake of gases by soil (Morishita *et al.,* 2004 and Yanai *et al.,* 2003). The mean uptake rate of methane in agroforestry plantation is similar/higher to that measured in other studies by Kumar *et al.,* (2012) and Merino *et al.* (2004). Verchot *et al.* (2008) reported that uptake of *Acacia mangium* and *Inga edulis* was ranges from 2.5-4.5 kg $ha^{-1}yr^{-1}$.

Soil-atmosphere CH_4 exchange is the result of simultaneously occurring production and consumption processes in soils, and is thus controlled by CH_4-producing methanogens operating at anaerobic conditions and CH_4-consuming methanotrophs that depend on oxygenas a terminal electron acceptor (Topp and Pattey, 1997). Merino *et al. (*2004) described that activity and population sizes of these microbes are dependent on a multitude of soil factors like soil temperature, moisture, pH, substrate availability and aeration of soil profile. In present study, lower methane uptake was observed in Pongamia and emission in Leucaena systems. N_2-?xing species are suspected to contribute to the increase of soil emissions of N_2O (Verchot *et al.,* 2008) and to the reduction of the soil CH_4 sink (Palm *et al.,* 2002), although to date results in the literature are contradictory.

Seasonality of N_2O fluxes : All five agroforestry systems have shown a pronounced seasonal variability for N_2O flux in Fig. 1. Mean weekly N_2O fluxes were low in Jatropha and Teak than Simaruba, Leucaena and Pongamia during the emission period (17th June to 1st August). Highest fluxes during measurement period were in Simaruba (140.62 kg $ha^{-1}yr^{-1}$), Leucaena (123.96 kg $ha^{-1}yr^{-1}$) and Pongamia (76.26 kg $ha^{-1}yr^{-1}$). Increased N availability generally leads to increased nitrous oxide emission (Firestone and Davidson, 1989) because this stimulates the microbial process of nitrification and denitrification, which produces the gas flux. When weekly fluxes were grouped in to seasonal period and then added to estimate annual N_2O fluxes, values ranging between 31.28 to 140 kg $ha^{-1}yr^{-1}$. Gas sampling time from 9.00 am to 11 am was driving great impact on N_2O emission (Alves *et al.,* 2012). During the study, some N_2O flux measurements occurred in negative values presented in Fig. 3. N_2O uptake seems to be stimulated by low availability of mineral N (Lardy *et al.,* 2007) which is the case for the studied soil, especially at the dates of occurring negative events. However, based on current knowledge, it is not yet possible to clearly de?ne a set of conditions promoting N_2O consumption (Lardy *et al.,* 2007; 2009). Similar result recorded by Lardy *et al.* (2009) which lends support to the current investigation.

The magnitude of fluxes largely depends on soil environmental conditions, with soil temperature and soil moisture, besides substrate availability, being major determinants (Luo *et al.,* 2013). For understanding relationship between environmental factors we tried different regressions models but quadratic model (second order

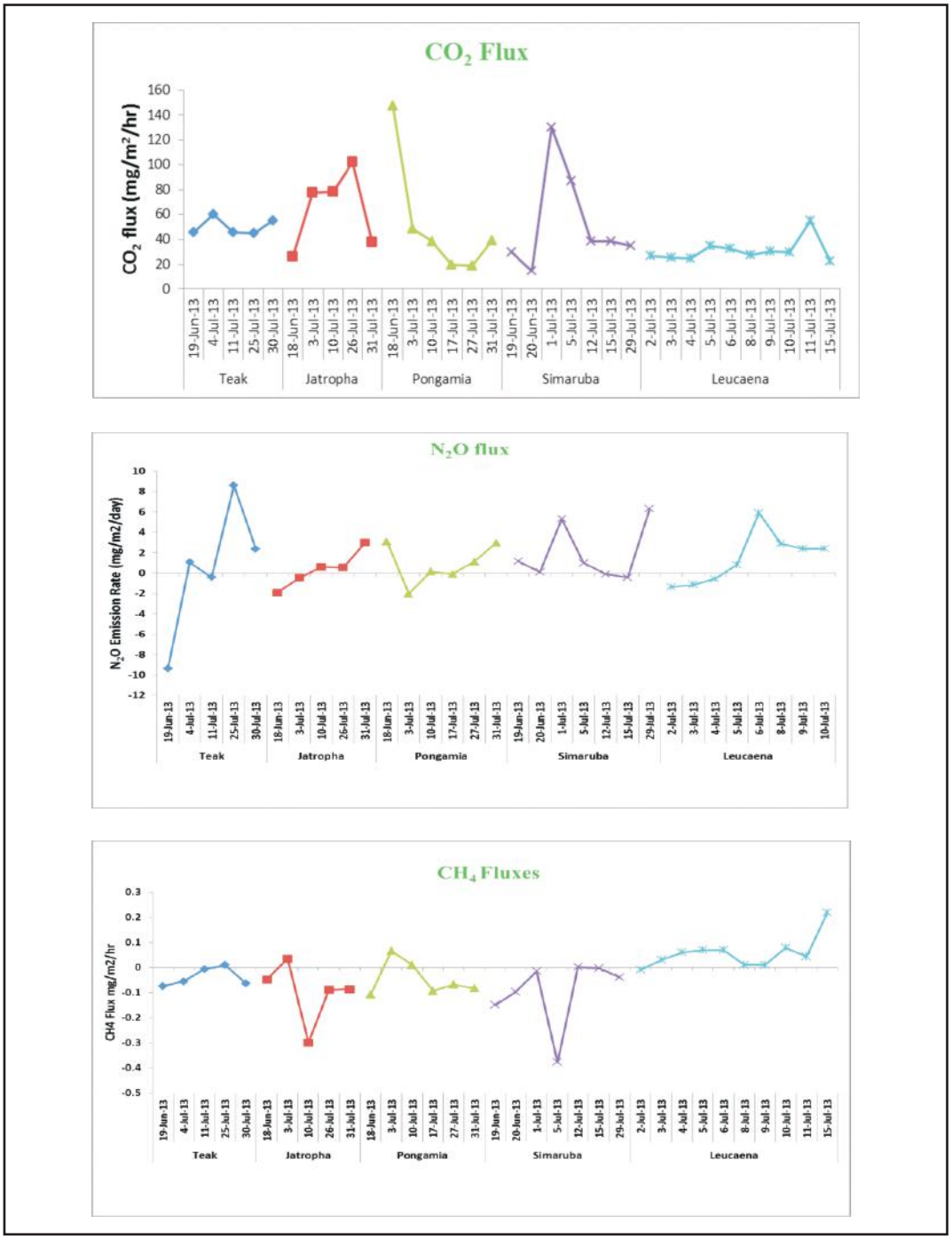

Fig. 1. Seasonal variation of soil CO_2, CH_4 and N_2O fluxes in agroforestry systems

polynomial equation) produced a better fit for the five systems with soil temperature and soil moisture (Fig. 3). The N_2O fluxes were second order polynomial equations positive non-significantly correlated with soil temperature in *Jatropha curcas* (R^2=0.79, p= 0.66) followed by *Simaruba gluaca* (R^2=0.48, p= 0.38), *Leucaena leucocephala* (R^2=0.41, p= 0.59) and negatively non-significant highly correlated in *Tectona grandis* (R^2=0.63, p= 0.62). Soil moisture also showed similar positive non-significant high to medium correlation in *Tectona grandis*, *Pongamia pinnata* and *Leucaena leucocephala* and negative non-significant medium to low correlation in *Jatropha curcas* and *Simaruba gluaca.* The controlling factors (temperature and soil moisture) expressing their impact on N_2O fluxes separately but in combination we observed very weak relationship was observed among them. This indicates that important

Table 1. Vegetation and soil characteristics of experimental material

Systems	Teak	Pongamia	Jatropha	Simaruba	Leucaena
Vegetation characteristics					
Age (Years)	19	8	4	10	4 (Coppice)
Spacing	,,,	5 × 5	2.5 × 2.5	6 × 6	1.5 × 2
Average height	10	2.9	2.3	4.23	7.8
Average dia.	20	8.46	17.5	16.47	16.5
Canopy Closure	60	50	80	65	40
Soil Characteristics					
Bulk Density	1.33	1.57	1.32	1.40	1.37
Soil type			Alfisol soil order		
Organic carbon	30.23	28.65	25.48	30.20	27.5

Table 2. Mean annual greenhouse gas flux of different agroforestry systems

Plantation	CO_2 Flux (kg $ha^{-1}yr^{-1}$)	CH_4 Flux (kg $ha^{-1}yr^{-1}$)	N_2O Flux (kg $ha^{-1}yr^{-1}$)
Tectona grandis	4422.90	-3.40	39.05
Jatropha curcas	5644.11	-8.57	31.28
Pongamia pinnata	4575.28	-4.02	76.26
Simaruba gluaca	4673.582	-7.37	140.62
Leucaena leucocephala	2556.94	3.50	123.96

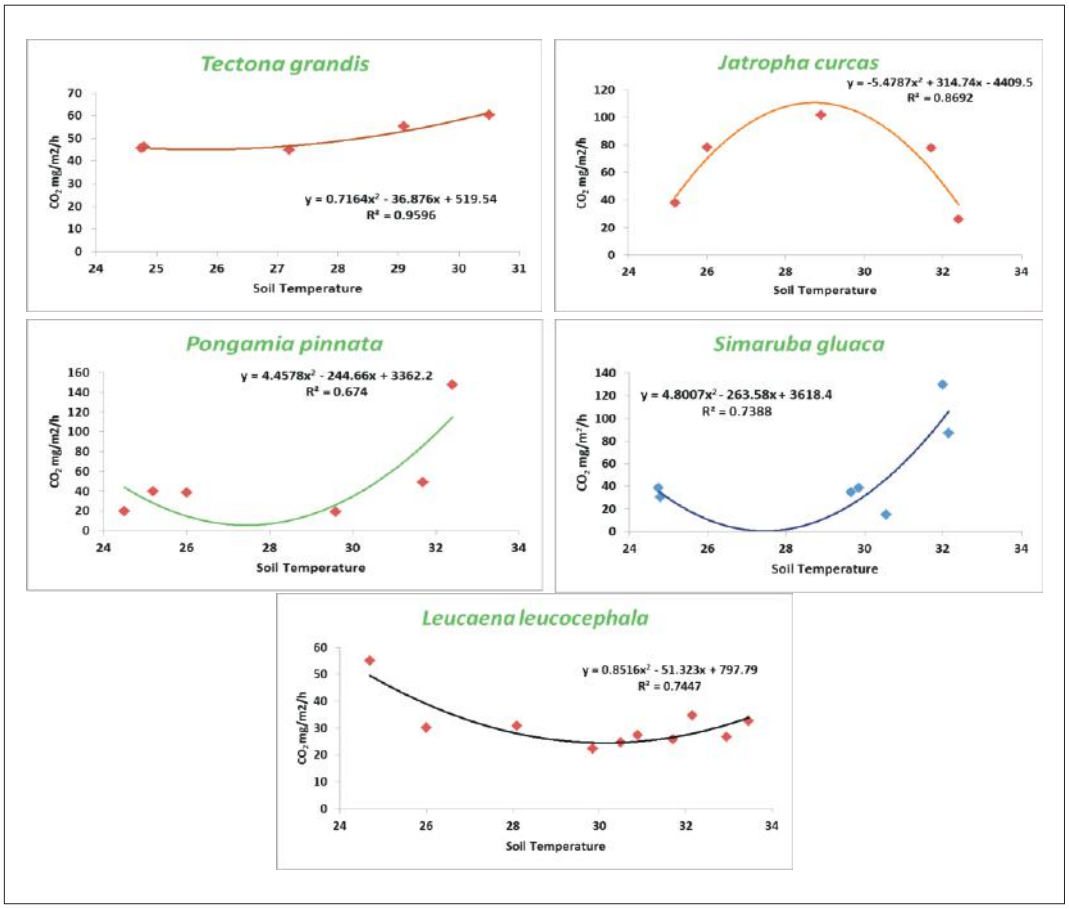

Fig. 2. Effect of soil temperature on soil CO_2 flux in agroforestry systems

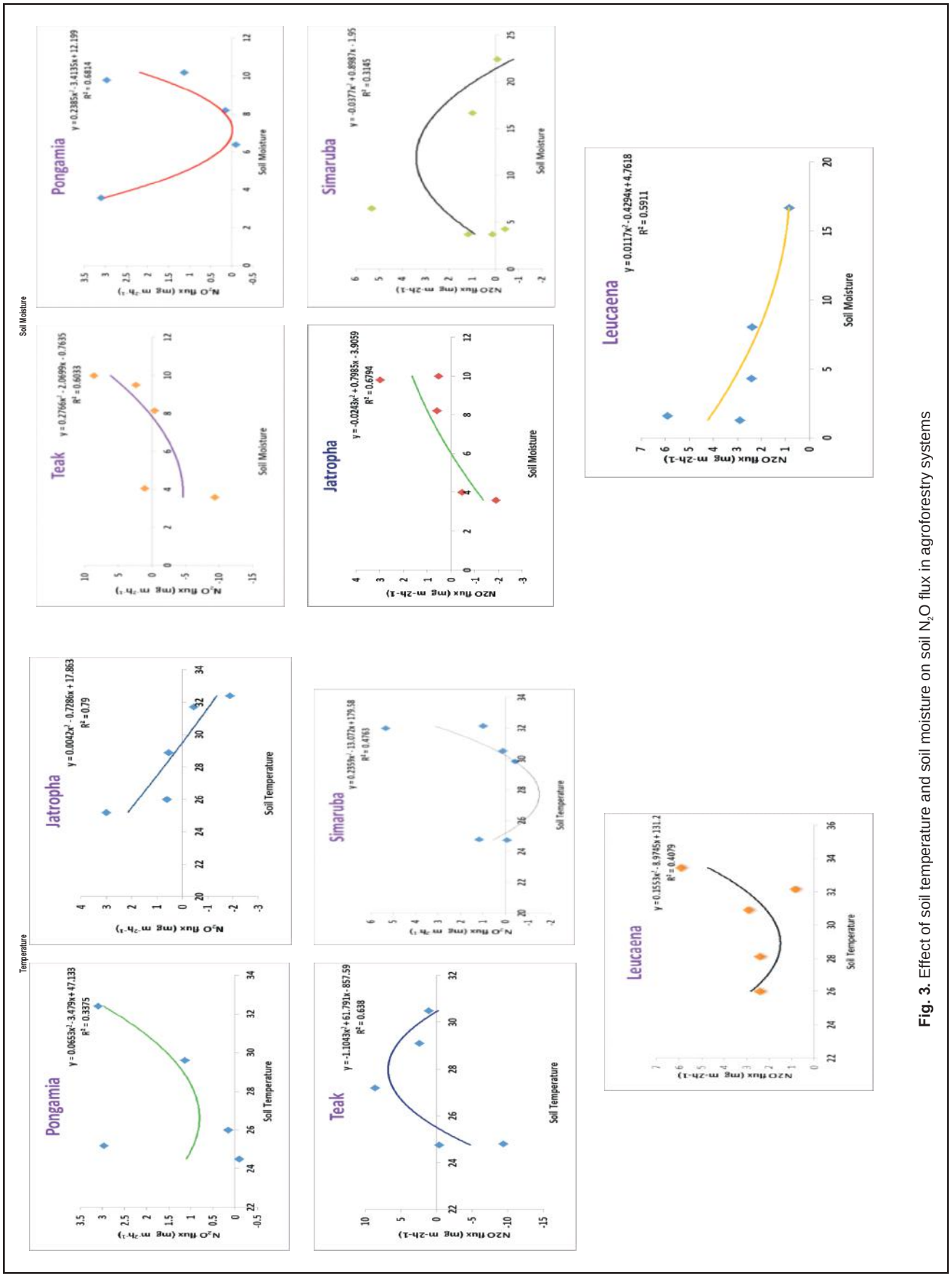

Fig. 3. Effect of soil temperature and soil moisture on soil N_2O flux in agroforestry systems

regulating factors such as moisture and temperature have both synergistic and antagonistic effect on status of other regulating factors (Luo *et al.,* 2013). Thus one cannot expect a simple relationship between them and the pattern in the rate of emission is associated with denitrification or nitrification in the soils. The graphs of correlation are presented here under to make proper understanding about relationship of soil temperature and soil moisture with N_2O flux in five agroforestry systems (Fig. 3).

Based on present short term study it is concluded that agroforestry systems could be the source of GHGs but it requires studies on net emission of agroforestry systems. All the five systems studied in the dryland region acted as a sources of these GHGs, with higher in rainy season. The type of species in agroforestry systems may exert impact on the emission of these gases and soil temperature formed second order polynomial relationship with fluxes. Due to fluctuations in the temperature and coarse textured soils can uptake more methane and showed that soil texture are the most important factor affecting balance of methane production and consumption. *Leucaena leucocephala* found low in soil CO_2 flux but high in methane and nitrous oxide. Furthermore, the results of this study show that the emissions of trace gases from different systems sites are highly variable and that temperature and moisture effects are prominent factors controlling the volume of emissions at a given site. Soil GHG fluxes have seasonal patterns, with maximum emission coinciding with period of active plant growth. Soil temperature and water content directly affect production and consumption of these greenhouse gases through their effects on metabolic activity of microorganisms and plants, soil aeration, substrate availability, and redistribution. However, it still needs to be noted that most of these estimates are based on low measuring frequencies, often not covering one season or total year, which introduces high uncertainty to the estimation of annual flux rated of greenhouse gases.

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Indigenous Ethnomedicines and Victuals of Malayans: An Indigenous Population of Peechi-Vazhani Wildlife Sanctuary, Western Ghats, India

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Abstract: An ethnobotanical study of the indigenous *Malayan* population of Peechi–Vazhani Wildlife sanctuary, Kerala revealed that they utilize 81 species of plants which included trees (29), herbs (15), climbers (16) and shrubs (21), distributed in 74 genera and 41 families. Drink or decoction made out of plant parts were observed as the most common mode of intake, while leaves were the common plant part used as medicine. Majority of the plants were used as anti-lacerative (11) and anti-diarrheal (10) agents. Despite rice continuing as their staple food, Malayan victuals included fruits (8 spp.), seeds (4 spp.), tubers and rhizomes (5 spp. each) and another 6 species used for their leaves. This study highlights the need for recording the local ecological knowledge of indigenous communities, which will help us formulate plans aimed at multiple-use-forestry.

Key Words: Ethnomedicine, Malayan tribes, Peechi –Vazhani, Traditional knowledge; Victuals, Western ghats, Wildlife sanctuary

The importance of traditional and local ecological knowledge in biodiversity conservation is reflected by Article 8(j) of the United Nations Convention on Biological Diversity (UNCBD), which states that the knowledge and practices of indigenous and local communities relevant for the conservation and sustainable use of biodiversity should be respected, preserved and applied [Anonymous, 1993]. Among nearly 45,000 plant species reported in India, about 7,000-8,000 species are considered medicinal and used by village communities, particularly tribal communities, or in traditional medicinal systems, such as the Ayurveda [Dubey *et al.,* 2004; Abu-Rabia., 2005]. Traditional medicinal plants are of interest now, as herbal preparations are increasingly being used in both human and animal healthcare systems [Offiah *et al.,* 2011; Elufioye *et al.,* 2012; Vikas *et al.,* 2014a]. The knowledge of plants and their uses is getting increasingly restricted to the older generation in these communities.

In Peechi-Vazahni Wildlife Sanctuary in Kerala state, India (Figure 1), resides the *Malayans* who are an indigenous group with a dark to dark brown complexion and short stature and have two sub-tribes, *Nattu Malayan* and the *Konga Malayan* [Encyclopaedia of Dravidian Tribes, 1996]. Several tribal welfare schemes have "modernized" the indigenous people resulting in the erosion of their indigenous knowledge which their ancestors had orally passed on through centuries. Considering the values of indigenous knowledge for a biodiversity rich nation like India, the present article attempts to document the traditional knowledge of the indigenous *Malayan* population residing inside the Peechi–Vazhani Wildlife Sanctuary, Kerela, India.

MATERIAL AND METHODS

The forest area of the 125 km^2 Peechi-Vazhani Wildlife Sanctuary (10^{0}26' N and 10^0 40' N longitudes 76^0 15' E and 76^0 28' N) has a dominant vegetation of moist deciduous species while the semi-evergreen species are confined to the higher reaches.

Malayans with a thorough knowledge of the therapeutics and ability to identify the plants were selected as key informants with the help of the tribal elders (> 45 years), who knew well about the surrounding cultivated and wild plants in forests, their local names, parts used, preparation of herbal medicine, mode of administration, dose and uses in different ailments and diseases. Likewise to document

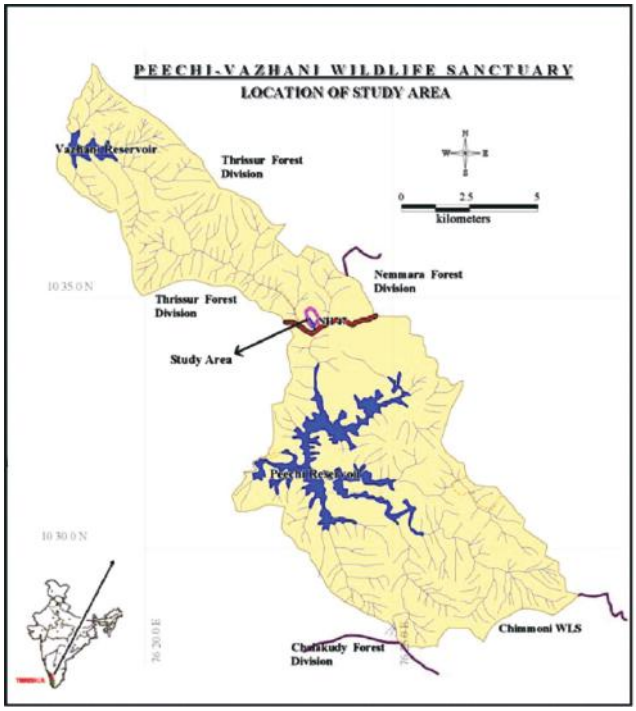

Fig. 1. Map showing the study site

detailed information on religious practices, members related with 'religious rituals' were separately approached. From the females, information regarding their diet and the different kinds of plants with food value was collected. The traditional healers or medicine men were approached by the help of local people after thorough rapport building and were interviewed informally in focused interviews with open ended questions. The interviews were focused on the most prevalent disorders among the folks as the chances of existence of a curative herbal formulation for a common or prevalent malady were always felt high. The compositions and disease specific nature of the formulations were cross checked with other respondents. The contact details of the respondents were also recorded for future need and reference. The disorder specific ethnomedicinal formulations collected during the years 2010-2013. Focus was held on collection of complete formulation for the treatment of a particular disorder rather than to record medicinal uses of a single plant and parts thereof. The local names of the plants were recorded. The plants were spot identified and later identification was done by using the Biodiversity Documentation for Kerala, Part 5 [Easa, 2003], Biodiversity documentation for Kerala, Part 6 [Sasidharan, 2004], The Flora of Kerala [Daniel, 2005], Flowering Plants of Kerala *[*Nayar *et al.,* 2006*],* Checklist of the bryophytes of Kerala, India [Manju *et al.,* 2008] and Flowering Plants of Kerala – Version *2.0*. DVD No. 14 [Sasidharan, 2012] and with the help of plant taxonomists.

RESULTS AND DISCUSSION

The present study revealed that Malayans use 81 plant species for treating and healing the diseases in their traditional way. Among these 81 species, there were trees (29 spp.), shrubs (21 spp.), climbers (16 spp.) and herbs (15 spp.) (Table 1-4). The 81 ethno-medicinally valuable plant species belonged to 74 genera and 41 families and included

Table 1. Ethno-medicinally important climbers used by Malayans

Sr. No.	Scientific name	Family	Uses
1	*Abrus precatorius* L.	Fabaceae	Decoction of dried seeds is taken ora lly to induce abortion and also used in tuber-culosis, painful swellings.
2	*Acacia torta* (Roxb.) Craib.	Mimosaceae	Bark is used for washing the hair. Seeds for cough, bronchitis and in the treatment of menstrual disorders.
3	*Aristolochia indica* L.	Aristolochiaceae	Fresh juice of the leaves is a popular antidote to snake poison. The leaves and bark are used in bowel complaints of children, diarrhoea and in intermittent fever.
4	*Asparagus racemosus* Willd	Lilliaceae	The roots of plant are considered to be effective as antispas-modic, aphrodisiac, antidiarhoeal, antidy-sentiric, blood purifier, and also in night blindness, kidney problems.
5	*Caesalpinia bo nduc* (L.) Roxb.	*Caesalpiniaceae*	Oil expressed from the seeds is locally applied over pimples. Decoction of the endosperm is considered effective against vomiting and bleeding.
6	*Caesalpinia crista* L.	*Caesalpiniaceae*	Oil expressed from the seeds is locally applied over pimples.
7	*Calycopteris floribunda* (Roxb.) Lam.	Combretaceae	The leaves are bitter, astringent, anthelmintic, depurative, diaphoretic and febrifuge. They are useful in intestinal worms, leprosy, malarial fever, dysenter and vomiting. The fruits are useful in jaundice, y ulcers and skin diseases.
8	*Coscinium fenestratum* (Goetgh.) Colebr	Menispermaceae	Paste of s tem is applied on the forehead in severe headache
9	*Cyclea peltata* (LAM.) Hook. F. & Thomson	Menispermaceae	The tuberous roots of this plant along with a little salt are used to treat stomach pain.
10	*Entada rheedii* Spreng.	Mimo saceae	Rice gruel prepared in the decoction of the endosperm of the seed is taken with coconut peels in joint pain
11	*Hemidesmus indicus* (L.) R.Br.	Apocynaceae	Syrup made with an infusion of the roots is used to make a Sherbet, and is served at most small refreshment shops in South India.
12	*Mucuna pruriens* (L.) DC.	Fabaceae	Blocking effect of King Cobra venom at neuromuscular junction is removed by the aqueous extract of the seeds.
13	*Naravelia zeylanica* DC	Ranunculaceae	Inhalation of fresh-crushed root removes common cold; bathing in water boiled with the leaves removes joint pain (rheumatism).
14	*Piper betle* L.	Piperaceae	Expectant mothers, who chew betel quid, during pregnancy, significantly increase adverse outcomes for the baby. Chewing areca nut and betel leaf is a remedy for bad breath.
15	*Piper longum* L.	Piperaceae	Decoction of dried immature fruit and the root is extensive ly used in acute and chronic bronchitis.
16	*Tylophora tetrapetala var.* tetrapetala	Asclepiadaceae	Outer skin of stem applied as a paste over body to repel leeches

Table 2. Ethno-medicinally important herbs used by Malayans

Sr. No.	Scientific name	Family	Uses
1	*Achyranthes aspera* L.	Amaranthaceae	Root of a single plant boiled with one glass of milk, reduced to half and taken as a single dose in mentally retarded people.
2	*Aloe vera* (L.) Burm.f.	Lilliaceae	Leaf pulp or juice is applied over burns
3	*Andrographis paniculata* (Burm.f.) Wall. ex Nees	Acanthaceae	Whole plant decoction is taken to cure fever
4	*Bacopa monnieri* (L.) Pennell	Scrophulariaceae	Leaves used to foment the pubic abdominal regions to cause a free flow of urine.
5	*Boerhavia diffusa* L. nom. cons.	Nyctaginaceae	Decoction of one whole plant in two glasses of water is taken thrice a day for one week or may continue for 14 days or 21 days depending upon the intensity of difficult in urination (may be for Kidney stones)
6	*Butea monosperma* (Lam.) Taub.	Fabaceae	Bark decoction is used for cleaning an open boil or other wounds.
7	*Capsicum annuum*	Solanaceae	Leaf paste mixed with salt is applied over the wounds in dog bite.
8	*Catharanthus roseus* (L.) G.Don	Apocynaceae	Decoction of white flowers and leaves is taken for loose motion.
9	*Curculigo orchioides* Gaertn.	Hipoxidaceae	Dried tubers sliced (ten plants) is stirred in 2 to 3 glass raw cow's milk and the thick mucilage is taken for yellow urine (jaundice).
10	*Cymbopogon flexuosus* (Nees ex Steud.) Will.Watson	Poaceae	Sold to the flavouring and perfumery industries
11	*Desmodium gange ticum* DC	Fabaceae	Whole plant used as Antipyretic.
12	*Eclipta prostrat a* (L.) L.	Aster aceae	Leaf juice applied to infection between toes
13	Emilia sonchifolia *(L.) DC. Ex Wight*	Asteraceae	Leaf juice applied to eyes for eye diseases
14	*Rauvolfia serpentin a* (L.) Benth. *ex* Kurz	Apocynaceae	Sold to ayurvedic medical shops
15	*Ruta chalepensis* L.	Rutaceae	Hot infusion of leaves taken as a remedy in case of constipation.

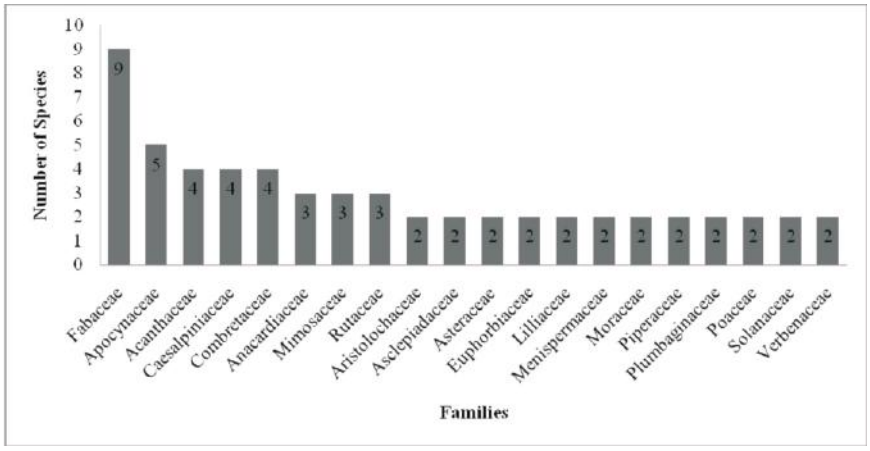

Fig 2. Ethno-medicinally important plant families

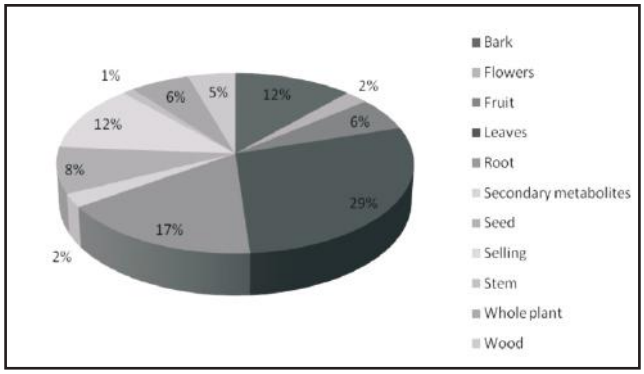

Fig 3. Usage pattern of the ethno-medicinal plants

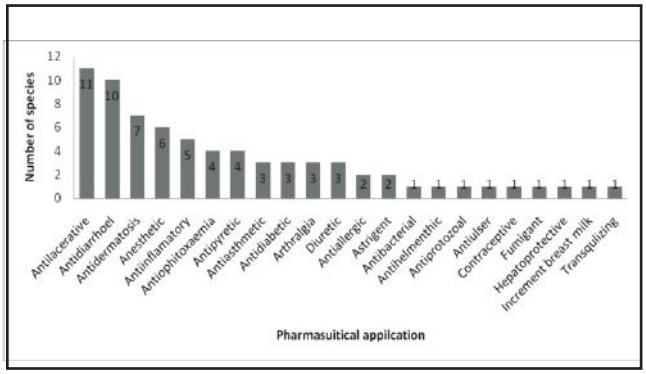

Fig 4. Pharmaceutical application of different plant species

seventy eight dicotyledons , three monocotyledons and one gymnosperm (Table 1-4). The maximum species (3) was represented by *Caesalpinia* and *Terminalia* genus, followed by *Albizia, Ficus* and *Piper* (2) species with each genus. Fabaceae (10.98 %) with 9 species was the largest plant family, followed by Apocynaceae (6.10 %) with 5 species (Figure 2).

For regular usage, the most frequently used plant part (Figure 3) were the leaves (24 spp.) followed by, root (14 spp.), bark (10 spp.), seed (7 spp.), fruits (5 spp.) and wood (4 spp.). In some cases, more than one plant part from the same species were observed to be used for the treating a diseases (eg. *Syzygium cumini* (bark & fruit) and *Catharanthus roseus* (flowers & leaves).

Modes of consumption of formulations also varied. The most common method of consumption was decoction (23 species), followed by paste (18), fresh juice extract (13), crushed mixture (6), massage oil (4), ointment (3), fruits (2), and tablet form (1).

Malayans were observed to be traditionally using these medicinal plants in various ways. A majority were used as anti-lacerative (11), followed by use as anti-diarrheal (10), anti-dermatosis (7), anesthetic (6), anti-inflammatory (5), anti-ophitoxaemia (4), anti-pyretic (4), anti-diabetic (3), arthralgia (3), diuretic (3), astringent (2) and anti-bacterial as *Cassia fistula*, anti-helmenthic as *Datura stramonium*, anti-

Table 3. Ethno-medicinally important shrubs used by Malayans

Sr. No.	Scientific name	Family	Uses
1	*Adhatoda beddome* Clarke	Acanthaceae	Juice of leaves mixed with one hen's egg and one or two pinches of black pepper powder is taken in empty stomach in early morning for relief from any type of cough .
2	*Baliospermum montanum* (Willd.)	Euphorhiaceae	Salted rice gruel prepared in the root decoction is used against block in anus (acidity) .
3	*Bambusa bambos*	Poaceae	Leaves are used as abortifacient in early conception by tribal women. Paste or ash of roots is used locally in skin disorders, ringworm infection and dermatoses. Fruits are useful in fat metabolism and obesity.
4	*Barleria pratten sis* Sant.	Acanthaceae	Whole plant paste is applied externally to treat paralysis.
5	*Calotropis gigantea* (L.) W.T.Aiton	Asclepiadaceae	Paste prepared with the milky juice of the plant along with the ginger and red chillies are applied over the wounds in dog bite.
6	*Carica papaya* L.	Caricaceae	Latex is applied locally to remove pimples.
7	*Citrus aurantifolia* Swingle	Rutaceae	Fruit juice is used for healing of wounds.
8	*Cycas circinalis*	Cycadaceae	Raw seed is poisonous, but after being cut into thin slices, dried, then steeped in water for a few minutes and dried again, it becomes edible. It can be used as a sago.
9	*Datura stramonium* L.	Solanaceae	Juice of 5-6 leaves with milk is taken for (vayaru kadi) expelling worms
10	*Dolichos trilbies* Linn	Fabaceae	Decoction of the whole plant with the powder of two black pepper is taken for swelling of any part of the body
11	*Helicteres isora* (L.)	Sterculiaceae	Used as ingredients in other medicine. Fruits used for intestinal problems
12	*Hibiscus hispidissimus* Griffith	Malvaceae	Used for making a dish it is consumed in the time of fever
13	*Ixora coccinea* Linn.	Rubiaceae	Flowers along with goat droppings boiled in coconut oil and applied externally against skin diseases
14	*Lantana camara* L.	Verbenaceae	Leaves are used to treat cuts, rheumatisms, ulcers, tetanus, malaria, cancer, chicken pox, asthma, ulcer, swelling, high blood pressure, bilious fever. Lantana oil is used in the treatment of skin, itches, as an anticeptic for wounds.
15	*Murraya Koenigii* L. Spreng.	Rutaceae	Leaf paste with a little salt is applied over the wounds in dog bite
16	*Plumbago zeylanica* Linn.	Plumbaginacea e	Cup of fresh cow milk is stirred with a piece of the root and taken internally to stop pregnancy.
17	*Pseudarthria viscid* L.	Fabaceae	The root is one of the Dasamoola in Ayurveda. It is used to treat ulcer, hepatic disorders, bronchitis, helminthiasis, piles, strangury, asthma, cardiovascular diseases, nerve disorders, snake bite etc.
18	*Ricinus communis* L.	Euphorbiaceae	Sold in ayurvedic medical shop
19	*Salacia reticulata* Wight	Hippocrateaceae	Drinking water is prepared by boiling the plant and is used to cure girdle pain
20	*Strobilanthes ciliat us* Nees	Acanthaceae	Leaves made in to a paste and used for swellings in the body.
21	*Thottea siliquosa* Lamk	Aristolochaceae	Roots are used in the treatment of many diseases like diarrhoea, dysentery, cholera, ulcers. The whole plant is used against snake bite.

Table 4. Ethno-medicinally important tree species used by Malayans

Sr. No.	Scientific name	Family	Uses
1	Albizia lebbek *(L.) Benth*.	Fabaceae	Bark powder mixed with honey is taken for relief of (valivu) asthma.
2	Albizia odoratissima *(L.f.) Benth.*	Mimosaceae	The bark of the tree is useful in ulcers, leprosy, skin diseases, cough, bronchitis, diabetes and burning sensation.
3	Alstonia scholaris *(L.) R. Br.*	Apocynaceae	Bark decoction given t o nursing mothers to increase breast milk.
4	Anacardium occidentale *L.*	Anacardiaceae	Shell oil applied over corns and warts.
5	Annona squamosa *L.*	Annonaceae	Macerated leaf pulp is locally applied for painful joints.
6	Azadirachta indica *A. Juss.*	Meliaceae	Decoction of the inner bark with honey is taken for yellow urine (jaundice) and as antidiabetic with some other specific plants.
7	Caesalpinia sappan *L.*	Caesalpiniaceae	Used for making drinking water and also helpful to solve problems in menstrual function.
8	Canarium strictum *Roxb.*	Burseraceae	Fume of the dried resin extracted from this tree repels mosquitoes and purifies air.
9	*Careya arborea*	Lecythidaceae	Bark made in to a paste and is applied around the wound of snake bite.
10	*Cassia fistula L.*	*Caesalpiniaceae*	Leaf paste is applied over the affected parts in leprosy.
11	Cocos nucifera *L.*	Arecaceae	Paste of charcoal with turmeric is applied over skin problems caused by centipedes.
12	Ficus hispida *L.F.*	Moraceae	Leaves used as cattle feed after delivery.
13	Ficus religiosa *L.*	Moraceae	Milky juice is externally applied over the swelling in neck region.
14	Gmelina arborea *Roxb.*	Verbenacea e	Roots posses antipyretic activity.
15	Holarrhena pubescens	Apocynaceae	One handful of crushed seeds boiled with two glasses of water, reduced to half the quantity and the decoction is taken thrice a day for a week along with honey for loose motion with blood content.
16	Hydnocarpus pentandra *(Buch.-Ham.) Oken*	Flacourtiaceae	Seed paste is applied over skin infections and used for covering of wounds (dressing).
17	Lannea coromandelica *(Houtt.) Merr*.	Anacardiaceae	The whole parts are giving it to med ical shop.
18	Magnolia champaca *(L.) Baill. ex Pierre*	Magnoliaceae	Root (10 cm) is used into a paste with black pepper and taken after menstruation for three continuous days for preventing pregnancy.
19	Mangifera indica *L.*	Anacardiacea e	Dried tender leaf powder or their ash is stirred in water and taken for frequent urination.
20	Pongamia pinnata *(L.) Pierre*	Fabaceae	Root bark applied over joint swelling.
21	Pterocarpus marsupium *Roxb.*	Fabaceae	Hardwood is used for making a drink and is used for back pain.
22	Santalum album *L.*	Santalaceae	Paste made with rice water is applied on the forehead against headache.
23	Sapindus trifoliatus *Auct. Non L.*	Sapindaceae	Fruit is used for stomach ache.
24	Stereospermum colais (*Buch.-Ham. Ex Dillw.) Mabb.*	Bignoniaceae	Bark is sold in the ayurvedic medical shop.
25	Syzygium cumini *(L.) Skeels*	Myrtaceae	The leaves and bark are used for controlling blood pressure and gingivitis. Wine and vinegar are also made from the fruit.
26	Terminalia arjuna	Combretaceae	Bark is used for urinary problems.
27	*Terminalia bellirica (Gaertn.) Roxb.*	Combretaceae	Fruits are used in the popular Indian herbal rasayana treatment triphala.
28	Terminalia tomentosa *(Roxb.Ex DC.) Wight & Arn*.	Combretaceae	A decoction of the bark is taken internally for intestinal problems
29	Wrightia tinctoria *(Roxb.) R.Br.*	Apocynaceae	To get relief from toothache, seven leaves of this tree are chewed like betel leaf

protozoal as *Tylophora teteapetala*, anti-ulseric as *Ficus hispida*, contaceptive as *Magnolia champca*, fumigant as *Canarium strictum*, hepatoprotective as *Curculigo orchioides*, as an inducer of barest milk (*Alstonia scholaris)* and as tranquilizer (*Achyranthes aspera*) (Fig 4).

Indigenous knowledge of victuals

We also observed that Malayan tribes consumed many wild plants including vegetables, tubers, fruits and seeds. We catalogued twenty four edible plants which highlighted their knowledge and dependence on the wild food sources. They use different parts of plants, including fruit, seed, leaves, tuber and rhizomes (Table 5). Most Malayans now prefer to consume rice than wild fruits and tubers. But still, fruits (35 %) constitute a major food item. Malayans also displayed considerable knowledge on the distribution of various tubers in the Peechi forest, which they collected according to their consumption requirement. To ward off the toxicity of some of the edible tubers they consume, they boil it. The recorded diets consist of 22 species, distributed in 21 genera and 15 families. Among that, trees (11), shrubs (5), herbs (5) and only one climber was recorded (Fig 5).

In India, scientists, natural resource managers and policy makers are working to recognize the non-wood values of forests (George and Shinaraju, 2002; Vikas *et al.,* 2014b). This is more important as, the "orally transmitted" traditional knowledge, like what the indigenous populations, Malayans, in our case, possess, are swiftly eroding due to the influx and influence of "mainstream culture". This traditional wisdom not only provides information about the various values of even

Table 5. Important edible parts and their used by Malayans

Sr. No.	Scientific name	Family	Specific use
1.	*Baccaurea ourtallensis* (Wight) Müll.Arg	Euphorbiacea e	Fruits are edible and eaten as special food. The mature fruit is also used to pickle by the tribal people.
2.	*Syzygium cumini* (L.) Skeels.	Myrtaceae	Mixture of fruit j uice and powder of inner bark taken as an antidote for vegetable poisoning.
3.	*Spondias mombin* L.	Anacardiaceae	Unripe fruits are pickled and ripe fruits are eaten as such.
4.	*Artocarpus heterophyllus* Lam.	Moraceae	Fruits are consumed as such; seeds are u sed to make curries.
5.	*Mangifera indica* L.	Anacardiaceae	Ripened fruit consumed as such, unripe mangos are pickled.
6.	*Aegle marmelos* (L.) Corrêa	Rutaceae	Fruits are roasted and eaten.
7.	*Phyllanthus emblica* L.	Euphorbiaceae	Consumed as such, and mature fruits are pick led.
8.	*Artocarpus hirsutus* Lam.	Moraceae	Fruits are edible; seeds are roasted in oil which is served as special food.
9.	*Terminalia bellirica* (Gaertn.) Roxb.	Combretaceae	Seeds consumed after frying.
10.	*Bumbusa bambos*	Poaceae	Seeds are powdered and used to make different food items.
11.	*Tamarindus indica* L.	Caesalpiniaceae	Seeds are consumed as such, also to make curries.
12.	*Cycus circinalis*	Cycadaceae	Seeds are powdered and used to make different food items.
13.	*Hibiscus Hispidissimus* Griffith	Malvaceae	The leaves are added wit h other vegetables to increase flavour. Outer covering of the fruit is also used to make a dish called "sammanthi"
14.	*Phyllanthus niruri* L.	Euphorbiaceae	Leaves and stem tender stems are used as vegetable because of its medicinal value.
15.	*Zanthoxylum rhetsa* (Roxb.) DC	Rutaceae	Leaves are used as vegetables.
16.	*Cycas circinalis*	Cycadaceae	Young leaves are boiled in the water to remove the toxic substances and then made to Cu rries.
17.	*Moringa pterygosperma* Gaertn.	Moringaceae	Leaves used as vegetable.
18.	*Boerhavia diffusa* L. nom. cons.	Nyctaginaceae	Leaves used as vegetable.
19.	*Zingiber officinale* Roscoe	Zingiberaceae	Used as such and also added in different food preparations.
20.	*Amorphosphallus paenonflodium*	Araceae	Rhizome is boiled in the water, also made into curries
21.	*Curcuma longa* L.	Zingiberaceae	It is added with curries and chuttnies.
22.	*Colocasia esculenta* (L.) Schott	Araceae	It is a commonly boiled in the water wi th salt and chilli powder and served as special food.
23.	*Dioscorea opposita* Thunb.	Dioscoreaceae	Consumed leaves after boiling in the water with a paste of Chilly and oil.

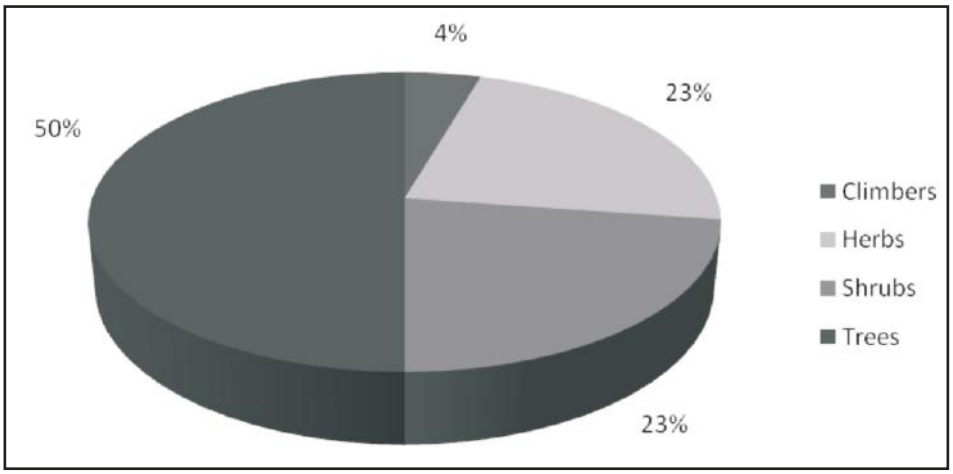

Fig 5. Different species in the diet of Malayans

some hitherto undiscovered or unaccounted wild species, but also provides indirect clues to the potential application of these species in answering many lingering questions regarding human health and nutrition. Our study further highlights the urgent significance of documenting the location specific ethnobotanical information associated with resident indigenous populations (irrespective of their population size) scattered in our country's forested landscape. Studies similar to the one we undertook also provides valuable basic information about the biological richness of a particular forest area, which can be made used to refine or re-define existing forest management strategies and concepts, while preparing working plans. Such information is also valuable in the context of the concept of multiple-use-forestry, which is now gaining widespread acceptance in tropical forestry establishments.

From the present study, it is evident that the Malayans depend upon the wild plant resources for their personal medical care; in order to supplement their requirements, it is suggested that the potential medicinal plants could be cultivated in their backyards/kitchen gardens. It is hoped that the information gathered from the indigenous community will provide further lead in developing new herbal formulation.

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Rainfall Probabilities for Crop Planning in Ludhiana by Markov Chain Analysis

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***Abstract*:** The rainfall data of Ludhiana for a period of 43 years covering 1970 to 2012 have been collected from School of Climate Change and Agricultural Meteorology to work out the wet and dry spells. The study was planned to find the rainfall variability and amount of rainfall at different probability levels for the year 1970-2012. The rainfall data was analyzed on weekly basis to work out the initial probability for rainfall at different levels i.e. > 5 mm, > 10 mm, > 20 mm, > 30 mm, > 40 mm and > 50 mm using Markov chain model. The study results in estimation of maximum and minimum initial probability for standard meteorological week. This will be useful to analyze the rainfall distribution patterns during different season's viz. monsoon (July-September), rabi season (October- December) and kharif season (June - October). Rainfall during the pre-sowing period is pre-requisite for land preparation as well as for moisture conservation. The results will be useful for deciding the sowing time of crop/ crop variety (early sown/late sown), irrigation/fertilizer scheduling and harvesting time for different crops. In addition to this study will also be useful for determining the runoff volume, peak runoff rate and hence can be used for designing of rainwater harvesting structures.

Key Words: Central Punjab, Markov chain, Probability, Rainfall, Variability

Rain is the primary source of water. It has been very important since the creation of human beings on earth. Rain has also significant effect on agriculture. Rainfall also determines the potential of any region in terms of crops to be grown, farming system to be adopted, the nature and sequence of farming operations to be followed and to achieve higher agricultural productivity as well. The main characteristics of rainfall are its amount, frequency and intensity. Precise knowledge of these is essential for planning its full utilization. In Punjab, Rainfall has been report either increased or decreased at different locations, over the past three decades (Kaur and Hundal, 2010). An unpredictable extreme daily weather event with 400 mm rainfall was observed on 12th August 2011 at Ludhiana and no rainy day was recorded in the month of June, 2012. More rainfall was recorded in June and July 2012 in Punjab. The monsoon months (June to August) were deficit months but the month of September received 41 per cent above normal rainfall. Variability in meteorological trends has been reported by Kaur *et al*, 2012. For example, a single unpredictable extreme daily weather event (on 12th August 2011) at Ludhiana (Punjab) can easily contribute 400 mm to the total seasonal rainfall and, thereby, increase the seasonal mean rainfall by more than 3 mm day^{-1}. When one compares this with the inter annual standard deviation of the mean June–September Ludhiana rainfall of 4 mm day-1, one realizes that isolating the predictable signal from the noise may be a rather delicate problem.

Markov chain model is widely used worldwide to understand the crop growing seasons based on dry and wet spells. Instead of mean rainfall, assured rainfall is also defined at 75% probability level. It is computed on the basis of rainfall distribution (Kumar, 2003 and Jat *et al*., 2005). Goswami *et al.* (2006) reports an increasing trend in the frequency of extreme precipitation events and increase in the intensity of precipitation. Patel and Shete (2008) also worked out the dry and wet spells for Gujarat and they revealed that crop planning is solely dependent on the distribution pattern and amount of rainfall especially in rainfed areas. In such conditions, knowledge of average annual rainfall is not useful in predicting the start of rains, wet and dry spells for deciding cropping pattern. Similarly, Vaidya *et al.*, (2008) studied the initial and conditional rainfall probabilities for crop planning in Gujarat.

In present study the Markov Chain Model is used to find the initial rainfall probability. Raudkivi (1979) has also calculated the rainfall probabilities using the Markov chain model to describe the hydrological phenomena.

MATERIAL AND METHODS

The rainfall data of Ludhiana for a period of 43 years covering 1970 to 2012 has been analyzed. The annual rainfall for the region is 700-800 mm from which 75 % is received during rainy season (June-September) and rest is

during winter season through western disturbances. The rainfall probabilities were worked out through different methods as below:

Markov chain analysis: Markov chain probability model has been found suitable to describe the long term frequency behaviour of wet or dry weather spells. The model calculates the initial probabilities of getting a dry spell / wet spell in a given standard meteorological week.

Initial rainfall probability (%): It provides tentative idea of particular week having highest or lowest probability of getting more than 20 mm of rains.

$$\text{Initial probability (\%) (w)} = \frac{\text{Number of years during which > 20 mm rainfall during x week}}{\text{Total number of years}} \times 100$$

RESULTS AND DISCUSSION

The initial probabilities were calculated for different years on weekly basis. The 52 weeks of a year are divided into 4 quarters. 1st -13th SMWs of the year represents Quarter 1 and consequently, 14th – 26th, 27th - 39th and 40th - 52nd SMWs are representing 2nd, 3rd and 4th Quarters, respectively.

Initial Rainfall Probability

The data pertaining to initial rainfall probability is presented in Table 1. The lowest and highest rainfall probabilities in the form of percentage were worked out for different quarters for Ludhiana region. Similarly, Raman Rao *et al.* (1975) analyzed the daily rainfall data for Bijapur from 1921 to 1970. Similar studies were also done by Schwab *et al.* (1966), USDA-SCS (1967) and Keller (1972) for different locations.

Quarter 1 (> 5 mm, > 10 mm and > 20 mm)

The perusal of data reveals that initial probability for > 5 mm was observed lowest (16%) during 13th SMW and highest (49%) during 7th SMW, for > 10 mm the probability was lowest (12%) during 2nd, 13th SMW and highest (35%) during 6th, 7th SMW and for > 20 mm the probability was lowest (2%) during 13th SMW and highest (19%) during 7th SMW, for > 30 mm was observed lowest (0%) during 10th, 13th SMW and highest (16%) during 7th SMW, for > 40 mm the probability was lowest (0%) during 1st, 10th, 13th SMW and highest (9%) during 7th SMW and for > 50 mm the probability was lowest (0%) during 1st to 3rd, 6th, 10th, 13th SMW and highest (7%) during 7th SMW.

Quarter 2 (> 5 mm, > 10 mm and > 20 mm)

The perusal of data reveals that initial probability for > 5 mm was observed lowest (14%) during 22nd SMW and highest (77%) during 26th SMW, for > 10 mm the probability was lowest (7%) during 15th SMW and highest (67%) during 26th SMW and for > 20 mm the probability was lowest (2%) during 17th SMW and highest (56%) during 26th SMW, for > 30 mm was observed lowest (2%) during 16-17th SMW and highest (40%) during 26th SMW, for > 40 mm the probability was lowest (0%) during 16-17th, 20th, 22nd SMW and highest (35%) during 26th SMW and for > 50 mm the probability was lowest (0%) during 16-17th, 19th, 20th, 22nd SMW and highest (26%) during 26th SMW.

Quarter 3 (> 5 mm, > 10 mm and > 20 mm)

The perusal of data reveals that initial probability for > 5 mm was observed lowest (28%) during 39th SMW and highest (86%) during 28th SMW, for > 10 mm the probability was lowest (19%) during 39th SMW and highest (84%) during 28th SMW and for > 20 mm the probability was lowest (12%) during 39th SMW and highest (72%) during 28th SMW, for > 30 mm was observed lowest (5%) during 39th SMW and highest (60%) during 29th SMW, for > 40 mm the probability was lowest (5%) during 39th SMW and highest (51%) during 31th SMW and for > 50 mm the probability was lowest (2%) during 39th SMW and highest (40%) during 27th, 28th SMW.

Quarter 4 (> 5 mm, > 10 mm and > 20 mm)

The perusal of data reveals that initial probability for > 5 mm was observed lowest (2%) during 43rd SMW and highest (21%) during 52nd SMW, for > 10 mm the probability was lowest (0%) during 43rd, 46th SMW and highest (12%) during 42nd, 47th, 52nd SMW and for > 20 mm the probability was lowest (0%) during 43rd, 45-48th SMW and highest (9%) during 51-52nd SMW, for > 30 mm was observed lowest (0%) during 41th, 43rd, 45th-48th, 50th SMW and highest (7%) during 51st SMW, for > 40 mm the probability was lowest (0%) during 40th, 41th, 43rd, 45th-48th, 50th, 52nd SMW and highest (5%) during 42th, 51th SMW and for > 50 mm the probability was lowest (0%) during 40-41th, 43th, 45th-48th, 50th, 52nd SMW and highest (5%) during 51th SMW.

For rainfall > 5 mm, > 10 mm, > 20 mm, > 30 mm, > 40mm, & > 50 mm the highest probability (%) was observed 86, 84, 72, 60, 51, 40 respectively and lowest probability (%) was observed 2 and 0, respectively.

Rainfall probability for *rabi* season

During the start of rabi season (October - December), the probability of occurrence of rainfall is not sufficient so farmer has to make arrangement of pre-sowing irrigation of wheat crop otherwise he has to use zero till drill for sowing of wheat. As the highest rainfall probability during 7th SMW i.e. in mid-February for >5 mm will not be useful as sowing of sunflower crop occurs during that period, so farmers are advised to complete sowing of sunflower by end of January otherwise the germination will be affected. The farmers opting for wheat crop can skip irrigation during that period as rainfall probability upto 50 mm is highest during 7th

Table 1. Weekly probabilities of rainfall at different intervals

Weeks	P(>5mm)	P(>10mm)	P(>20mm)	P(>30mm)	P(>40mm)	P(>50mm)
1	19	14	9	5	0	0
2	23	12	7	5	2	0
3	28	14	7	7	2	0
4	28	26	16	12	7	2
5	23	16	5	5	5	2
6	40	35	16	7	2	0
7	49	35	19	16	9	7
8	42	26	9	2	2	2
9	30	21	12	9	5	2
10	28	16	7	0	0	0
11	21	14	7	5	2	2
12	30	23	7	2	2	2
13	16	12	2	0	0	0
14	19	14	9	5	2	2
15	21	7	5	5	2	2
16	23	21	12	2	0	0
17	21	9	2	2	0	0
18	21	14	7	7	2	2
19	26	14	12	5	2	0
20	30	14	12	7	0	0
21	19	19	12	5	2	2
22	14	9	7	7	0	0
23	44	30	26	14	9	7
24	58	44	26	14	12	7
25	51	44	28	23	12	9
26	77	67	56	40	35	26
27	72	65	58	44	40	40
28	86	84	72	58	44	40
29	77	72	65	60	47	35
30	81	72	60	49	40	30
31	79	74	65	56	51	40
32	77	72	65	51	44	30
33	84	72	53	40	21	16
34	74	63	56	44	37	30
35	70	58	47	40	30	26
36	58	53	37	28	23	21
37	51	40	33	28	14	12
38	42	37	28	14	12	9
39	28	19	12	5	5	2
40	14	9	5	2	0	0
41	7	7	5	0	0	0
42	16	12	5	5	5	2
43	2	0	0	0	0	0
44	7	5	5	2	2	2
45	5	2	0	0	0	0
46	7	0	0	0	0	0
47	14	12	0	0	0	0
48	9	2	0	0	0	0
49	9	5	2	2	2	2
50	14	9	2	0	0	0
51	12	9	9	7	5	5
52	21	12	9	2	0	0

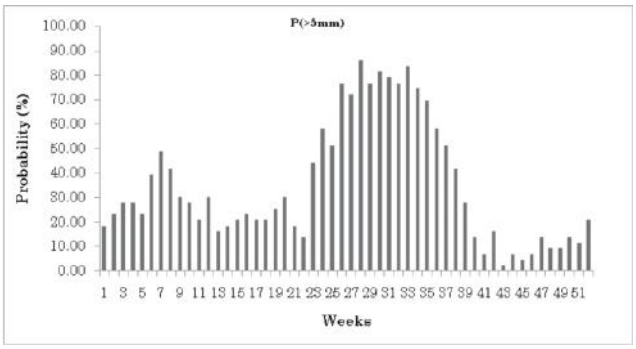

Fig. 1.1 Initial Probability of rainfall > 5 mm

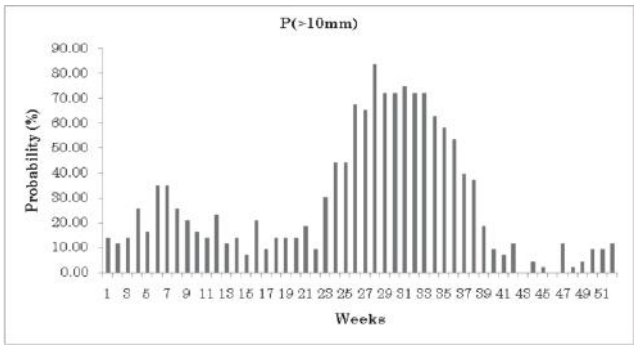

Fig. 1.2 Initial Probability of rainfall > 10 mm

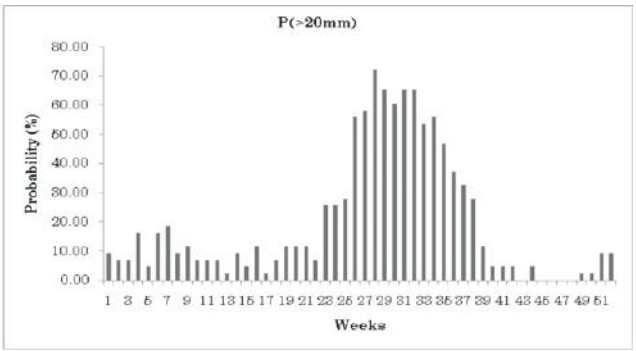

Fig. 1.3 Initial Probability of rainfall > 20 mm

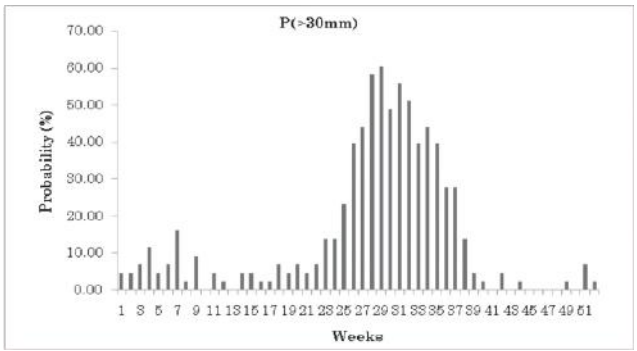

Fig. 1.4 Initial Probability of rainfall > 30 mm

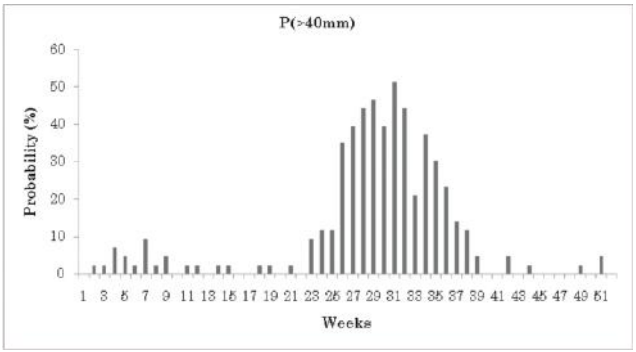

Fig. 1.5 Initial probability of rainfall > 40 mm

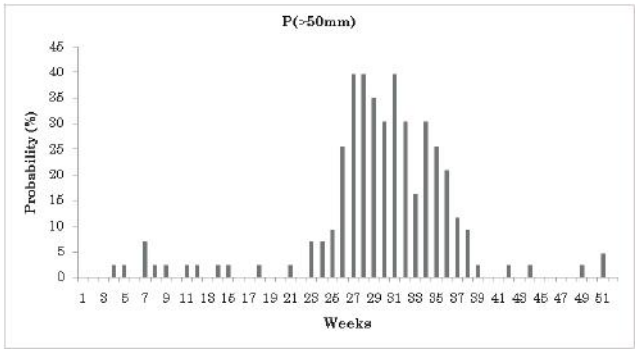

Fig. 1.6 Initial probability of rainfall > 50 mm

SMW. The probability of rainfall is minimum during 13th SMW i.e. first week of April, this will be favorable for farmer as wheat is at maturity stage and rainfall occurrence will be harmful.

Rainfall probability for *kharif* season:

As rainfall probability is lowest during 17th - 22nd SMW i.e. the first week of May to first week of June and it is time of raising paddy nursery , so the farmers should take special care to irrigate the paddy nursery especially nursery raised for mechanized transplanting. The highest rainfall probability during 26th SMW i,e, end of June so farmers can skip the irrigation according to in situ conditions as water is very much required during that period of crop season. On the other hand, maize growing farmers can take advantage of this period as they can skip pre-sowing irrigation as rainfall probability is high prior to sowing period. However, the probability of 40 mm rainfall is highest during 31st SMW i.e. start of August that is very beneficial for maize crop as crop is at pre-tasseling stage.

The probability of occurrence of rainfall is highest during 27th to 29th SMW i.e. during first three weeks of July. So, farmers can avoid irrigation during this period depending upon prevailing weather conditions. The rainfall probability is lowest during 39th SMW i.e. last week of September and paddy is at maturity stage so that will be favourable for the farmer. However, for late sown varieties as well as Basmati,

depending upon the crop stage, farmer has to ensure irrigation. For cotton growers, it is advised that they can ensure last irrigation to cotton crop, which is very essential during this period as chances of rainfall are low.

The information generated for maximum and minimum initial probability for different standard meteorological weeks will be helpful for deciding the sowing time, irrigation/fertilizer scheduling and harvesting time. The information generated will be helpful for probability of estimating the insect/pest attack depending upon the crop and probability of occurrence of diseases. In addition to this study will be useful for determining the runoff volume and peak rate of runoff and hence can be used for designing of rainwater harvesting structures.

It was revealed from this study that rainfall during the pre-sowing and sowing periods is an important determinant of crop acreage. The purpose of this study is to analyze the rainfall distribution patterns during monsoon (July-September), rabi crops sowing (October-December) and growing periods (June-July) of kharif crops. Rainfall during the pre-sowing period is pre-requisite for land preparation as well as for moisture conservation for rabi planting. Low rainfall is likely to give a poor crop, while good rainfall will give a bumper kharif crops.

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Impact of Catchment Land Use on Water Quality of Pong Wetland of Himachal Pradesh

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Abstract **:** Four tributaries *viz*., Buhal, Dehar, Gaj and Baner those directly drain into Pong reservoir of Himachal Pradesh and three land uses *viz*., agriculture, pasture, forest in the tributries' catchment were selected and their impact was studied on the water and silt quality of the wetland during the year 2:11-12. The results of correlation studies exhibited that the characteristics of the wetland catchment area has a bearing on the quality of lake water which further indicated that the land use in the catchment of wetland has started impacting the water quality of the wetland. Bathymetric analysis revealed that lake was sedimented upto the level of 6 meters since its formation during 1975.

Key Words **:** Agriculture, Bathymetric, Forest, Pasture, Sediment, Tributaries

The Pong Dam Wetland also known as the Maharana Pratap Sagar is a Ramsar site (No. 1211) of international importance. The wetland is located at the base of Dhauladhar ranges in Kangra District of Himachal Pradesh. It was formed by the construction of Pong Dam during 1975 across the River Beas and is one of the largest man-made wetlands of northern India. Pong lake, its islands, surrounding forests and historical environs offer an unique opportunity to the nature loving tourists. The site has unlimited potential to become the most sought national and international tourist destination and the winter home of largest number of water birds. However, catchment characteristics like hydrology, geology, land use pattern and topography play important role in maintaining quality of wetland. Therefore, activities in the catchment have strong bearing on the health of the lakes. Improper and unscientific practices adopted in the catchment areas of lakes may influence the quality of lakes and enhance their vulnerability (Junk, 2002). Thus, keeping in view the land use pattern in the catchment of pong wetland, the present study was conducted to investigate its impact on water quality of the lake.

MATERIAL AND METHODS

The Pong dam reservoir extends between latitudes 31°49' to 32°14' N and longitudes 75°53' to 76°17' E. The total catchment area of 12,561 km^2 extends over Kangra, Mandi and Kullu Districts. The present study was conducted in the Kangra district which forms the immediate catchment of pong wetland upto the distance of 20 km from the reservoir. The catchment has considerable diversity in soil, physiography, land use pattern and cropping systems and the catchment of four main tributaries *viz.*, Buhal, Dehar, Gaj and Baner directly drains into Pong reservoir comprised the actual study area. The catchment of each tributary was divided into 4 equal sub-catchments or locations/distances such that each covers 5km i.e. L1(0-5km), L2(5-10km), L3(10-15km) and L4(15-20km). Location which does not forms the catchment of any of the tributary was avoided. In this way number of sites formed for water sampling were 15 as L4 of Buhal tributary does not form the catchment of Pong dam wetland. Similarly for soil sampling, Location 4 was not considered because L4 of Buhal tributary does not form the catchment of Pong wetland and therefore, number of sites selected for soil sampling were 15 so that proper statistical design would be applied. Within each location, 3 land uses *viz.,* agriculture, pasture/ grassland and forests were considered and 3 replications were taken under each land use. Water samples from the tributaries and the lake were collected randomly from layer close to the surface (0-15cm) but the scum layer was avoided and soil samples were collected from surface layer (0-25cm) of the tributaries catchments to study the physical and chemical properties.

Soil samples thus collected were air-dried and sieved with 2mm sieve for further analysis. Soil pH (Soil water suspension method), electrical conductivity (Soil water suspension method), organic carbon (Rapid titration method), available nitrogen (Alkaline permanganate method), available phosphorus (Extracting soil with 0.5M $NaHCO_3$), available potassium (neutral ammonium acetate extraction method) and Ca (neutral ammonium acetate extraction method) were determined as per standard procedures described by Jackson (1973). Magnesium was analysed using Inductively coupled plasma atomic emission spectrometry (ICP-AES) as per standard procedure described by Edgell (1988) . Soil erodibility index (EI) was also determined by using simulated rain drops i.e. Rain drop impact (RDI) method given by Bruce and Lal (1975). Three representative samples of silt were collected from different locations of the lake (depth 0-25cm) at the point of their entry

into the lake (e.g. point where tributaries joins the lake) and analysed for similar parameters used in soil analysis.

Water samples thus collected were analysed for pH (glass electrode method), EC (glass electrode method), suspended and dissolved solids (gravimetric method), dissolved oxygen (Winkler method). The other elements *viz*., chlorides, sulphates and phosphates were estimated spectrophotometrically by using Spectroquant Pharo 300 (APHA, 1998). Correlation coefficients between various physical and chemical properties of catchment soils under different land uses and silt of the wetland as well as between water quality parameters of tributaries and lake were worked out as per method suggested by Gomez and Gomez (1984).

Bathymetric analysis was carried out to find the depth profile of the lake by dividing the lake into different segments as transects. The depth at various points was determined by using a rope tied to a stone at one end. The length of the rope was measured using measuring tape. This analysis was undertaken around the periphery upto a 5 km distance towards central core.

RESULTS AND DISCUSSION

Physico-chemical attributes of catchment soils under different land use systems : The mean pH values of pong lake catchment soils were 6.49, 6.51 and 6.63 with a co-efficient of variation values of 6.45, 6.45 and 4.73 for agriculture, pasture and forest lands, respectively (Table 1). The reaction of soils was slightly acidic to neutral which was probably due to more accumulation of leaf litter and its further decomposition to organic acids under forest land use which constituted relatively large area in the catchment of the wetland. The mean electrical conductivity value was 0.10 dS/m with a coefficient of variation value of 34.28 for agriculture, 0.07 dS/m with a coefficient of variation value of 43.54 for pasture and 0.07 dS/m with a coefficient of variation value of 50.63 for forest soils indicating normal salt concentration in the soils of the lake catchment. The mean soil organic content under agriculture, pasture and forest land were 0.46, 0.57 and 0.70 percent and co-efficient of variation values of 48.38, 41.65 and 51.41, respectively. Relatively low organic carbon content in agricultural land use may be due to its fast decomposition under frequent cultivation practices. These results were in conformity with the findings of Six *et al*. (2000). The mean available N content in soils under agriculture, pasture and forest land were 212.3, 233.5 and 201.4 kg/ha and co-efficient of variation values of 39.74, 34.17 and 26.76, respectively. The low to medium range of available N in the catchment area under different land uses was in conformity with the findings of Kaistha *et al*. (1990) who have also reported this trend in the soils of Kangra district of Himachal Pradesh. The mean available P content was 14.25 kg/ha and co-efficient of variation value of 32.02 for agricultural soils, whereas, for pasture and forest soils mean available P content was 13.34 and 12.09 kg/ha and co-efficient of variation values of 32.62 and 37.75, respectively. The medium to high range of available P in soils under different land uses was in conformity with the results reported by Rajeshwar *et al*. (2009). In agriculture, pasture and forest areas, the mean values of available K were 273.2, 344.1 and 302.4 kg/ha and co-efficient of variation values were 31.53, 32.34 and 25.04, respectively.

The mean Ca content in agriculture, pasture and forest land was 1696, 1590 and 1914 kg/ha and coefficient of variation values of 25.20, 29.78 and 32.99, respectively. The mean Mg content in agriculture, pasture and forest land was 197.5, 295.4 and 310.3 mg/kg and coefficient of variation values of 16.73, 14.17 and 10.03, respectively.

The mean erodibility index value in agricultural soils was 0.68 X 10^{-2} and coefficient of variation value of 3.44, whereas, in pasture and forest soils, the mean EI values were 0.55 X 10^{-2} and 0.56 X 10^{-2} and coefficient of variation values of 5.10 and 3.84, respectively. The cultivation practices under agriculture land use have increased the erodibility of soil as compared to other land uses.

Physico-chemical characteristics of lake silt : Silt parameters in lake varied with different sampling stations (Table 2). The mean pH of silt was 7.71 with coefficient of variation value of 4.55 while mean electrical conductivity was 0.12 dS/m with a coefficient of variation value of 39.67. The mean organic content of silt was 0.43 percent and co-efficient of variation value of 69.34 . Available nutrients like N, P, K had mean values of 237.2 kg/ha, 11.75 kg/ha and 285.6 kg/ha, and coefficient of variation values of 38.78, 22.44 and 33.51, respectively. The silt samples collected from lake with respect to exchangeable Ca and Mg content had mean values of 1892 kg/ha and 501.4 mg/kg and coefficient of variation values of 36.71 and 12.61, respectively.

Physico-chemical properties of tributaries' water : The most of the physico-chemical properties of water *viz.,* pH, EC, total dissolved solids, total suspended solids, total solids, total hardness, chlorides and sulfates except dissolved oxygen and phosphates of various tributaries flowing through the catchment area was found within the permissible limits prescribed by WHO (1996) for irrigation. The mean pH value of the tributaries water was 7.21, while EC was 0.34 dS/m which indicated that the water was near neutral in reaction with low salt concentration (Table 3). The mean values for dissolved and suspended solids were 130 mg/l and 16.5 mg/l with coefficient of variation values of 22.37 and 14.88, respectively. The values of dissolved and suspended solids were low in range and indicated low rate of sedimentation. Dissolved oxygen had mean value of 9.7 mg/l and coefficient of variation value of 3.55. The high value of dissolved oxygen was probably due to the high organic material in the areas lying close to weed bed. The water of the tributaries contained chlorides and sulphates with mean values of 7.4 and 11.6 mg/l, respectively, which was in the permissible limits for drinking water as per WHO (1996). Phosphates with a mean value of 10.7 mg/l and coefficient of variation value of 62.99 were above the permissible limits. This was probably

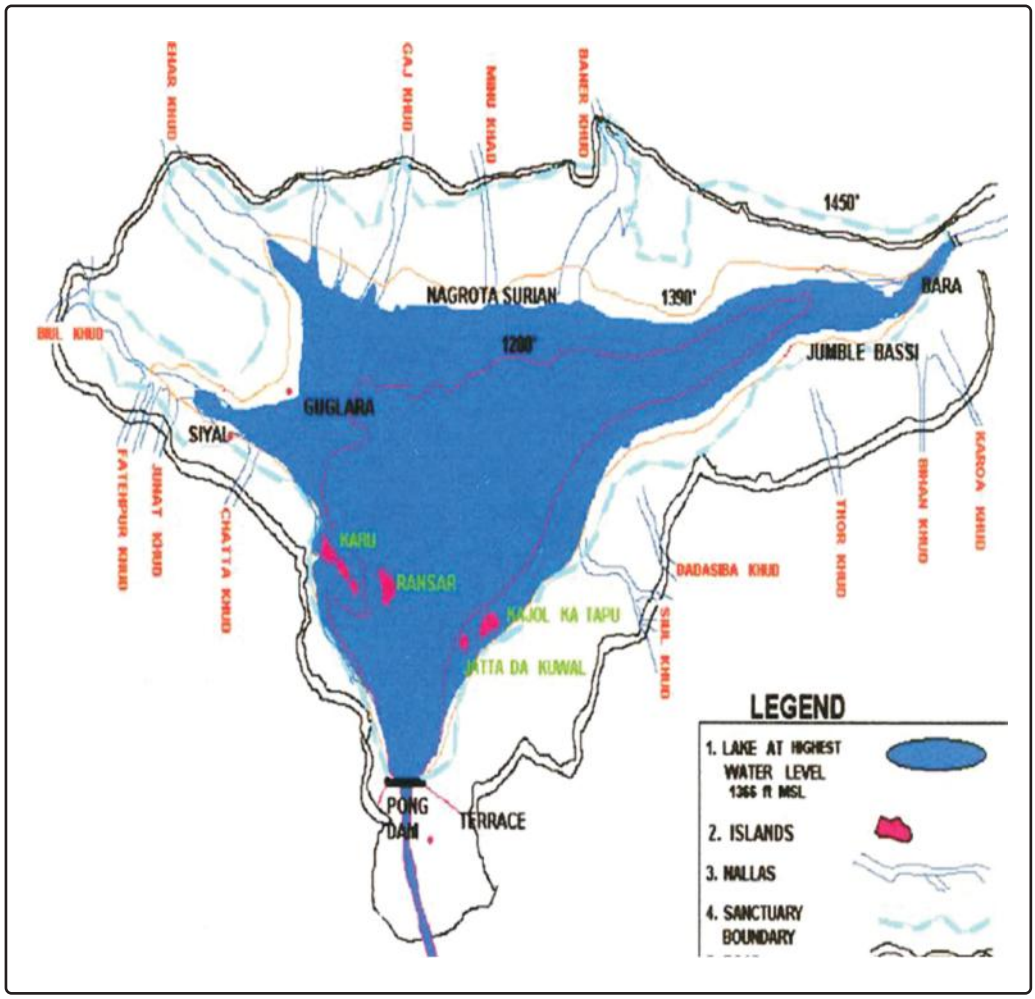

Fig. 1. Map showing the study area

Table 1. Physico-chemical characteristics of catchments soils under different land uses

Land use systems Parameters	Agriculture		Pasture		Forest	
	Mean (Range)	CV	Mean (Range)	CV	Mean (Range)	CV
pH	6.49 (5.91-7.35)	6.45	6.51 (5.93-7.03)	6.45	6.63 (6.30-7.50)	4.73
EC (dS/m)	0.10 (0.07-0.19)	34.28	0.07 (0.04-0.15)	43.54	0.07 (0.03-0.15)	50.63
Organic carbon(%)	0.46 (0.18-0.88)	48.38	0.57 (0.23-1.02)	41.65	0.70 (0.29-1.81)	51.41
Available N(kg/ha)	212.3 (82.9-369.8)	39.74	233.5 (94.6-384.7)	34.17	201.4 (92.7-301.1)	26.76
Available P(kg/ha)	14.25 (8.96-25.09)	32.02	13.34 (8.44-24.92)	32.62	12.09 (8.59-26.03)	37.75
Available K(kg/ha)	273.2 (140.0-490.9)	31.53	344.1 (180.7-573.1)	32.34	302.4 (196.3-436.8)	25.04
Calcium(kg/ha)	1696 (971-2221)	25.20	968-2584	29.78	1914 (731-2738)	32.99
Magnesium(mg/kg)	197.5 (129.2-282.7)	16.73	295.4 (232.6-392.9)	14.17	310.3 (247.3-354.2)	10.03
EI(No. of drops × 10^{-2})	0.68 (0.63-0.72)	3.44	0.55 (0.51-0.61)	5.10	0.56 (0.54-0.6)	3.84

CV – Coefficient of variation

Table 2. Physico-chemical characteristics of lake silt

Sampling Station	pH	EC (dS/m)	OC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	Ca (kg/ha)	Mg (mg/kg)
Station 1	7.81	.09	0.75	297.9	14.20	386.4	1254	570.2
Station 2	7.32	.09	0.16	131.4	12.09	274.4	2632	487.9
Station 3	8	0.17	0.38	282.2	8.96	196.0	1792	446.0
Mean	7.71	0.12	0.43	237.2	11.75	285.6	1892	501.4
Coefficient of variation	4.55	39.67	69.34	38.78	22.44	33.51	36.71	12.61

Table 3. Physico-chemical characteristics of water of the tributaries passing through the catchment and the lake water

Parameters	Tributaries water		Lake water	
	Mean (Range)	CV	Mean (Range)	CV
pH	7.21 (7.02-7.56)	2.15	7.76 (7.1-8.5)	9.04
EC(dS/m)	0.34 (0.23-0.58)	38.87	0.62 (0.33-0.99)	55.78
Dissolved solids(mg/l)	130 (101.1-172.5)	22.37	157.7 (140-172)	10.31
Suspended solids(mg/l)	16.5 (13.8-19.6)	14.88	21.2 (20- 23)	7.39
Dissolved oxygen(mg/l)	9.7 (9.4-10.5)	3.55	8.2 (7.6-9)	8.61
Chlorides(mg/l)	7.4 (3.5-18)	61.7	21.3 (9-31)	52.68
Sulphates(mg/l)	11.6 (3-25)	69.0	162.3 (67-263)	60.43
Phosphates (mg/l)	10.7 (1.2-19.5)	62.99	11.3 (0.2-22)	96.5

CV – Coefficient of variation

due to agricultural runoff and activities like bathing and washing of clothes on the bank of tributaries. Increased amount of phosphates and coliform contamination in streams closer to anthropogenic activities was also reported by Karthick and Ramachandra (2007). Physico-chemical properties of lake water : The mean value of pH of lake water was 7.76 which indicated its slight alkaline nature (Table 3). The mean value for EC was 0.62 dS/m. Dissolved and suspended solids had mean values of 157.7 and 21.2mg/l and coefficient of variation values of 10.31 and 7.39, respectively. The mean dissolved oxygen in the lake water was 8.2 mg/l with a coefficient of variation value of 8.61. In the lake water, chlorides, sulphates and phosphates had mean values of 21.3, 162.3 and 11.3 mg/l and coefficient of variation values of 52.68, 60.43 and 96.5, respectively.

Correlation studies : Silt pH revealed positive and significant correlation with soil pH under forest land use (r= 0.98), however it showed negative and non significant correlation with other two land uses (Table 4). The positive correlation between pH values of silt and forest soils may probably be due to more catchment area under forest land use. The electrical conductivity values of silt showed positive and significant correlation with EC of soils under agriculture land use (r=0.57). This may be ascribed to application of fertilizers and manures under agriculture land use. Correlation between available potassium of silt and forest soils was found positive and significant with r- value of 0.77. Calcium content of the silt exhibited significantly positive correlation with Ca content of soils under pastoral land use (r=0.55). Rest of the properties of the silt of the wetland resulted in negative or non- significant correlations with the physical-chemical properties of catchment soils.

Physico-chemical attributes of water of tributaries registered positive and highly significant correlation with those of the lake water indicating thereby that activities carried out in the catchment has impact on water quality of the lake (Table 5). The pH of water of tributaries revealed positive and significant correlation (r=0.84) with pH of lake water. Correlation between tributaries water EC and lake water EC was found to be positive and highly significant (r=0.90). Similarly other physico-chemical properties of tributaries water *viz*., total dissolved solids (TDS), total suspended solids (TSS), dissolved oxygen (DO), chlorides, sulphates and phosphates exhibited significant correlations with lake water TDS, TSS, DO, chlorides, sulphates and phosphates with corresponding r-values of 0.69, 0.99, 0.54, 0.98, 0.80 and 0.75, respectively. The results indicated that the characteristics of the wetland catchment area has a bearing on the quality of lake water.

Silt accumulation rate : The results of Bathymetric analysis revealed that lake was sedimented upto a level of 6 meters since 1975. This showed that silt was accumulating in the lake approximately at the rate of 16 cm per year. The reduction in depth of lakes by accumulation of silt has also been reported by Ranjani and Ramachandra (2000).The study indicated that most of the physical-chemical properties of the lake water are in permissible limits except for dissolved oxygen and phosphates. The silt accumulation rate and higher values of DO (7.6-9 mg/l) and phosphates (0.2-22 mg/l) with respect to lake water indicated that land use pattern and characteristics of the catchment area have an impact on the wetland quality.

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Table 4 . Correlation coefficient (r-values) between soils under different land uses in the catchment and silt in the wetland

Silt properties	Soil characteristics under different land uses																				
	pH			EC			OC			Available N			Available P			Available K			Ca		
	A	P	F	A	P	F	A	P	F	A	P	F	A	P	F	A	P	F	A	P	F
pH	-0.23	-0.27	0.98*																		
EC				0.57	-0.81*	-0.77*															
OC							-0.98*	-0.6*	-0.6*												
Available N										-.36	0.35	-.99*									
Available P													-.58*	0.25	0.39						
Available K																-.15	-0.99*	0.77*			
Ca																			-.97*	0.55*	-.0001

A- Agriculture P- Pasture F- Forest
*Significant at 5 per cent level

Table 5. Correlation coefficient (r-values) between water of tributaries flowing through the catchment and lake water

Characteristics of wetland water	Water characteristics of tributaries in the catchment							
	pH	EC	Total dissolved solids	Total suspended solids	Dissolved oxygen	chlorides	Sulphates	Phosphates
pH	0.84*							
EC		0.90*						
TDS			0.69*					
TSS				0.99*				
Dissolved oxygen					0.54*			
Chlorides						0.98*		
Sulphates							0.80*	
Phosphates								0.75*

* Significant at 5 per cent level

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Comparative Assessment of Yield and Water Use Efficiency of Different Groundnut Varieties (*Arachis hypogaea*) of Semi-Arid Bundelkhand Region

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***Abstract*:** The groundnut varieties were evaluated during *kharif* 2012 in Parasai Sindh watershed of Jhansi in Bundelkhand region, where only 20% of net sown area is irrigated by open wells as life saving irrigation. Six improved varieties of groundnut viz., ICGS-5, ICGV-350, ICGV-86015, ICGV-8784, ICGV-91114, ICGV-9346, Kaushal and one local varieties viz., Jhumku were evaluated for yield potential. The fresh pod yield of groundnut was significantly higher in ICGV-86015, ICGV-8784, ICGV-91114 and ICGV-9346 as compared to Jhumku. But the dry pod yield was higher in ICGV-350, ICGV-8784, ICGV-91114 and ICGV-9346 followed by Jhumku. Average RWUE of fresh and dry pod yield of groundnut were recorded 2.85 and 1.77 kg/ha/mm, respectively. However, average WUE using effective rainfall of fresh and dry pod yield of groundnut were 6.52 and 4.03 kg/ha/mm, respectively.

Key Words: Effective rainfall, Groundnut varieties, RWUE, WUE, Yield

Rainfall is one of the most important factors affecting agricultural production, especially in the arid and semi-arid regions. Drought is a characteristic of rain fed agriculture in which groundnut is primarily grown in India is a major risk factor leading to its low productivity under low-input farming system (Nigam*et. al.,* 2001). Rainfall of Bundelkhand region is highly erratic, both in terms of total amount and its distribution over time about 90% of which is received during South-West monsoon period from June to September (Singh *et. al.,* 2014). *Kharif* crop largely depends upon the amount and distribution of rain especially during monsoon season and water stress occurring at critical times in the crop growing season could result in agricultural drought, which is frequently associated with rainfall variability. In rain fed agriculture, WUE is linked to the effective use of precipitation (Hatfield *et. al.,* 2001; Varvel, 1995). This study was undertaken with the objective of improving groundnut productivity based on WUE.

MATERIAL AND METHODS

The on-farm research was conducted in Parasai-Sindh watershed of Sindh river catchment located at 25º 23' 47.6"-25º 27' 05.1" latitude and 78º 20' 06.5"-78º 22' 33.0" longitudes (Fig. 1). The watershed is characterized by dry and hot summer, warm and moist rainy season and cool winter with occasional rain showers. The annual rainfall of the watershed region varies from 800 to 1300 mm. Groundnut was the predominant *kharif* crop grown in watershed. The length of growing season in Bundelkhand ranges between 90 to 150 days depending upon rainfall and temperature regimes. Low rainfall and drought are common features. Long dry spells during rainy season were also experienced often, which adversely affects the crops.The study was comprise viz. one local variety i.e. Jhumku (local variety) and seven hybrid varieties (ICGS-5, ICGV-350, ICGV-86015, ICGV-8784, ICGV-91114, ICGV-9346 and Kaushal) of groundnut grown in one acre for each in watershed during *kharif* season, 2012. Out of one acre three samples of each variety of 9 m^2 were taken for study and their mean value was calculated.

Daily rainfall was measured during growing season from rain gauges located in watershed.Growing season precipitation (GSP) was computed from the daily rainfall. The effective rainfall was estimated by using U.S. Bureau of Reclamation method (Rahman *et. al.,* 2008). Rainwater water use efficiency was estimated using total seasonal rainfall data and water use efficiency was estimated by effective rainfall. Pod yield of all groundnut varieties was recorded on fresh and dry weight basis. Increment in yield of hybrid varieties of groundnut was compared with local variety. The RWUE and WUE are estimated by

$$RWUE=\frac{Y}{R}.....(1)$$

$$WUE=\frac{Y}{R}.....(2)$$

Where,

Y=yield (kg ha^{-1}); R = total rainfall (mm); ER= effective rainfall (mm)

RESULTS AND DISCUSSION

Growth Parameters: The plant/9$m^2$was significantly higher under ICGV-9346 variety (31.6), it was 54.15, 62.89, 21.07, 42.34, 7.48, 78.53 and 46.30 % higher than ICGS -5, ICGV-350, ICGV -86015, ICGV-8784, ICGV-91114, Kaushal and Jhumku, respectively. The plant height of Kaushal was observed 1.10 m, which was lower than in other hybrids. Nodules/plant was shown similar trend as plant height.The minimum tillers/plant was in ICGV-9346 and maximumin local variety (Jhumku) followed by ICGV–8784 and ICGV -86015.The plant biomass of Jhumku was 1.60 kg/ 9m^2 which was lower than in other hybrids (Table 1).

Yield and water use efficiency: Yield of groundnut was significantly affected by different varieties. The maximum fresh pod yield (3160 kg/ha) was in ICGV -9346, while maximumdry pod yield (1878 kg/ha) was in ICGV -91114 (Table 2). The Kaushal was obtained 1770 kg/ha fresh pod yield, it was significantly lower than other varieties. The lowest dry pod yield was 1411 kg/ha in Jhumku. The maximum kernel yield of 1070 kg/ha was observed in ICGV -91114 and minimum of 591 kg/ ha in ICGS -5.

The effective rainfall was 361.6 mm of total rainfall of 825.5 mm. S oil has a definite and limited water intake rate and moisture holding capacity. Hence greater intensities of rainfall normally reduce the effective rainfall. Higher intensities increase the run-off and reduce infiltration. Similarly, uneven distribution decreases the extent of effective rainfall while an even spread enhances it and well distributed rainfall in frequent light showers is more conducive to crop growth than heavy downpours. Benjamin *et al.* (2007) also observed similar results in China. Average RWUE and WUE dry pod yield of groundnut were recorded 1.77 and 4.03 kg/ha/mm, respectively. RWUE of fresh and dry pod yield of groundnut were obtained significantly higher 3.83 and 2.27 kg/ha/mm under ICGV-9346 and ICGV-91114, respectively. Whereas, minimum RWUE of fresh and dry pod yield of groundnut were observed under Kaushal (2.14 and 2.27 kg/ha/mm). WUE of fresh and dry pod yield of groundnut were significantly and shown similar trend as RWUE. The water use efficiency of all groundnut varieties for both fresh and dry pod shows higher values than RWUE (Fig. 2). Yadav *et al.* (2000) also reported similar range of WUE of groundnut of semi-arid regions. All hybrid varieties were suitable for semi-arid Bundelkhand region except three

Table 1. Evaluation of growth parameters of different groundnut varieties

Groundnut Variety	No. of plant/ 9 m^2	Plant height (m)	No. nodules/ plant	No. tillers/ plant	Plant biomass (kg/ 9 m^2)
ICGS -5	20.50	1.14	12.64	2.08	1.85
ICGV – 350	19.40	1.29	14.33	2.42	1.75
ICGV –86015	26.10	1.19	13.17	3.29	2.24
ICGV – 8784	22.20	1.36	15.11	3.46	2.00
ICGV – 91114	29.40	1.69	18.78	2.70	2.65
ICGV – 9346	31.60	1.46	16.17	2.05	2.85
Kaushal	17.70	1.10	12.27	3.00	1.95
Jhumku	21.60	1.27	14.11	3.88	1.60
CD (p=0.05)	0.40	0.02	0.17	0.05	0.04

Table 2. Comparison on yield and WUE of different variety groundnut

Groundnut Variety	Pod yield (kg /ha)		Kernels yield (kg/ha)	RWUE (kg/ha/mm)		WUE using ER(kg/ha/mm)	
	Fresh	Dry		Fresh	Dry	Fresh	Dry
ICGS -5	2050.00	1264.00	591.00	2.48	1.53	5.67	3.50
ICGV -350	1940.00	1433.00	731.00	2.35	1.74	5.37	3.96
ICGV -86015	2610.00	1317.00	876.00	3.16	1.60	7.22	3.64
ICGV -8784	2220.00	1511.00	623.00	2.69	1.83	6.14	4.18
ICGV -91114	2940.00	1878.00	1070.00	3.56	2.27	8.13	5.19
ICGV -9346	3160.00	1617.00	756.00	3.83	1.96	8.74	4.47
Kaushal	1770.00	1227.00	626.00	2.14	1.49	4.89	3.39
Jhumku	2160.00	1411.00	871.00	2.62	1.71	5.97	3.90
CD (p=0.05)	40.0 5	17.23	13.23	0.05	0.02	0.11	0.0 6

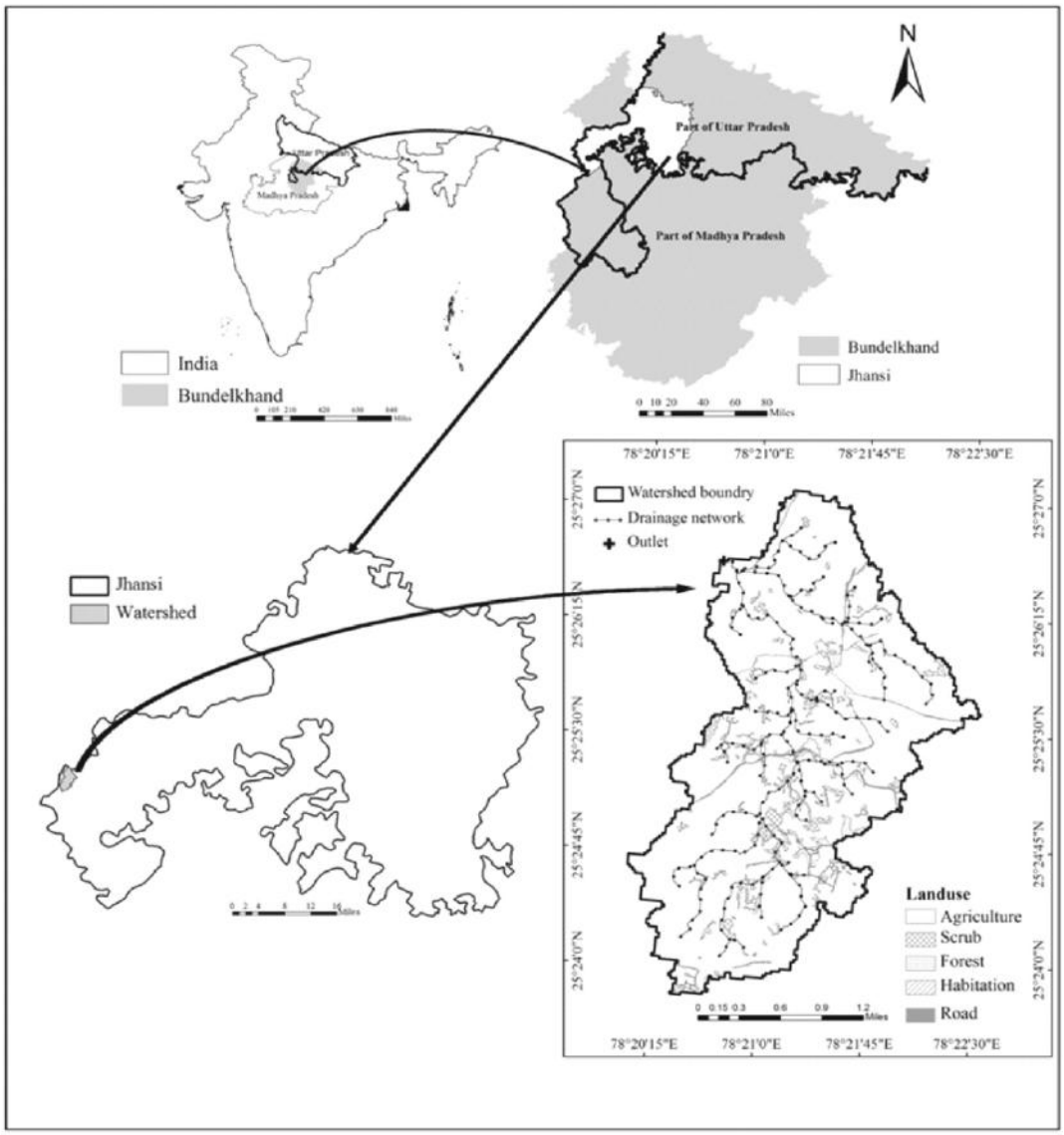

Fig. 1. Location map of Parasai-Sindh watershed

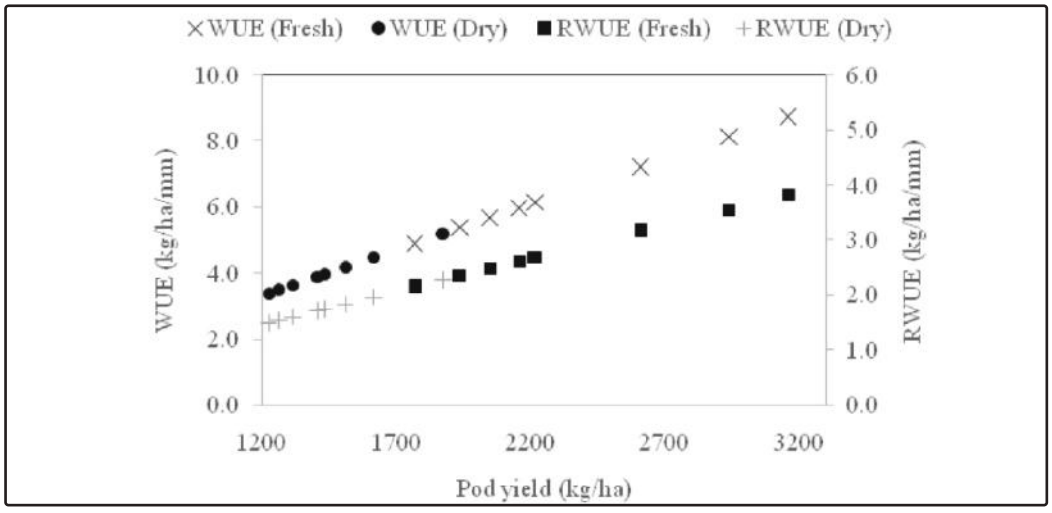

Fig. 2. Relation between RWUE, WUE and pod yield (fresh and dry) of groundnut varieties

varieties viz. Kaushal, ICGS-5 and ICGV-86015.

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Life Table and Population Parameters of Bihar Hairy Caterpillar, *Spilarctia obliqua* Walker on Jute

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***Abstract*:** Life tables and population parameters of the Bihar hairy caterpillar (BHC), *Spilarctia obliqua* Walker were constructed in an environment with unlimited food supply. The highest mortality occurred in the immature stage, especially in the first, second and third instars. The life table analysis showed that the population density of *S. obliqua* decreased gradually. The females lived for a maximum of 6.0 days. Two braconid larval parasitoids, *Meteorusspilosomae* and *Protapantelesobliquae* were the key mortality factors during early stage whereas in late instars, mortality due to virus was more. The population of *S. obliqua* has been predicted to be much higher in the ensuing generation as trend index was positive. This indicates the need of insecticidal intervention to manage this pest as the natural mortality factors were inadequate to suppress the increasing population of the pest in the jute ecosystem. The net reproductive rate (Ro) and intrinsic rate of natural increase (r_m) have been determined to be 533.56 females offspring's/female/generation and 1.15 female's offsprings/female/day, respectively. The mean generation time was 46 days and it is predicted that the population would double within a span of 6.0 days with the existing daily finite rate (ë) of increase of 3.16.

***Key Words*:** Bihar hairy caterpillar, Fertility table, Jute, Life table, Net reproductive rate, *Spilarctia obliqua*

Life table provides an important tool in understanding the changes in population of insect pests during different developmental stages throughout their life cycle. Further, it help to analyze the mortality of insect population to determine key factors responsible for the highest mortality within population from one life stage to another (Kakde *et al*., 2014). It generates simple summary statistics including life expectancy, key mortality factors and natality rate (Ali and Rizvi, 2007). Fertility life tables are appropriate to study the dynamics of arthropods as an intermediate process for estimating parameters related to the population growth potential also called demographic parameters (Southwood and Henderson, 2000). Bihar hairy caterpillar, *Spilarctia obliqua* Walker (Lepidoptera: Arctiidae) is a highly polyphagous nature and it attacks cultivated crops including bastfibre crops such as jute,mesta, ramie and sunnhempand causes severe economic damage (Gupta and Bhattacharya, 2008). The pest infestation besides having direct adverse effect on yield also affect the quality of the fibres. In recent years, outbreaks of this pest noticed during 2011 in jute and 2012 in sunnhemp crop and causing substantial loss to the fibre yield (Satpathy *et al.,* 2014). Timely management of this pest is very important as delay may even lead to complete defoliation of crop if remains unchecked in the field. Thorough understanding of the key mortality factors, population parameters and fecundity rate, can serve as important tools for *S. obliqua* management through more exact predicting and forecasting of its population. Studies of its host plant spectrum, natural enemies, life cycle and breeding potential on various hosts, including jute have been carried out by many workers. However, the life table statistics of this pest has not been studied very elaborately in jute ecosystem. Therefore, the role of natural enemies for management of this pest needs to be explored. Information on spectrum and type of native natural enemies is a pre-requisite for large scale inoculative releases of biocontrol agents. Thus, the objective of the current study was to evaluate fecundity, life expectancy variables, and fertility tables for *S. obliqua* in jute plants in the field.

MATERIAL AND METHODS

Nucleus culture of *S. obliqua* was collected from unsprayed crop at Central Research Institute for Jute and Allied Fibres (CRIJAF) Research farm. Further, the nucleus culture was maintained on jute plant (*Corchorusolitorius* L) in the rearing container (13cm height x13cm dia) with temperature 27±2°C and RH 85±5% in BOD. Ten pairs of freshly emerged moths were allowed to oviposit on 45 days jute plants (*C. olitorius*) which was grown in earthen pot (37.5 upper radiusx15.5 cm lower radius x 27 cm height) and caged in mylar film sheet with 10cm wide base provided with 10% honey solution (soaked on cotton swab) as a food for adults. After 48 h of moth's release, eggs were found in clusters on the lower sides of the leaves were used in the experiments with ?ve replication.

A cohort comprising 100 eggs was taken and kept in an incubator. After hatching, the larvae were reared individually in a plastic vials (13cm height x13cm dia) on jute plants (*C. olitorius*). The centre of the screw was cut open and fine brass mesh of 80 gauge fixed for ventilation. The inner side of top half of each vial was lined with a moist filter paper to prevent desiccation of the leaves. For the final instar larvae moist sterilized sand in each vial was provided for pupation. Observation on hatching, larval and pupal development, adult emergence and daily mortality in eggs, larvae, pupae

and adults were recorded at 24 hrs interval. The female obtained were paired and released in separate plastic jar containing seedling of test plant. The females kept in an incubator at temperature 27±2°C and RH 85±5% with 12:12 hrs photoperiod. Observations on adult mortality, fecundity were recorded.

When larval density of *S. obliqua* was highest, the field populations were examined by sampling randomly selected plant from each corner and the centre of the field to assess the parasitoids present. Each site consisted of 100 jute plants. Observations were taken at 15-day interval for four months (May to August) during 2012 and 2013. Parasitized larvae were collected from the colony after counting total colony size then reared individually in jars until parasitoid emergence. From the above data, simple percentage parasitism was calculated separately for each species of parasitoid.

The age-specific life tables were constructed as per the standard methodology described by Harcourt (1969). The 'k' value indicating the effectiveness of a mortality factor was worked out as per Varley and Gradwell's (1960) method. Age-specific fecundity tables were constructed as per the standard methodology described by Birch (1948). Several population growth indices *viz.,* intrinsic rate of increase, finite rate of increase, net reproductive rate, weekly multiplication rate, mean generation time and doubling time were estimated.

RESULTS AND DISCUSSION

Biology of *S. obliqua*: The incubation period was 4.10±0.42 days and the caterpillar pupated after six instars, an average larval duration of 29.84±2.11 days. The pupal stage lasted about 8.62±0.46 days. The fecundity/femalewas 566.76±24.12. The adult population was predominantly female, with a mean sex ratio (M: F) of 1:2.4. Male longevity was 4.06±0.195 days, whereas females survived for 7.34±0.24 days. These results were in close agreement with Varatharajan*et al.* (1998); Das and Chaudhuri (2005). They found that, egg incubation period, larval, pupal period, adult female moth survival, fecundity andsex ratio (M: F) as 4.0-5.0 days, 28.8-33.0 days, 8.0-11.2 days, 8.0-10 days, 530-618 female and 1:3.6 respectively on sunflower and jute crops. However, Taleb *et al.* (1998) reported that 6.18, 22.37, 7.26, 4.36, 6.10 and 887.60 days of incubation period, total larval period, pupal period, longevity of adult male and female and fecundity, respectively on jute.

Age-specific survival life table of jute hairy caterpillar, *S. obliqua:* The survival rate (lx) of the *S. obliqua*in two different cohortsduring 2012 and 2013 (Fig.1 a, b) showed a similar pattern including high mortality occurred during larval stage, particularly at the early instar growth.The observed survival pattern indicated that the immature *S. obliqua* are more susceptible to the density dependent mortality factors and later stages susceptible unknown virus. The *S. obliqua* survival curve indicated a modest increased rate of mortality during early life stages but a relatively gradual decrease as they reach adult wood. The *S. obliqua* population assumed a type-III survivorship curve according to the classification of Speight *et al.* (1999). Two braconid larval parasitoids, *Meteorusspilosomae*Narendran& Rama and *Protapantelesobliquae* (Wilkinson) were the key mortality factors with the 'k' value of 0.18 whereas in late instars, mortality due to virus was more with 0.21 'k'value. The generation survival was 0.39. The population of *S. obliqua* has been predicted to be much higher in the ensuing generation as trend index was positive. This indicates the need of insecticidal intervention to manage this pest as the natural mortality factors were inadequate to suppress the increasing population of the pest in the jute ecosystem. Higher trend index of *S. obliqua* instead of considerable mortality due to parasitisation and viral infection necessitates the insecticidal management intervention. These results were in close agreement with Varatharajan*et al.* (1998) who have found that *S. obliqua* caterpillars were parasitized by two braconids, *Apantelesobliquae* Wilkinson and *Glyptapantelescreatonoti*Viereck, and a tachnid, *Carcelia* sp. The average parasitism rates in the field were 12.0, 6.0 and 4.0% respectively for the three parasitoids.

Parasitoids: *S. obliqua* caterpillars were parasitized by two braconidslarval parasitoids, *M.spilosomae* and *P.obliquae*. The average parasitism rates in the field were 30.0and 48.0% respectively for the two parasitoids. *M.spilosomae*was found throughout the period of observation with a maximum of 57.0% in June. The parasitization potential of *Meteorus*spp. on *S. obliqua* feeding on cultivated *Vignamungo* and wild weeds, *Xanthium strumarium* and *Partheniumhysterophorus* was to the extent of 77.0% (Gupta and Narendran, 2007). The parasitization of *P. obliquae* was recorded on from Mid-June to Mid-July during the cropping season.

Age-specific fecundity life table of *S. obliqua:* The survivorship (l_x) and fecundity (m_x) of*S. obliqa* are shown in Fig. 2 based on data of Table 1. The first female emerged on day 43.0 and the first first female died on day 49.0.The last females died on day 53.0. The females remained alive for maximum of 6.0 days. Females started laying eggs from 45.0 or within 2.0 days of emerging as adults. The number of eggs deposited was gradually increased in the early stages and decreased during later stages of life span. The population and reproductive parameters of *S. obliqua* are summarized in table 2. The net reproductive rate (Ro) and intrinsic rate of natural increase (r_m) have been determined to be 533.56 females offspring's/female/generation and 1.15 female'soffsprings/female/day, respectively. The mean generation time was 46 days and it is predicted that the population would double within a span of 6.0 days with the existing daily finite rate (ë) of increase of 3.16.Other growth indices including mean generation time (days) (T_c), capacity for increase (r_c)and weekly multiplication rate (WMR) were 47.87, 0.10 and 2.12, respectively (Table 2). The results were close in agreement with Varatharajan*et al*. (1998); Das and Chaudhuri (2005).There reported that the net reproductive rate (Ro) and intrinsic rate of natural increase (rm) as 264.43-

Table 1. Age-specific fecundity of *S. obliqua* on jute

Pivotal age in days (x)	Survival of females at age (lx)	Age-specific fecundity (mx)	No. of progeny per female (lxmx)
0-42* immature stages			
43	0.10	0.00	0.00
44	0.10	0.00	0.00
45	0.10	61.17	61.17
46	0.10	67.91	67.91
47	0.10	70.40	70.40
48	0.10	75.38	75.38
49	0.09	78.33	78.33
50	0.09	71.23	68.47
51	0.07	66.88	50.82
52	0.05	75.47	61.08
53	0.00	0.00	0.00
		566.77	533.56

*4.10, 29.84 and 8.62 days for egg hatching, larval and pupaldurations respectively, i.e. 0-42 days immature stages, 43th day adult emergence

Table 2. Population and reproductive parameters of *S. obliqua* on jute

Parameter	Formula	Value
Approximate generation time (Tc) (days)	$\acute{O} l_X m_X x / \acute{O} l_x m_x$	47.87
Corrected generation time (T) (days)	ln R_o/r_m	46.00
Innate capacity for increase (rc)	log e R0) /Tc	0.10
Intrinsic rate of natural increase (rm)	$\acute{O} e^{-r} m^x l_x m_x = 1$	1.15
Finite rate of increase (ë)	e^rm	3.16
Doubling time (DT) (days)	ln 2/r	6.0
weekly multiplication rate (WMR)	t= 0.69315/rm	2.12
Net reproduction rate (Ro)	$\acute{O} l_x m_x$	533.56

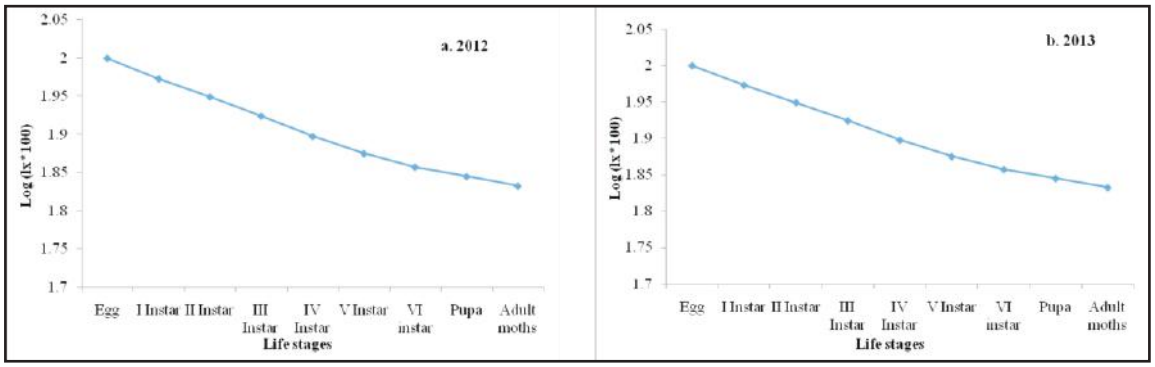

Fig. 1. Survivorship curve (lx) of *S. obliqua* for during 2012 and 2013 cropping season (a, b) as different cohort

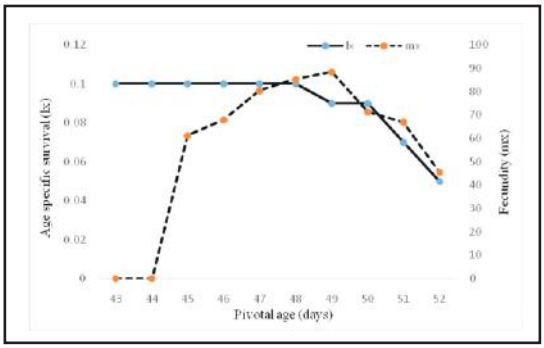

Fig. 2. Daily age-specific survival (lx) and fecundity (mx) of female *S. obliqua*on jute

513 females offspring's/female/generation and 0.129-0.157 female's offsprings/female/day, respectively. Similarly, finite rate of increase, generation time and doubling time as 1.14-1.17, 35.51-48.19 days, 4.41-5.35 days, respectively on sunflower and jute crops. The rm, Tc and DT are useful indices of population growth under a given set of growth conditions. It is generally presumed that short developmental time and high reproduction rate on a host reflect suitability of the plant tested. Life tables with data on the rm of a particular species provide insight into the characteristic life patterns of different species (Satpute *et al*. 2005). There is a range of innate capacity for individual of a population. Insect growth, longevity and reproduction can be influenced by the available food sources (host plants or host prey) and also by environmental factors such as temperature (Ellers-Kirk and Fleischer, 2006).

For present studies it can be concluded that the pattern of survivorship of *S. obliqua* during present study indicated that the immature stage was more susceptible to density dependent factors. The survivorship curve indicated a modest rate of mortality during the early life stages and a gradual decrease as it approached adulthood. The net reproductive rate (Ro) and intrinsic rate of natural increase (r_m) have been determined to be 533.56 females offspring's/female/generation and 1.15 female's off springs/female/day, respectively. The mean generation time was 46 days and it is predicted that the population would double within a span of 6.0 days with the existing daily finite rate (ë) of increase of 3.16.

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Genetic Relatedness of Bacterial Species Isolated from Local Entomopathogenic Nematode Strains of Punjab

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Abstract: Symbiotic bacteria are associated with entomopathogenic nematodes e.g. *Photorhabdus* and *Xenorhabdus* spp with *Heterorhabditis* and *Steinernema,* respectively. In this study bacterial species were isolated from five local strains of EPN, isolated from Punjab soil and their genetic relatedness was studied using RAPD-PCR. Bacterial isolates (1, 2, 3, 4 & 5), isolated from local EPN strains (N-12, N-13, N-14, N-15 & N-17) produced brick red coloured colonies and were non-bioluminescent. The infective juveniles (IJs) of each EPN strains developed into adults within 72 hours, when fed on respective bacterial isolates. This confirmed the association between bacterial isolates and respective EPN strains. The genetic relatedness dendrogram developed based on RAPD-PCR analysis showed isolate 2, 4 and 5 are very closely related. Isolates 1 and 3 have 65% similarity, while these two are different from other isolates by 70 per cent.

Key Words: Bacterial isolates, Dendrogram, EPN, New strains, RAPD-PCR

Entomopathogenic nematodes (EPNs) are known to be symbiotically associated with different bacterial species. The most important are *Xenorhabdus* and *Photorhabdus*, which are associated with infective juveniles of *Steinernema* (Steinernematidae) and *Heterorhabditis* (Heterorhabditidae), respectively (Kaya and Gaugler, 1993). In the family Rhabditidae, a new genus, *Heterorhabditidoides,* has been described which was found to be associated with bacteria, *Serratia nematodiphila* sp. nov. (Zhang *et al*., 2009). Till date, 25 species and 85 strains of *Xenorhabdus* and 3 species (*P. luminescens P. asymbiotica* and *P. temperata)* and 58 strains of *Photorhabdus* have been identified. Symbiotic bacteria cause toxicity to insects by secreting hydrolytic enzymes and toxins like *Toxin complex* (Tca, Tcb, Tcc, Tcd), *Photorhabdus insect related* (Pir), *Makes caterpillar floppy toxins* (Mcf1, Mcf2), *Photorhabdus virulence cassettes* (PVC). The host normally dies due to septicemia within 24-72 hours after nematode penetration (Rodou *et al*., 2010). *Photorhabdus* and *Xenorhabdus* bacteria isolated from *Heterorhabdus* and *Steinernema* nematodes, respectively caused upto 100 per cent mortality of *Plutella xylostella* (Linnaues), *Helicoverpa armigera* (Hubner)*, Pieris brassicae* (Linnaues), *Spodoptera litura* (Fabricius), etc. (Zheng *et al*., 2003; Abdel-Razek, 2003; Mahar *et al*., 2004; Kaya *et al*., 2006). A number of studies have reported success in using RAPD assays to distinguish bacterial strains among diverse species (Saxena *et al*., 2014).

The different EPN strains isolated from different states of India have been tested and found effective against various insect pests *like H. armigera, S. litura*, *Galleria mellonella Linnaeus, Corcyra cephalonica (Stainton), Phenacoccus solenopsis Tinsley*, *Aphis gossypii* Glover and *Bemisia tabaci* (Gennadius) *(Divya et al., 2010*, *Ali et al., 2008;* Kumar and Ganguly, 2011; Pervez and Ali, 2009; Pranaw *et al*., 2013). Recently, five local EPN strains have been isolated from Punjab soils (personal communication). As these strains were new ones, the present study was planned with an aim to isolate bacteria associated with local EPN strains and study the genetic relatedness among these bacterial isolates using RAPD-PCR analysis. Molecular markers provide a means for constructing the molecular phylogenies to study the genetic divergence and polymorphism.

MATERIAL AND METHODS

EPN culture: *Galleria mellonella* (Linnaeus) larvae were collected from bee hives from Apiary, Department of Entomology, Punjab Agricultural University, Ludhiana and stored in incubator at 10ºC. These larvae were used for multiplication of EPN. The EPN strains (N-12, N-13, N-14, N-15 and N-17), procured from Biological Control Laboratory, Department of Entomology, Punjab Agricultural University, Ludhiana, were multiplied on *G. mellonella* larvae and harvested using White Trap technique (Bedding and Akhurst, 1975). Ten *G. mellonella* larvae were exposed to one ml IJs suspension of EPN strain in a petri plate (125 mm diameter) lined with filter paper. The dead insects were placed in modified White trap for collection of infective juveniles (IJs) in water. After washing, these IJs were stored in incubator at

10ºC until used.

Isolation of symbiotic bacteria: The bacterial spp were isolated from each local strain of EPN separately. The IJs were surface sterilized with 0.1 per cent thiomersal, crushed in 100ìl of NBTA (Nutrient bromothymol blue triphenyl tetrazolium chloride agar) broth in sterilized pestel and mortor. The broth was streaked on NBTA media in petri plates with the help of sterile needle. The petri plates were incubated at 28±1ºC for 48 hours (Akhurst, 1980). Alternatively, the proleg of larvae infected by EPN was given a cut and drop of haemolymph from cadaver was streaked on NBTA medium in sterile petri plates (Mahar *et al*., 2004). Five bacterial spp isolated from EPN strains, N-12, N-13, N-14, N-15 and N-17 were named as isolate 1, 2, 3, 4 and 5, respectively. Each bacterial isolate was mixed in glycerol (25%) and preserved at -40ºC till further use. Culture purity was tested by subculturing on NBTA medium. The bacterial colonies were observed for colour and bioluminescens.

Development of IJs on bacterial lawn: To confirm association of bacterial spp with EPNs, the developmental pattern of IJs of local EPN strains was studied. Lawns were prepared by spreading 50 ìl of each bacterial broth on NBTA medium containing the cholesterol (10ìg/ml) (Zhang et al., 2008). The plates were incubated at 28ºC for 48 hours to allow the growth of bacteria. Ten IJs of each isolate were released on bacterial lawn, which represents one replication and there were three replications. Plates were incubated at 22ºC for the growth of IJs. The plates were observed daily to record the development of IJs into adults and next generation.

RAPD analysis: The total genomic DNA was isolated from each bacterial isolates using a modified CTAB method (Cubero *et al*., 1999). The molecular differences between the different bacterial isolates were assessed through comparative RAPD-PCR using six different primers (OPB-07 (GGTGACGCAG), OPB-10 (CTGCTGGGAC), OPG-03 (GAGCCCTCCA), OPL-08 (AGCAGGTGGA), OPN-10 (ACAACTGGGG) and OPP-O4 (GTGTCTCAGG))**.**

PCR reactions were performed in 25 ìl reaction mixture, each containing 20 ng template DNA solution (2 ìl), 1 m*M* dNTPs mix (5 ìl), 10 ì M RAPD primer (5 ìl), Taq Polymerase (0ìl), 1.5 mMMgCl_2 in 10X Taq reaction buffer (2.5 ìl) and sterile milliQ water. The PCR amplification programme consisted of 95°C for 5 min (preheating), 95°C for 1 min, 38°C for 1 min, 72°C for 2 min (36 cycles), 72°C for 10 min (final extension) and stored at 4°C until used. The amplified DNA products were separated by electrophoresis along with a marker (100 bp DNA ladder plus, Fermentas Life Sciences) using 1.5% agarose gel in TAE buffer. The gel was stained with ethidium bromide and the banding profile was visualized and photographed using UV-Gel Documentation system (UltraLum).

All the individual bands in RAPD banding profile, from gel photograph, were scored for presence (1) or absence (0). The data were processed with NTSYS software to calculate Jaccard's coefficient and for developing genetic relatedness dendrogram using 'SimQual' function of UPGMA (NTSYS pc version 2.02) (Rohlf, 1998).

RESULTS AND DISCUSSION

Isolation of symbiotic bacteria: All the bacterial isolates gave brick red coloured and non-bioluminescent colonies on NBTA.

Development of IJs on bacterial lawns**:** The development of IJs of different EPN strains was observed on their respective isolate bacterial lawns. After 24 hrs, out of 10 IJs released, no one developed into adult (Table 1). On next day (48 hrs), IJs of all 5 EPN strains (N-12, N-13, N-14, N-15, N-17) started developing into adults (10.00, 8.67, 9.33, 8.67 and 9.00, respectively). Observation after 72 hours showed that all EPN strains developed into adults and 1st instar IJs of next generation were also observed on the bacterial lawns.

These results showed that these bacterial isolates are involved in development and reproduction of IJs of respective EPN strains. However, at this stage we cannot conclude whether these bacterial isolates are symbiotically associated with the EPN strains or simply act as staple in the nematode diet.

RAPD-PCR analysis: Comparative RAPD-PCR generated a unique set of amplified products ranging from 150 base pairs (bp) to 2900 bp size (Fig. 1). A total of 144 consistent polymorphic bands generated by these ten-mer primers were used for presence/absence data.

Five primers produced ten polymorphic bands to differentiate different bacterial isolates (Table 2). Primer OPB-07 produced a 350 base pair (bp) for isolate 1, OPB-10 produced 2100 and 1600 bp for isolate 1 and 2800 bp fragment for *isolate 3, OPG-03 produced* a 250 bp for isolate 1and 2400 bp fragment for isolate 3, OPN-10 gave a 2100 bp for isolate 3 and OPP-04 produced 1000 and 400 bp for isolate 1 and 1500 bp for isolate 3. Genetic relatedness dendrogram showed isolate 2, 4 and 5 are closely related. Isolate 2 and 5 are 98 per cent similar while these two are different from isolate 4 by only 6 per cent. Isolate 1 and 3 have 63 per cent similarity, however these two are different from isolate 2 and 5 by 70 per cent (Fig. 2).

The RAPD markers can be ideal tools for a large number of species, populations of bacteria which belong to different geographical locations, morphologically different and without any prior knowledge of genetic information.

Table 1. Growth and development of infective juveniles of different EPN strains when released on respective bacterial lawns

EPN strains	Number of IJs or adults								
	0 hrs		24 hrs		48 hrs		72 hrs		
	IJs	Adults	IJs	Adults	IJs	Adults	IJs	Adults	2nd generation
N-12	10	0	10	0	0	10	0	10	Yes
N-13	10	0	10	0	1.33	8.67	0	10	,,
N-14	10	0	10	0	0.67	9.33	0	10	,,
N-15	10	0	10	0	1.33	8.67	0	10	,,
N-17	10	0	10	0	1.00	9.00	0	10	,,

Table 2. Banding profile of RAPD-PCR amplified DNA of different bacterial isolates using different RAPD primers

RAPD primer	Size of amplified DNA bands (bp)				
	Bacterial isolates				
	1	2	3	4	5
OPB-07	1500, 600, 350	1200, 1000	1500, 1200, 1000	1500, 1200, 1000, 600	1200, 1000
OPB-10	2900, 2100, 1600, 1000, 600	700, 450, 250	2900, 2800, 1200, 1000, 600, 450, 250	700, 600, 450, 250	700, 450, 250
OPG-03	1700, 1500, 1200, 450, 400, 250	2900, 1200, 700, 500, 450, 300	2400, 1700, 1500, 1200, 600, 450, 400	2900, 1200, 700, 500, 450, 300	2900, 1200, 700, 500, 450, 300
OPL-08	900, 700, 450, 350	2900, 2100, 1500, 1200, 250	2100, 1500, 900, 700, 450, 350	2900, 2100, 1500, 1200, 250	2900, 2100, 1500, 1200, 250
OPN-10	2000, 1900, 900, 700	1200, 700, 500, 200	2100, 2000, 1900, 900, 700	1200, 700, 500, 200	1200, 500, 200
OPP-04	1900, 1300, 1000, 600, 400	1900, 1200, 1100, 900, 700, 350, 150	1900, 1500, 1300, 1100, 900, 600	1900, 1200, 1100, 900, 700, 350, 150	1900, 1200, 1100, 900, 700, 350, 150

Figures in bold represents the polymorphic marker bands amongst different bacterial isolates

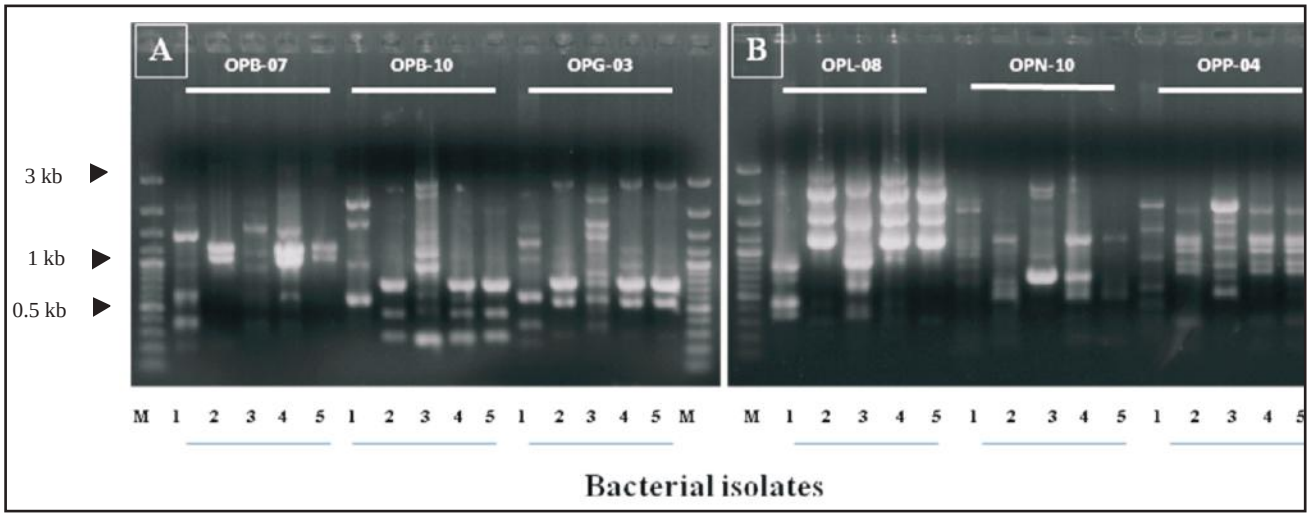

Fig. 1. Comparative RAPD-PCR amplification profile (banding pattern) of different bacterial isolates with six different RAPD primers. M: 100 bp DNA ladder (Fermentas Life Sciences). A: RAPD profile with OPB-07, OPB-10, OPG-03 primers, B: RAPD profile with OPL-08, OPN-10, OPP-04 primers

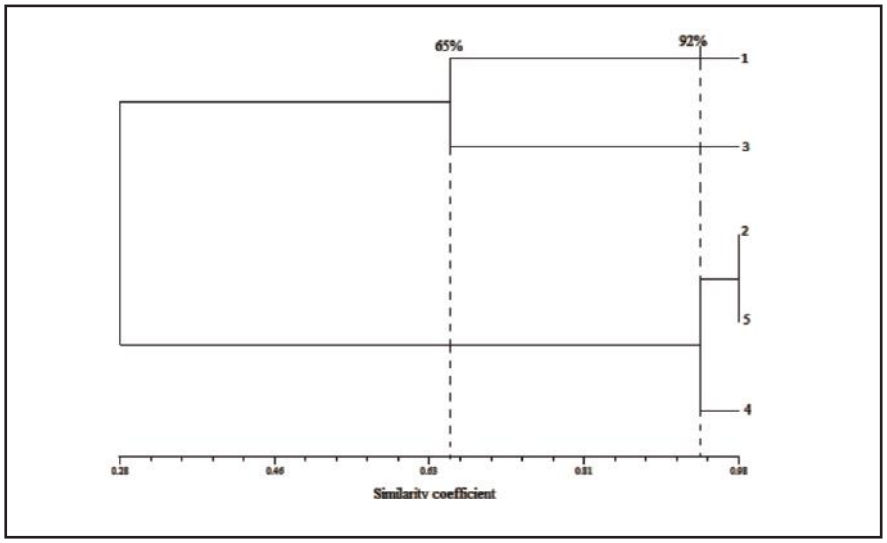

Fig. 2. RAPD-PCR data based genetic relatedness dendrogram amongst different bacterial isolates

RAPD is one of the powerful tools for studying genetic variation in living organisms as it amplifies fragments of genomic DNA (Saxena *et al*., 2014). The molecular characterization of symbiotic bacteria associated with entomopathogenic nematodes isolated from agro climatic zone 5 of Karnataka was studied using RAPD markers by Kumar *et al.* (2011). A total of 44 bands were scored out of which 42 bands were found to be polymorphic. The analysis depicted that the 20 symbiotic bacterial isolates were divided into four major clusters based on RAPD profile. The percent polymorphism observed in the isolates was 95.45% which is quiet high and suggests that the symbiotic bacterial population exhibit high genetic diversity. Tailliez *et al* (2006) also determined the RAPD profiles of *Xenorhabdus* bacteria by using primers P1 (5' TGCTCTGCCC 3'), P2 (5' GGTGACGCAG 3') and P3 (5' TCGCTGGGAC 3') in separate reactions and enterobacterial repetitive intergenic consensus (ERIC) PCR profile was determined using the primers ERIC1R (5'-GCTATGCTCCYGGGGRTT-3') and ERIC2 (5'-ACTATGTGAYTGGGGTGA-3'). At present, PCR amplification of the rDNA analysis method has brought a valuable tool for characterization of bacterial genes. So, for the further confirmation of bacterial spp, there is need of molecular characterization by 16S rDNA sequencing.

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Comparative Biology of Whitefly, *Bemisia tabaci* (Gennadius) on Bt Cotton Hybrids in Punjab

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***Abstract*:** The biology of whitefly, *Bemisia tabaci* was studied on cotton cultivars, viz Ankur 3028 BG II, MRC 6301 Bt and LH 2076 (non-Bt) under screen house conditions for two seasons at Entomological Research Farm, Punjab Agricultural University, Ludhiana. Pooled mean duration of egg, first, second and third nymphal instar, pupal and adult stage varied from 4.20 to 5.30, 4.67 to 4.93, 3.73 to 4.30, 4.37 to 4.93, 3.60 to 4.32 and 4.82 to 5.35 days, respectively on different cultivars. The total life cycle of *B. tabaci* was shortest on Ankur 3028. The overall mean sex-ratio was being in the favour of females. The fecundity of *B. tabaci* was maximum on Ankur 3028. Survival of different immature stages was also higher on Bt cotton than non-Bt cotton. Compared with the non-Bt cotton, the Bt transgenic cotton was more advantageous to the development and reproduction of *B. tabaci*.

***Key Words*:** *Bemisia tabaci*, Biology, Bt cotton

Among several insect pests, whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) has assumed the status of a serious pest of cotton. Up to 1995, it was a minor pest in Punjab, but became a major pest 1996 onwards (Dhawan *et al*., 2007). Owing to the abrupt changes in weather from wet towards dry conditions and indiscriminate use of conventional insecticides especially synthetic pyrethroids in the cotton against bollworm complex before the introduction of *Bt* cotton, the importance of whitefly as a pest of economic importance in different ecosystems has expanded recently. Also, due to the reduction of broad-spectrum insecticides in *Bt* cotton, whitefly survive better and occasionally reach a pest status (Xu *et al.,* 2003). In cotton, it transmits a deadly cotton leaf curl virus (CLCuV) causing a loss of 10.5-92.2 per cent seed cotton yield in Punjab (Singh *et al.,* 1994). Keeping in view its status as a pest and a vector of CLCuV, the detailed studies on its biology were made on Bt and non-Bt cotton.

MATERIAL AND METHODS

The studies on the biology of *B. tabaci* were conducted on Bt cotton hybrids Ankur 3028 BG II and MRC 6301 Bt and cotton variety LH 2076 (non-Bt) under screen house conditions during monsoon season (July-August) of 2012 and 2013 at Entomological Research Farm, Punjab Agricultural University, Ludhiana.

The culture of *B. tabaci* was raised on the potted cotton plants covered with split cages. *B. tabaci* adults were collected from the fields using an aspirator and were released on these cotton plants. Cotton leaves containing red eyed pupae were also plucked from field and placed in screen house. The whiteflies were allowed to develop and multiply on these plants till newly emerged adults appeared on the plants. For maintaining good colonies, the old plants were replaced with new ones, whenever needed. The whiteflies from this culture were further used to conduct the experiment.

The biological parameters of *B. tabaci* were determined by confining the adults in leaf cages (Aneja, 2000). The leaf cages were attached to the lower surface of fully opened top leaves with the help of a hair clip @ 1 leaf cage per plant on 10 potted cotton plants of each cultivar. The newly emerged *B. tabaci* adult pairs were released @ 5 pairs in each leaf cage. The test plant was covered with plant cage, which was supported with the help of 3 sticks around the pot. The plant cage (1.50 m height and 50 cm diameter) was prepared using muslin cloth keeping very small portion open to check the plant. The adults were removed from the cotton leaves after an oviposition exposure of 24 hours. In a leaf cage, only 3 eggs were retained for observations while the remaining eggs were removed carefully. The nymphal instars were observed twice daily as above for their change into next developmental stage. From pupa daily observation for adult emergence was made. The adults were sexed into males and females to determine the sex-ratio. The duration of different life stages i.e. egg, nymphal instars, pupa and adults from 30 individuals were recorded and their means were calculated. The time of emergence and death of *B. tabaci* adults (both male and female) was recorded to calculate its adult longevity.

For studying the fecundity, one pair of the newly emerged adults was released per leaf cage in 10 leaf cages. The first serial transfer was made 72 hours after their release

followed by the subsequent transfer after every 24 hours till the death of the female. The eggs laid by each female before and after each transfer were counted and labeled separately. In this experiment, longevity of adult was also worked out. The sex-ratio was calculated by counting the males and females that emerged in different experiments and in the random field adult collections.

The data on temperature and relative humidity (RH) were obtained from the Meteorological Observatory of Punjab Agricultural University, Ludhiana. Mean temperature and relative humidity during the experiment in 2012 and 2013 were 31.8±1.95 and 31.3±1.33^{0}C and 66.8±9.57 and 73.03±6.27 per cent, respectively.

RESULTS AND DISCUSSION

Biology

Egg: The incubation period differed significantly on different cultivars in 2012 and 2013 (Table 1). The incubation period was significantly lower on cultivar Ankur 3028 (4.13 days) as compared to MRC 6301 and LH 2076 during 2012. Incubation period on Ankur 3028 during 2013 was on a par with MRC 6301 and was significantly lower than LH 2076. Pooled incubation period differed significantly on different cultivars. The minimum period was recorded on Ankur 3028 (4.20 days) followed by MRC 6301. Maximum incubation period was recorded on LH 2076. However, Jindal (2004) reported duration of egg stage as 6.15 days during June-July and 6.00 days during August-September on Bt cotton hybrid 6304.

Nymphal instars: The difference in first instar duration on different cotton cultivars was non-significant during both the years (Table 1). The minimum pooled first instar nymphal period was recorded on MRC 6301(4.67 days) and maximum on LH 2076 (4.93days). On cultivar Ankur 3028 mean duration of first instar nymph was 4.75 days (Table 1). The duration of second instar nymph differed significantly on different cultivars. The minimum period was on cultivar MRC 6301 (3.67 days) which was on a par with Ankur 3028 and followed by LH 2076 during 2012 (Table 1). During 2013, minimum duration was recorded on Ankur 3028 followed by MRC 6301and LH 2017. Pooled duration of second instar nymph was minimum on Ankur 3028 (3.73 days) which was at par with MRC 6301. Maximum duration was recorded on LH 2076. The mean duration of the third instar nymphs varied from 4.26±0.78 to 5.03±0.85 days on different cultivars during 2012 and 2013. Pooled duration of third instar nymph was minimum on Ankur 3028 (4.37days) which was on a par with MRC 6301.

Pupa: The pupal period differed significantly on different cultivars in 2012 and 2013 (Table 1). The minimum pupal period was recorded on Ankur 3028 (3.70 days) which was at par with MRC 6301 and followed by LH 2076 during 2012. Mean pupal period was 3.50, 3.83 and 4.27 days on Ankur 3028, MRC 6301 and LH 2017, respectively during 2013. Pooled pupal period also differed significantly on different cultivars. The minimum period was recorded on Ankur 3028 (3.60 days) followed by MRC 6301 days and LH 2076. However, Jindal (2004) reported duration of pupal period as

Table 1. Duration of different developmental stages of *B. tabaci* on different cultivars of cotton

Cultivar	*Mean duration of different developmental stages (days)						
	Egg	Nymphal period			Pupa	Adult	Total life cycle
		1st instar	2nd instar	3rd instar			
				2012			
Ankur 3028	4.13 (3-5)	4.67 (4-6)	3.93 (3-5)	4.47 (4-6)	3.70 (3-5)	4.77 (4-6)	25.67 (23-28)
MRC 6301	4.57 (3-5)	4.70 (4-6)	3.67 (3-5)	4.83 (4-6)	3.97 (3-5)	5.17 (4-6)	26.90 (24-29)
LH 2076	5.37 (4-6)	4.90 (4-6)	4.43 (4-6)	5.03 (4-6)	4.37 (3-5)	5.27 (4-6)	29.37 (26-30)
CD (p=0.05)	0.31	NS	0.33	0.41	0.34	0.37	0.76
				2013			
Ankur 3028	4.27 (3-5)	4.83 (4-5)	3.53 (3-5)	4.27 (3-5)	3.50 (3-4)	4.87 (4-6)	25.27 (24-29)
MRC 6301	4.40 (3-5)	4.63 (4-6)	3.87 (3-4)	4.26 (3-5)	3.83 (3-4)	5.23 (5-7)	26.23 (23-28)
LH 2076	5.23 (4-6)	4.97 (4-6)	4.17 (3-5)	4.83 (4-6)	4.27 (4-5)	5.43 (4-6)	28.90 (26-30)
CD (p=0.05)	0.35	NS	0.29	0.35	0.23	0.34	0.66
				Pooled			
Ankur 3028	4.20 (3-5)	4.75 (4-6)	3.73 (3-5)	4.37 (3-6)	3.60 (3-5)	4.82 (4-6)	25.47 (23-29)
MRC 6301	4.48 (3-5)	4.67 (4-6)	3.77 (3-5)	4.55 (3-6)	3.90 (3-5)	5.22 (4-7)	26.58 (23-29)
LH 2076	5.30 (4-6)	4.93 (4-6)	4.30 (4-6)	4.93 (4-6)	4.32 (3-5)	5.35 (4-6)	29.13 (26-30)
CD (p=0.05)	0.23	NS	0.22	0.27	0.20	0.25	0.51

* Mean of 30 individuals
Figures in the parentheses denote range

2.83 days during June-July and 1.80 days during August-September on Bt cotton hybrid 6304.

Adult: There was significant difference in longevity of adults on different cultivars. The minimum adult longevity was found on Ankur 3028 (4.77 days) followed by MRC 6301and LH 2076 being at par with each other during 2012 (Table 1). Similar results were obtained during 2013 (Table 1). Pooled adult longevity was minimum on Ankur 3028 (4.82 days) followed by MRC 6301 (5.22 days) which was at par with LH 2076 (5.35 days). However, Jindal (2004) reported that on Bt cotton hybrid 6304 males lived an average of 4.30 and 1.77 days, and females lived an average of 14.17 and 10.73 days during July and August, respectively. Zhou (2006) reported that the life span of female increased by 12.14 per cent on Bt cotton Guokang 22 as compared to non-Bt cotton Simian.

Total life-cycle: Total development period differed significantly on different cultivars in 2012 and 2013 (Table 1). The period was minimum on Ankur 3028 (25.67 days) followed by MRC 6301 and LH 2076 during 2012. During 2013, period was 25.27, 26.23 and 28.90 days on Ankur 3028, MRC 6301 and LH 2017, respectively. Pooled development period also differed significantly on different cultivars. The minimum period was recorded on Ankur 3028 (25.47 days) followed by MRC 6301 (26.58 days) and LH 2076 (29.13 days). The present studies corroborate the findings of Zhou (2006) who reported that the developmental time (from egg to adult) of *B. tabaci* on Bt cotton Guokang No. 22 was shortened by 17.79 per cent than on non-Bt cotton Simian 3. Jindal (2004) reported development period (from egg to adult) as 19.00 days during June-July and 20.20 days during August-September on Bt cotton hybrid 6304.

Sex-ratio: Observations made during 2012 and 2013 revealed overall mean sex-ratio of 1:1.41 being in favour of female. On cultivars Ankur 3028, MRC 6301 and LH 2076 mean sex-ratio of 1:1.47, 1:1.40 and 1:36 was recorded, respectively (Table 2).

Fecundity: The fecundity differed significantly on different cotton cultivars in 2012 and 2013 (Table 2). The fecundity was maximum on Ankur 3028 (50.7 eggs/female) which was on a par with MRC 6301 and followed by LH 2076 during 2012. During 2013, fecundity was 51.2, 49.1 and 45.3 eggs per female on Ankur 3028, MRC 6301 and LH 2017,

Table 2. Fecundity and sex-ratio of *B. tabaci* on different cultivars of cotton

Cultivar	Fecundity		Pooled fecundity	Sex- ratio		Mean sex-ratio
	2012	2013		2012	2013	
Ankur 3028	50.7 (49-54)	51.2 (48-53)	50.95 (48-54)	1:1.43	1:1.50	1:1.47
MRC 6301	48.4 (44-52)	49.1 (45-53)	48.75 (44-53)	1:1.38	1:1.43	1:1.40
LH 2076	44.5 (42-49)	45.3 (44-50)	44.90 (42-50)	1:1.38	1:1.33	1:1.36
CD (p=0.05)	2.52	1.84	1.50	Overall mean sex-ratio		1:1.41

Figures in the parentheses denote range

Table 3. Survival of *B. tabaci* in different immature stages on different cultivars of cotton

Cultivar	Per cent survival in different immature stages				
	Egg stage	Nymph			Pupa
		I	II	III	
			2012		
Ankur 3028	86.67 (68.63)	90.00 (71.80)	93.33 (75.24)	90.00 (71.68)	100 (89.96)
MRC 6301	83.33 (65.95)	93.33 (75.43)	96.67 (80.57)	93.33 (75.36)	100 (89.96)
LH 2076	73.33 (58.94)	86.67 (68.67)	90.00 (71.78)	86.67 (68.88)	96.67 (81.25)
CD (p=0.05)	(1.65)	(2.45)	(2.81)	(2.57)	(2.63)
			2013		
Ankur 3028	83.33 (66.05)	86.67 (68.79)	90.00 (71.82)	93.33 (75.56)	100 (89.96)
MRC 6301	80.00 (63.47)	90.00 (71.65)	93.33 (75.45)	93.33 (75.35)	96.67 (80.45)
LH 2076	70.00 (56.81)	83.33 (65.92)	86.67 (68.69)	90.00 (71.70)	93.33 (75.21)
CD (p=0.05)	(2.03)	(1.95)	(2.54)	(2.65)	(2.30)
			Pooled		
Ankur 3028	85.00 (67.34)	88.33 (70.29)	91.67 (73.53)	91.67 (73.62)	100 (89.96)
MRC 6301	81.67 (64.71)	91.67 (73.54)	95.00 (78.01)	93.33 (75.36)	98.33 (85.21)
LH 2076	71.67 (57.87)	85.00 (67.29)	88.33 (70.23)	88.33 (70.29)	95.00 (78.23)
CD (p=0.05)	(1.41)	(1.73)	(2.11)	(1.93)	(2.40)

Figures in the parentheses are arc sine transformed values

respectively. Pooled fecundity also differed significantly on different cultivars. The maximum fecundity was recorded on Ankur 3028 (50.95 eggs/female) followed by MRC 6301 (48.75 eggs/female) and LH 2076 (44.90 eggs/female). Our results are in agreement with the findings of Jindal (2004) who reported that the average fecundity was 96 eggs per two females on Bt cotton hybrid 6304. Also, Zhou (2006) reported that fecundity on Bt cotton Guokang No. 22 increased by 39.62 per cent than on non-Bt cotton Simian 3.

Survival of different immature stages: Survival of different immature stages differed significantly on different cultivars in 2012 and 2013 (Table 3). Pooled survival in egg stage was significantly higher in Ankur 3028 (85%) followed by MRC 6301 and LH 2076. However, nymphal survival was higher in MRC 6301 as compared to the other two test cultivars. Maximum survival in pupal stage was observed in Ankur 3028 (100%) which was on a par with MRC 6301 (98.33%) and followed by LH 2076 (95%). Our results corroborate the findings of Zhou (2006) who reported that survival of *B. tabaci* on Bt cotton Guokang No. 22 increased by 4.5 per cent than on non-Bt cotton Simian 3. In a similar study Jindal (2004) reported that on Bt cotton hybrid 6304 survival of egg, nymphs and pupa was 85, 53.80 and 75 per cent during June-July and 70, 69.57 and 93.33 per cent during August-September, respectively.

It may be concluded that the Bt transgenic cotton was more advantageous to the development and reproduction of *B. tabaci* as compared to non-Bt transgenic cotton.

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Effect of Transgenic Bt Cotton Hybrids on Larval Mortality of Tobacco Caterpillar, *Spodoptera litura* (Fabricius)

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***Abstract*:** Effect of the promising two BGI hybrids viz., Yuvraj (Cry1Ac + Cry1Ab) and JKCH-1050 (Modified Cry1Ac), three BG II hybrids (Cry1Ac + Cry2Ab) viz., NCS 855, Ankur 3028 and MRC 7017 and one non Bt variety LH 2076 were studied for their effect on first, third and fifth instar larvae of *S. litura*. Among the Bt cotton hybrids, highest mortality of 1st and 3rd instar larvae of *S. litura* was observed in BG II hybrids followed by BG I (Yuvraj and JKCH 1050) when fed on leaves followed by squares and bolls. Among the Bt cotton hybrids, higher mortality of 1st instar larvae of *S. litura* was observed on leaves of BG II hybrids, MRC 7017, Ankur 3028 and NCS 855 (53.61, 53.61 and 52.77 %, respectively) being at par with each other but significantly higher as compared as compared to other hybrids. Among the different days after treatment, significantly highest mortality was observed after 7 DAT (59.16%) followed by 3 DAT (27.91 %). Significantly higher 1st instar larval mortality (32.92 %) was recorded when fed on leaves of 105 day old crop being at par with 120 day old crop (31.67%) followed by 135 day old crop (30.87%). Highest mortality of 3rd instar larvae of *S. litura* was recorded on leaves of BG II hybrids MRC 7017, Ankur 3028 and NCS 855 (18.88, 18.61 and 18.61 %, respectively) as compared to all other hybrids. However, among the days after treatment, significantly highest mortality was observed after 7 DAT (25.56%) followed by 3 DAT (4.72 %) whereas, no mortality was observed after 1 DAT. Highest mortality of 5th instar larvae of *S. litura* was observed on leaves of BG II hybrids whereas no mortality was observed in BG I (Yuvraj and JKCH 1050). However, among the days after treatment, significantly highest mortality was observed after 7 DAT (3.47%) whereas no mortality was observed after 1 and 3DAT. Whereas, non-significant differences in larval mortality was recorded when the 3rd and 5th instars were fed on leaves, squares and bolls of 105, 120 and 135 day old crops.

***Key Words*:** Bt Cotton, Instars, Non-Bt, Mortality, *Spodoptera litura*

The insect pests spectrum of cotton is quite complex and as many as 1326 species of insect pests have been listed on this crop throughout the world. About 134 species of arthropods are found to be associated with cotton crop in Punjab and these include 54 species of insect pests (Bal and Dhawan, 2008). Before the introduction of Bt cotton the cotton crop was attacked by many pests, among them bollworm compex i.e. american bollworm, *Helicoverpa armigera* (Hubner), spotted bollworm, *Earias vittella (*Fabricius), spiny bollworm, *Earias insulana* (Biosdual), pink bollworm, *Pectinophora gossypiella* (Saunders) were most serious and the country ended up consuming insecticides worth Rs. 12 million for managing bollworms alone (Manjunath, 2011).The adoption of transgenic Bt cotton changed the pest scenario and pest status of bollworm complex has declined (Vennila, 2008). However, transgenic Bt cotton with Cry1Ac proved in-effective against *Spodoptera.litura* (Arshad and Suhail, 2011) and the population of *S litura* increased by 119 per cent after introduction of Bt cotton (Cry1Ac) that caused considerable losses in cotton by defoliating it (Jeykumar *et al* 2007). It has greater potential to survive in the presence of *Bt* toxins as compared to other bollworms. Moreover, Saini and Dhawan (2011) found decline in the expression of *Cry1Ac* toxin with increase in the age of crop and also reported higher *Cry1Ac* expression in terminal parts as compared to lower plant parts and more in foliage as compared to fruiting parts. Therefore, Bollgard-II cotton expressing both Cry1Ac and Cry2Ab proteins were introduced with increased efficacy against tobacco caterpillar. However, reports were coming from the field that grown up larvae of *S. litura* were able to feed on the leaves of Bt cotton especially during late in the season when sanitation of cotton fields gets neglected and the population builds up on weeds and alternate hosts. More importantly, every season new Bt cotton cultivars are introduced in Punjab. So, keeping in view the polyphagous nature of the pest and availability of large number of Bt hybrids for cultivation, there was need to study larval mortality of different instars of *S. litura* on transgenic Bt *cotton* hybrids under Punjab conditions on different plant parts at different stages of plant growth.

MATERIAL AND METHODS

The study on the larval mortality of *S. litura* on different cotton hybrids (BG I & BG II) was conducted in the IPM Laboratory, Department of Entomology, PAU, Ludhiana. during *kharif* 2012. It was done on LH 2076 (non Bt) grown specifically for this purpose only from the field collected egg

masses of *S. litura* under laboratory conditions. The required number of freshly hatched neonate larvae (12 hours after hatching), 3rd and 5th instar larvae for the different treatments were obtained from this culture. Six cotton hybrids i.e. two Bt or BGI viz., Yuvraj (Cry1Ac + Cry1Ab) and JKCH 1050 (Modified Cry1Ac), three Bollgard II hybrids (Cry1Ac + Cry2Ab) viz., NCS 855, Ankur 3028 and MRC 7017 and a non Bt LH 2076 hybrid were grown at Entomological Research Farm, Department of Entomology, PAU, Ludhiana during *kharif* 2012 as per PAU recommendations but were kept unsprayed (Anonymous, 2012).

Different plant parts viz. leaves (3rd terminal leaf), squares (from 1st internode i.e. 5-6 days old) and bolls (8-10 days old) collected from 105, 120 and 135 days old plants. The leaves, squares and bolls after suitable trimming were placed individually in petri dishes containing solidified agar to avoid drying. The 1st instar (12 hours old approximately), 3rd and 5th instar larvae were releases in each petri dish containing different plant parts. There were four replications and ten larvae per replication were released. The leaves, squares and bolls were changed daily, the fecal pellets and dead larvae were also removed and the mortality of larva was recorded daily upto 7 days of release.

RESULTS AND DISCUSSION

Mortality of 1st instar larvae of *S. litura*

Among the Bt cotton hybrids, highest mortality of 1st instar larvae of *S. litura* was observed in BG II hybrids followed by BG I (Yuvraj and JKCH 1050) when fed on leaves followed by squares and bolls (Table 1) . When the larvae of *S. litura* were fed on leaves, significantly higher larval mortality was recorded in BG II hybrids MRC 7017, Ankur 3028 and NCS 855 (53.61, 53.61 and 52.77 %, respectively) as compared to other hybrids. However, among the different days after treatment, significantly highest mortality was observed after 7 DAT (59.16%) followed by 3 DAT (27.91 %). When the larvae of *S. litura* were fed on squares highest mortality was observed on BG II hybrids MRC 7017, Ankur 3028 and NCS 855 (51.94, 51.38 and 50.83 %, respectively) being at par with each other as compared to all other cultivars. However among the different days after treatment, significantly highest mortality was observed after 7 DAT (58.47%) followed by 3 DAT (26.25 %). When the larvae of *S. litura* were fed on bolls, highest mortality was observed on BG II hybrids MRC 7017, Ankur 3028 and NCS 855 (49.44 48.61and 48.33 % , respectively) being at par with each other as compared to all other cultivars. However, among the days after treatment, significantly highest mortality was observed after seven DAT (56.53%) followed by three DAT (24.58%).

Significantly, higher per cent larval mortality of the *S. litura* was recorded on the leaves when fed on 105, 120 and 135 day old crop (Table 2). Significantly higher larval mortality (32.92 %) was recorded when fed on leaves of 105 day old crop being at pare with 120 day old crop (31.67%) followed by 135 day old crop (30.87%). However, non-significant differences were recorded when the larvae were fed on squares and bolls of 105, 120 and 135 day old crops.

Mortality of 3rd instar larvae of *S. litura*

Among the Bt cotton hybrids, highest mortality of 3rd instar larvae of *S. litura* was observed in BG II hybrids followed by BG I (Yuvraj and JKCH 1050) when fed on leaves followed by squares and bolls (Table 3) . When the larvae of *S. litura* were fed on leaves, significantly higher larval mortality was recorded in BG II hybrids MRC 7017, Ankur 3028 and NCS 855 (18.88, 18.61 and 18.61 %, respectively) as compared to all other hybrids. However, among the days after treatment, significantly highest mortality was observed after 7 DAT (25.56%) followed by 3 DAT (4.72 %). However no mortality was observed after 1 DAT. When the 3rd instar larvae of *S. litura* were fed on squares, highest mortality was observed on BG II hybrids MRC 7017, Ankur 3028 and NCS 855 (15.83, 15.83 and 14.72 %, respectively) being at par with each other as compared to all other hybrids. However, among the days after treatment, significantly highest mortality was observed after 7 DAT (21.11%) followed by 3 DAT (3.75 %). However, no mortality was observed after one DAT. When the 3rd instar larvae of *S. litura* were fed on bolls, highest mortality was observed on BG II hybrids MRC 7017, Ankur 3028 and NCS 855 (13.06, 12.22 and 11.11 %, respectively) being at par with each other as compared to all other hybrids. However, among the days after treatment, significantly highest mortality was observed after seven DAT (16.39%) followed by three DAT (3.19%). However, no mortality was obs erved after one DAT. Non significant differences were recorded when the 3rd instar larvae of *S. litura* were fed on leaves, squares and bolls of 105, 120 and 135 day old crops (Table 4).However, higher mortality was observed on the leaves of 105 days old crop as compared to 120 and 135 days old crop.

Mortality of 5th instar larvae of *S. litura*

Among the Bt cotton hybrids, highest mortality of 5th instar larvae of *S. litura* was observed in BG II hybrids whereas no mortality was observed in BG I (Yuvraj and JKCH 1050) when fed on leaves followed by squares and bolls (Table 5). When the 5th instar larvae of *S. litura* were fed on leaves, significantly lower larval mortality was recorded in BG II hybrids MRC 7017, Ankur 3028 and NCS 855 (4.16, 3.61 and 3.61 %, respectively). However, among the days after treatment, significantly highest mortality was observed after 7 DAT (5.69%) whereas no mortality was observed after one

Table1. Effect of different plant parts of Bt cotton hybrid on the mortality of 1st instar larvae of *Spodoptera litura*

Cultivar	Larval mortality (%)*											
	Leaves				Squares				Bolls			
	1DAT	3DAT	7DAT	Mean	1DAT	3DAT	7DAT	Mean	1DAT	3DAT	7DAT	Mean
Yuvraj (BG I)	6.66 (12.29)	20.00 (20.64)	33.33 (34.94)	20.00 (24.64)	5.00 (9.21)	19.17 (25.87)	32.50 (34.70)	18.89 (23.26)	5.00 (9.24)	17.50 (24.52)	32.50 (34.62)	18.33 (22.82)
JKCH 1050 (BG I)	3.33 (6.14)	7.50 (13.82)	18.33 22.82	9.72 (14.26)	0.00 (0.05)	5.83 (10.75)	15.83 (23.16)	7.22 (11.31)	0.00 (0.05)	5.00 (9.24)	15.83 (23.16)	6.94 (10.79)
NCS 855 (BG II)	13.33 (21.13)	45.00 (42.09)	100.00 (89.96)	52.77 (51.06)	10.00 (18.43)	42.50 (40.65)	100.00 (89.96)	50.83 (49.68)	9.17 (16.89)	40.83 (39.69)	95.00 (80.75)	48.33 (45.78)
Ankur 3028 (BG II)	13.33 (21.13)	47.50 (43.59)	100.00 (89.96)	53.61 (51.53)	10.00 (18.43)	44.17 (41.58)	100.00 (89.96)	51.38 (49.99)	9.17 (16.89)	41.67 (40.18)	95.00 (80.75)	48.61 (45.93)
MRC 7017 (BG II)	13.33 (21.13)	47.50 (43.59)	100.00 (89.96)	53.61 (51.54)	10.00 (18.43)	45.83 (42.57)	100.00 (89.96)	51.94 (50.32)	10.00 (18.42)	42.50 (40.65)	95.83 (82..28)	49.44 (47.12)
LH 2076 (Non-Bt)	0.00 (0.05)	0.00 (0.05)	3.33 (6.14)	1.11 (2.07)	0.00 (0.05)	0.00 (0.05)	2.50 (4.61)	0.83 (1.53)	0.00 (0.05)	0.00 (0.05)	5.000 (9.24)	1.67 (3.07)
Mean	8.33 (13.65)	27.91 (28.24)	59.16 (56.38)	–	5.83 (10.75)	26.25 (26.91)	58.47 (55.39)	–	5.55 (10.24)	24.58 (25.71)	56.53 (51.80)	–

* Mean of 4 replications; DAT-days after treatment; Figure in parentheses are angular transformations

CD (p=0.05)	Cultivars	Plant parts	Interaction
Leaves	(2.25)	(1.59)	(3.91)
Squares	(2.09)	(1.47)	(3.62)
Bolls	(2.71)	(1.91)	(4.69)

Table 2. Effect of different plant parts and plant stages of Bt cotton hybrids on the mortality of 1st instar larvae of *Spodoptera litura*

Cultivar	Larval mortality (%)*											
	Leaves				Squares				Bolls			
	105 DAS	120 DAS	135 DAS	Mean	105 DAS	120 DAS	135 DAS	Mean	105 DAS	120 DAS	135 DAS	Mean
Yuvraj (BG I)	21.66	20.00	18.33	20.00 (24.64)	19.17	19.17	18.33	18.89 (23.26)	19.17	18.33	17.50	18.33 (22.82)
JKCH 1050 (BG I)	10.83	10.00	8.33	9.72 (14.26)	8.33	6.67	6.67	7.22 (11.31)	7.50	6.67	6.67	6.94 (10.79)
NCS 855 (BG II)	54.16	52.50	51.66	52.77 (51.06)	51.67	50.83	50.00	50.83 (49.68)	50.83	48.33	45.83	48.33 (45.78)
Ankur 3028 (BG II)	55.00	53.33	52.50	53.61 (51.53)	51.67	51.67	50.83	51.38 (49.99)	50.83	49.17	45.83	48.61 (45.93)
MRC 7017 (BG II)	55.00	53.33	52.50	53.61 (51.54)	53.33	51.67	50.83	51.94 (50.32)	51.67	49.17	47.50	49.44 (47.12)
LH 2076 (Non-Bt)	0.83	0.83	1.66	1.11 (2.07)	0.83	0.83	0.83	0.83 (1.53)	1.67	1.66	1.67	1.67 (3.07)
Mean	32.92 (33.62)	31.67 (32.75)	30.87 (31.89)	_	30.83	30.14	29.58	_	30.28	28.89	27.50	_

* Mean of 4 replications; DAS-days after sowing ; Figure in parentheses are angular transformations

CD (p=0.05)	Cultivars	DAS	Interaction
Leaves	(2.25)	(1.09)	NS
Squares	(2.09)	NS	NS
Bolls	(2.71)	NS	NS

Table 3. Effect of different plant parts of Bt cotton hybrid on the mortality of 3rd instar larvae of *Spodoptera litura*

Cultivar	Larval mortality (%)*											
	Leaves				Squares				Bolls			
	1DAT	3DAT	7DAT	Mean	1DAT	3DAT	7DAT	Mean	1DAT	3DAT	7DAT	Mean
Yuvraj (BG I)	0.00 (0.05)	0.83 (1.53)	9.17 (16.89	3.33 (5.57)	0.00 (0.05)	0.00 (0.05)	6.67 (12.28)	2.22 (4.09)	0.00 (0.05)	0.00 (0.05)	6.66 (12.28)	2.22 (4.08)
JKCH 1050 (BG I)	0.00 (0.05)	0.00 (0.05	3.33 (6.14)	1.11 (2.05)	0.00 (0.05)	0.00 (0.05)	2.50 (4.61)	0.83 (1.53)	0.00 (0.05)	0.00 (0.05)	0.83 (1.53)	0.28 (0.51)
NCS 855 (BG II)	0.00 (0.05)	10.00 (18.42)	45.83 (42.57)	18.61 (20.34)	0.00 (0.05)	7.50 (13.82)	36.67 (37.21)	14.72 (17.01)	0.00 (0.05)	5.83 (10.75)	27.50 (31.54)	11.11 (14.09)
Ankur 3028 (BG II)	0.00 (0.05)	9.17 (16.89)	46.67 (43.05)	18.61 (20.34)	0.00 (0.05)	7.50 (13.82)	40.00 (39.20)	15.83 (17.67)	0.00 (0.05)	6.67 (12.28)	30.00 (33.10)	12.22 (15.13)
MRC 7017 (BG II)	0.00 (0.05)	8.33 (15.35)	48.33 (44.02)	18.88 (19.79)	0.00 (0.05)	7.50 (13.82)	40.00 (39.20)	15.83 (17.67)	0.00 (0.05)	6.67 (12.28)	32.50 (34.70)	13.06 (15.66)
LH 2076 (Non-Bt)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05	0.83 (1.53)	0.28 (0.51)	0.00 (0.05)	0.00 (0.05)	0.83 (1.53)	0.28 (0.51)
Mean	0.00 (0.05)	4.72 (8.71)	25.56 (25.16)	_	0.00 (0.05)	3.75 (6.91)	21.11 (22.34)	_	0.00 (0.05)	3.19 (5.88)	16.39 (18.97)	_

*Mean of 4 replications; DAT-days after treatment; Figure in parentheses are angular transformations

CD (p=0.05)	Cultivars	Plant parts	Interaction
Leaves	(1.98)	(2.41)	(2.47)
Squares	(1.40)	(1.71)	(1.75)
Bolls	(3.44)	(4.18)	(4.29)

Table 4. Effect of different plant parts and plant stages of Bt cotton hybrids on the mortality of 3rd instar larvae of *Spodoptera litura*

Cultivar	Larval mortality (%)*											
	Leaves				Squares				Bolls			
	105 DAS	120 DAS	135 DAS	Mean	105 DAS	120 DAS	135 DAS	Mean	105 DAS	120 DAS	135 DAS	Mean
Yuvraj (BG I)	4.17	2.50	3.33	3.33 (5.57)	2.50	2.50	1.67	2.22 4.09)	2.50	2.50	1.67	2.22 (4.09)
JKCH 1050 (BG I)	1.67	0.83	0.83	1.11 (2.05)	0.83	0.83	0.83	0.83 (1.53)	0.83	0.00	0.00	0.28 (0.51)
NCS 855 (BG II)	19.17	18.33	18.33	18.61 (20.34)	15.83	15.00	13.33	14.72 (17.01)	11.67	10.83	10.83	11.11 (14.09)
Ankur 3028 (BG II)	19.17	19.17	17.50	18.61 (20.34)	16.66	15.83	15.00	15.83 (17.67)	14.17	11.67	10.83	12.22 (15.13)
MRC 7017 (BG II)	20.00	19.17	17.50	18.88 (19.79)	16.66	15.83	15.00	15.83 (17.67)	14.17	13.33	11.67	13.06 (15.66)
LH 2076 (Non-Bt)	0.00	0.00	0.00	0.00 (0.05)	0.00	0.00	0.83	0.28 (0.51)	0.00	0.00	0.83	0.28 (0.51)
Mean	10.69	10.00	9.58	_	8.75	8.33	7.78	_	7.22	6.39	5.97	_

* Mean of 4 replications; DAS-days after sowing; Figure in parentheses are angular transformations

CD (p=0.05)	Cultivars	DAS	Interaction
Leaves	(1.98)	NS	NS
Squares	(1.40)	NS	NS
Bolls	(3.44)	NS	NS

Table 5. Effect of different plant parts of Bt cotton hybrid on the mortality of 5th instar larvae of *Spodoptera litura*

Cultivar	Larval mortality (%)*											
	Leaves				Squares				Bolls			
	1DAT	3DAT	7DAT	Mean	1DAT	3DAT	7DAT	Mean	1DAT	3DAT	7DAT	Mean
Yuvraj (BG I)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)
JKCH 1050 (BG I)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)
NCS 855 (BG II)	0.00 (0.05)	0.00 (0.05)	10.83 (19.17)	3.61 (6.41)	0.00 (0.05)	0.00 (0.05)	9.16 (16.89)	3.06 (5.67)	0.00 (0.05)	0.00 (0.05)	6.66 (12.29)	2.22 (4.14)
Ankur 3028 (BG II)	0.00 (0.05)	0.00 (0.05)	10.83 (19.17)	3.61 (6.41)	0.00 (0.05)	0.00 (0.05)	10.00 (18.43)	3.33 (6.18)	0.00 (0.05)	0.00 (0.05)	6.66 (12.29)	2.22 (4.14)
MRC 7017 (BG II)	0.00 (0.05)	0.00 (0.05)	12.50 (20.41)	4.16 (6.85)	0.00 (0.05)	0.00 (0.05)	10.00 (18.43)	3.33 (6.18)	0.00 (0.05)	0.00 (0.05)	7.50 (13.83)	2.50 (4.64)
LH 2076 (Non-Bt)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)	0.00 (0.05)
Mean	0.00 (0.05)	0.00 (0.05)	5.69 (9.81)	–	0.00 (0.05)	0.00 (0.05)	4.86 (8.99)	–	0.00 (0.05)	0.00 (0.05)	3.47 (6.43)	–

* Mean of 4 replications; DAT-days after treatment; Figure in parentheses are angular transformations

CD (p=0.05)	Cultivars	Plant parts	Interaction
Leaves	(0.57)	(0.58)	(1.82)
Squares	(0.41)	(0.56)	(1.29)
Bolls	(1.02)	(1.07)	(3.18)

and three DAT. When the 5th instar larvae of *S. litura* were fed on squares, lowest mortality was observed on BG II hybrids MRC 7017, Ankur 3028 and NCS 855 (3.33, 3.33 and 3.06 %, respectively) being at par with each other. However, among the days after treatment, significantly highest mortality was observed after 7 DAT (4.86%) whereas no mortality was observed after one and three DAT. When the 5th instar larvae of *S. litura* were fed on bolls, lowest mortality was observed on BG II hybrids MRC 7017, Ankur 3028 and NCS 855 (2.50, 2.22 and 2.22 %, respectively) being at par with each other, whereas no mortality was observed on BG I hybrids. However, among the days after treatment, significantly highest mortality was observed after 7 DAT (3.47%) whereas no mortality was observed after one and three DAT

Non-significant differences were recorded when the 5th instar larvae of *S. litura* were fed on leaves, squares and bolls of 105, 120 and 135 day old crops (Table 6). However, higher mortality was observed on the leaves of 105 days old crop (2.08 %) as compared to 120 and 135 days old crop**.**

The present findings are in accordance with Naik *et al* (2013) who reported maximum mortality (100.00%) of first instar larvae of *S. litura* at 72 hours of treatment when fed with leaves of RCH 2 (BG-II) compared to RCH 2 *Bt*, RCH 2 non *Bt*, JK Durga *Bt*, JK Durga non *Bt*, Nath baba *Bt* and Nath baba non *Bt* and reported similar pattern on squares. Saini and Dhawan (2013) gave similar reports that maximum mean per cent mortality of *S. litura* when fed on leaves of RCH 134 BG II followed by RCH 134 BG I after seven days of exposure. They further reported significant decline in the larval mortality with increase in the crop. Similarly, Selvi *et al* (2012) reported that fusion Bt hybrids tested showed lesser mortality of *S litura* neonate larvae in comparison to BG II cultivars. Soujanya *et al* (2011) reported cent per cent mortality of 1st instar larvae of *S. litura* when fed on leaves of the dual toxin BG II cultivars as compared to 15 per cent in single toxin Bt cultivars as well as non Bt and further reported similar trend of higher per cent mortality of 3rd instar of *S. litura* on leaves as well as squares of BG II cultivars as compared to BG I and non Bt hybrids which showed no mortality. However, in case of 5th instar no mortality was observed in any of the BG II, BG I and non Bt hybrids. Prasad and Sreedhar (2011) in his studies on age specific survivorship and mortality of *S. litura* also reported that survival of early instars was significantly low on BG-II hybrid (Mallika) in comparison to BG I and non-Bt hybrids. Hallad *et al* (2011) also recorded highest mortality of 2nd instar larvae *S. litura* in Tulasi 4 BG-II as compared to its BG-I counterpart i.e.Tulasi-4 recorded least mortality of 2nd instar larvae at 80 and 110 DAS respectively. However, Govindan *et al* (2009) reported that RCH 2 Bt young green bolls showed highest per cent mortality 1st instar larva of *S.*

Table 6. Effect of different plant parts and plant stages of Bt cotton hybrids on the mortality of 5th instar larvae of *Spodoptera litura*

Cultivar	Larval mortality (%)*											
	Leaves				Squares				Bolls			
	105 DAS	120 DAS	135 DAS	Mean	105 DAS	120 DAS	135 DAS	Mean	105 DAS	120 DAS	135 DAS	Mean
Yuvraj (BG I)	0.00	0.00	0.00	0.00 (0.05)	0.00	0.00	0.00	0.00 (0.05)	0.00	0.00	0.00	0.00 (0.05)
JKCH 1050 (BG I)	0.00	0.00	0.00	0.00 (0.05)	0.00	0.00	0.00	0.00 (0.05)	0.00	0.00	0.00	0.00 (0.05)
NCS 855 (BG II)	4.17	3.33	3.33	3.61 (6.41)	3.33	3.33	2.50	3.06 (5.67)	2.50	2.50	1.67	2.22 (4.14)
Ankur 3028 (BG II)	4.17	3.33	3.33	3.61 (6.41)	3.33	3.33	3.33	3.33 (6.18)	2.50	2.50	1.67	2.22 (4.14)
MRC 7017 (BG II)	4.17	4.17	4.17	4.17 (6.85)	3.33	3.33	3.33	3.33 (6.18)	2.50	2.500	2.50	2.50 (4.64)
LH 2076 (Non-Bt)	0.00	0.00	0.00	0.00 (0.05)	0.00	0.00	0.00	0.00 (0.05)	0.00	0.00	0.00	0.00 (0.05)
Mean	2.08	1.81	1.81	–	1.67	1.67	1.53	–	1.25	1.25	0.97	–

* Mean of 4 replications; DAS-days after sowing; Figure in parentheses are angular transformations

CD (p=0.05)	Cultivars	DAS	Interaction
Leaves	(0.57)	NS	NS
Squares	(0.41)	NS	NS
Bolls	(1.02)	NS	NS

litura followed by top fully opened young leaves, squares and middle leaves 168 hours after the treatments.

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Population Dynamics of Citrus Leaf Miner, *Phyllocnistis citrella* Stainton on Kinnow and Rough Lemon

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Abstract: The observation on population dynamics of citrus leaf miner, *Phyllocnistis citrella* Stainton during 2012 and 2013, revealed that larval population was present on Kinnow and rough lemon from February to November and no population was found during December and January but during this period only pupae were present. The population started appearing on citrus shoots by mid February and a significant increase was observed in the month of April. There was a progressive increase and reached at its peak in May (12.85 and 12.0 larvae/10 cm twig on Kinnow and rough lemon). During this period, the maximum and minimum temperature (°C), relative humidity (%), rainfall (mm) and sunshine (hrs) ranged from 31.8-35.1, 15.3-18.9, 50.0-59.0, 0-19.8 and 7.6-9.4, respectively. Thereafter, a sharp decline in citrus leaf miner population was observed on both the host plants and reached at its minimum during June but from July onwards it started increasing and had another peak period during September. Correlation analysis indicated that the maximum and minimum temperature (°C), and sunshine (hrs) were positively correlated with larval population during both the years. The rainfall was found positively correlated during 2012 and negatively correlated during 2013.

Key Words: Citrus leaf miner, Kinnow, *Phyllocnistis citrella,* Population dynamics, Rough lemon

Citrus leaf miner, *Phyllocnistis citrella* Stainton (Gracillariidae: Lepidoptera), is an important pest of citrus, other species of Rutaceae family and some related ornamental plants. **It** is the most destructive pest and mostly attacks nurseries, young plantations and tender flushes with about 16 overlapping generations during the active period in a year. Kalidas and Shivankar (1994) reported that more than 80 per cent nurseries were infested by this pest in India but the damage is less significant in mature trees (Uygun *et al*., 2000). Keeping in view the importance of citrus leaf miner, the present study was carried out under Punjab conditions to find out weak links for its management.

MATERIAL AND METHODS

In order to estimate the population fluctuation of citrus leaf miner, weekly observations were made from January, 2012 to December, 2013 at Fruit Research Farm, Department of Fruit Science, Punjab Agricultural University, Ludhiana on Kinnow and rough lemon. Larval counts were made from 10 cm apical portion of 5 terminal shoots/plant. Five plants of each species were taken and single plant represented as a replication. No insecticide sprays were applied during the period of the study. In each observation, the trees were selected randomly and 5 shoots were taken from all the directions of the tree. Larval counts were made from lower and upper surface of the leaves and were pooled month-wise. The monthly larval counts were then correlated with minimum and maximum temperatures (°C), relative humidity (%), rainfall (mm) and sunshine (hrs). Regression analyses were also performed with the different abiotic factors.

RESULTS AND DISCUSSION

The fluctuation of citrus leaf miner population during 2012 and 2013 on Kinnow and rough lemon (Fig. 1) indicated that the larval population was present from mid-February to November but there was no population during December and January. The population started appearing on citrus shoots from mid-February onwards during both the years and a significant increase was recorded in the month of April. The population remained quite high during this month and subsequently reached at its first peak in May (13.7 in 2012, 12.0 in 2013 and with an average of 12.85 larvae/10 cm twig on Kinnow and 12.1 in 2012, 11.9 in 2013 and with an average of 12.0 larvae/10 cm twig on rough lemon) when maximum and minimum temperature (°C), relative humidity (%), rainfall (mm) and sunshine (hrs) ranged from 39.6-40.6, 22.6-23.0, 31.8-38.0, 1.2-1.6 and 7.6-9.7, respectively. The results showed that high temperature coupled with low humidity were conducive for the build up of *P. citrella* population on both the host (Kinnow and rough lemon). It was further clear that the trend of leaf miner infestation remained same during both the years. Zeb *et al.* (2011) reported that leaf miner attack started from mid-January in Palai and Charbagh while in Khanpur its attack started from February which is at variation to the present study as tha incidence of leaf miner in Punjab appeared slightly late. The variations could be due to prevailing climatic conditions and host plant.

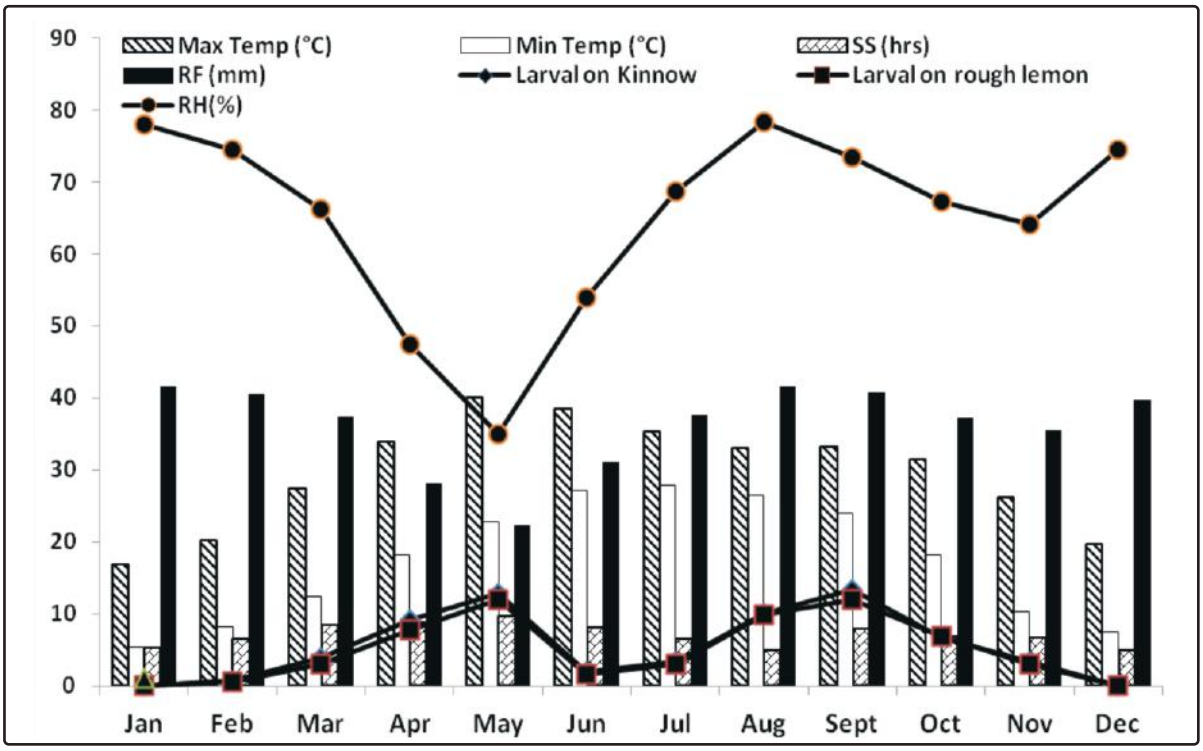

Fig. 1. Larval population of *P. citrella* during different months in relation to different abiotic factors on Kinnow and rough lemon

High population densities of *P. citrella* are usually recorded in spring and summer due to greater availability of new shoots leaves, as well as higher temperatures (Diez *et al*., 2006). The population of leaf miner declined sharply in the month of June (Fig. 1) and remained quite low upto mid-July. Thereafter, the larval population started increasing and reached at its second peak of the year in September (13.6 and 13.1 in 2012 and 2013) with an average of 13.4 larvae/10 cm apical portion of twig on Kinnow, and 10.5 in 2012, 11.3 in 2013 with an average of 10.9 larvae/10 cm apical portion of shoot/twig of rough lemon). The results further indicated that rough lemon being the rootstock of Kinnow scion had slightly low population of *P. citrella.* The hypothesis of high temperature and dry climatic condition put forth in the month of May for the build up of P. citrella population was nullified in the month of September due to the fact that maximum and minimum temperature, relative humidity, rainfall and sunshine during this period varied from 32.8-33.8°C, 24.0-24.1°C, 73.5 percent, 37.5-141.7 mm and 7.8-8.1 hrs, respectively. The availability of new flush could be the major biotic component for the high population build up of *P. citrella.*

Under Punjab conditions, Sharma *et al.* (2006) showed that citrus leaf miner had two peaks of infestation i.e. first during April-May and again during September-October which corroborate the present study. The present study is also in agreement with the findings of Ahmed *et al.* (2013) who reported that the larval population of leaf miner was higher during August-September than during the rest of the period of their study but these authors had not shown any peak period of infestation during April-May. Lad et al. (2010) recorded two peaks during second week of October and fifth week of March in Maharahtra which also corroborate the present study. In Mexico, Legaspi *et al.* (2001) reported that *P. citrella* populations began to increase earlier (in April) and numbers per leaf were generally higher, reaching at its peak in early July and then in late September which is at variation to the present study. Minimum and medium temperature and relative humidity were the abiotic factors showing the strongest influence in the numbers of *P. citrella* mines and larvae (Jesus *et al*., 2008) which also support the current studies especially during September-October. Elekcioðlu *et al.* (2013) reported that *P. citrella* populations declined in November and December through April and Zeb *et al.* (2011) recorded zero fresh attack of leaf miner from mid-December till first half of January in Charbagh. These findings corroborate the present study and it can be concluded that non-availability of new growth and low temperature could be detrimental for the build up of *P. citrella population from mid-November to mid-February.* The environmental temperature and relative humidity of spring and autumn influenced the incidence of citrus leaf miner resulting in higher pest population and plant damage but the low environmental temperature in the winter months and excessive rainfall in the monsoon season adversely affected the pest in Bangladesh

(Rahman *et al.,* 2005), however, the moderate environmental conditions of spring and autumn were, therefore, the most favourable periods for *P. citrella* which was similar to the present findings. The correlation between larval populations of citrus leaf miner on Kinnow and rough lemon (Table 1) showed that the the maximum and minimum temperature (°C), and sunshine (hrs) were positively correlated with larval population during both the years, however, the rainfall showed positive correlation with the population during 2012 and negative correlation in next year. Ahmed *et al.* (2013) reported that maximum, minimum and average temperature (°C) had positive relationship with leaf miner incidence which corroborate the present findings. While, the relative humidity was negatively correlated with the population during both the years. In Gujarat, the larval population was higher during August-September than at any other time and minimum temperature had a positive association with pest population, while sunshine hours and vapour pressure deficit showed negative associations (Patel *et al.*, 1994). Rao *et al*. (2002) found that the infestation of citrus leaf miner was positively correlated with maximum and minimum temperatures and negatively correlated with relative humidity which is also true

Table 1. Correlation and regression between citrus leaf miner with different abiotic factors on Kinnow

Kinnow

Simple correlations (r)

	2012	2013	Overall
Max. Temp. (^oC)	0.62*	0.73**	0.68*
Min. Temp. (^oC)	0.59*	0.61*	0.60*
Rel. Humidity (%)	-0.29	-0.48	-0.41
Sunshine (hrs)	0.34	0.54	0.49
Rainfall (mm)	0.47	-0.06	-0.39

Multiple correlations (R)

$R_{2012} = 0.94$; $R^2 = 0.88$; Adjusted $R^2 = 0.78$

$R_{2013} = 0.82$; $R^2 = 0.67$; Adjusted $R^2 = 0.39$

$R_{overall} = 0.70$; $R^2 = 0.49$; Adjusted $R^2 = 0.35$

Multiple regression line

$$Y_{2012} = -26.15 + 1.63X_1 - 1.52X_2 - 0.03X_3 + 0.76X_4 + 0.14X_5$$

$$Y_{2013} = -22.26 + 0.63X_1 + 0.004X_2 + 0.12X_3 + 0.30X_4 - 0.02X_5$$

$$Y_{overall.} = -31.10 + 0.99X_1 - 0.38X_2 + 0.18X_3 + 0.34X_4 - 0.004X_5$$

Rough lemon

Simple correlations (r)

	2012	2013	Overall
Max. Temp. (^oC)	0.62*	0.72**	0.68*
Min. Temp. (^oC)	0.60*	0.61*	0.61*
Rel. Humidity (%)	-0.27	-0.47	-0.39
Sunshine (hrs)	0.34	0.47	0.45
Rainfall (mm)	0.49	-0.06	-0.37

Multiple correlations (R)

$R_{2012} = 0.93$; $R^2 = 0.86$; Adjusted $R^2 = 0.75$

$R_{2013} = 0.81$; $R^2 = 0.66$; Adjusted $R^2 = 0.38$

$R_{overall} = 0.70$; $R^2 = 0.49$; Adjusted $R^2 = 0.35$

Multiple regression line

$$Y_{2012} = -21.31 + 1.51X_1 - 1.37X_2 - 0.04X_3 + 0.28X_4 + 0.12X_5$$

$$Y_{2013} = -23.87 + 0.86X_1 - 0.14X_2 + 0.14X_3 - 0.23X_4 + 0.02X_5$$

$$Y_{overall} = -27.76 + 1.06X_1 - 0.45X_2 + 0.16X_3 - 0.15X_4 - 0.003X_5$$

Where, X_1 = Maximum temperature (^oC); X_2 = Minimum temperature (^oC); X_3 = Relative Humidity (%); X_4 = Sunshine (hrs); X_5 = Rainfall (mm)

Correlation is significant at the 0.01** level and 0.05* level

in the present findings. The co-efficient of determination (R^2) indicated that all abiotic factors contributed about 88.0 (2012), 67.0 (2013) and 49.0 (average) per cent on Kinnow, and 86.0 (2012), 66.0 (2013) and 49.0 (average) per cent on rough lemon, for the build up of larval population of *P. citrella*.

There was no population during December and January except pupal stage but started to appear by mid February and a significant increase was observed in the month of April. There was a progressive increase and reached at its peak in May (12.85 and 12.0 larvae/10 cm twig on Kinnow and rough lemon). Thereafter, a sharp decline in citrus leaf miner population was observed on both the host plants and reached at its minimum during June but from July onwards it started increasing and had another peak period during September.

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Bio-efficacy of *Nomuraea rileyi* against *Helicoverpa armigera* (Hubner)

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Abstract: *In vitro* investigations were carried out to assess the susceptibility of different larval instars of *Helicoverpa armigera* (Hub.) against entomogenous fungus, *Nomuraea rileyi (Farlow) Samson* by different bio-assay methods *viz.* leaf dip, larval treatment by topical application and leaf + larval treatment (combination). Bioassays of different instars of *H. armigera* with critical concentrations of *N. rileyi* revealed that mortality in 2nd, 3rd and 4th instar ranged from 46.67% to 83.33%, 43.33% to 76.67% and 30.0% to 70.00 % in leaf dip, larval and leaf + larval bioassay, respectively. The dose mortality response (LC_{50} value) of 3.96 x 10^5, 4.29 x 10^4 and 9.96 x 10^3 spores/ml for 2nd instar larvae, 1.67 x 10^6, 4.56 x 10^5 and 6.11 x 10^4 spores/ml for 3rd instar larvae, whereas, LC_{50} values of 2.79 x 10^7 spores/ml, 1.99 x 10^6 spores/ml and 2.94 x 10^5 spores/ml for 4th instar *H. armigera* larvae by leaf dip, larval bioassay and leaf dip + larval bioassays were estimated, respectively. The corresponding LT_{50} value for various concentrations under evaluation (10^9 - 10^5 spores/ml) was in the range of 119.64 to 206.09 hr, 105.16 to 189.45 hr and 95.53 to 164.43 hr for respective bioassay methods. The LC_{50} and LT_{50} data revealed reducing susceptibility trend for higher larval instars.

Key Words: Bioassay, *Helicoverpa armigera,* Instar-wise susceptibility, *Nomuraea rileyi*

Helicoverpa armigera (Hubner) (Lepidoptera:Noctuidae) is the most notorious insect pest that causes heavy losses in several important crops like pigeonpea, chickpea, tomato, sorghum etc. Management of *H. armigera* relies mainly on utilization of chemical insecticides including carbamates, oraganochlorines, pyrethroids, organophosphates along with newer chemistries. Moreover, *H. armigera* has developed resistance to most of these insecticides (Kranthi, 2012; Yang *et al.,* 2013). Alternatively, there is an eco friendly option in utilizing biological agents such as bacteria, viruses, and fungi for the management of insect pests. Among the various biological agents use of entomogenous fungi, *Nomuraea rileyi* (Farlow) Samson (Deuteromycotina: Moniliales) provides an option for the management. *N. rileyi* as a bio-control agent have several advantages when compared with conventional insecticides, to name a few, low cost, high efficiency, safety for beneficial organisms, reduction of harmful residues in environment translating in increased biodiversity in human managed ecosystems.

Preceding bioassays have shown that *N. rileyi* isolates from different geographical locations and different hosts vary in their virulence and specificity (Manjula and Krishna Murthy, 2005 and Sonai Rajan and Muthukrishnan, 2009). Hence, present studies were conducted to evaluate the critical concentrations of *N. rileyi* under laboratory condition by employing three different bioassay methods for evaluation of *N. rileyi* efficacy against various larval instars of *H. armigera*.

MATERIAL AND METHODS

Fungus culture: Pure culture of *N. rileyi* (Local Nr-PDKV) was used in the present investigation. It was originally isolated from the naturally infected cadavers of *H. armigera.*

Insect culture: *H. armigera* larvae were collected from cotton fields. Field collected populationwas reared on semi synthetic diet using standard rearing technique under laboratory conditions (Temperature: 25$\pm$ 2^{0}C and Relative humidity: 75 $\pm$ 5 per cent). For the bioassays, laboratory reared F_1 culture was used as per the instar wise requirement of experiment.

Bio-assay study: For deciding the concentration range for bioassays, the preliminary trials having concentration of 10^{11}, 10^{10}, 10^9, 10^8, 10^7, 10^6, 10^5, 10^4, 10^3 and 10^2 spores per ml of the fungal suspension (Nr-PDKV) were tested against laboratory reared ten larvae of second, third and fourth instar of *Helicoverpa armigera.* The larval mortality was recorded for 6 days after treatment. On the basis of mortality, (Ranged between 20-80%) the concentrations were decided for final testing. Based on preliminary studies the concentrations, 10^9 to 10^5 spore/ml were selected. Three different bioassay methods were used *viz*., exposure of treated food material, larval treatment and treatment of both larvae and food material. Laboratory reared second, third and fourth instar larvae were sterilized with 1% sodium hypo-chloride solution and rinsed twice with distilled water. The excess water was removed with blotting paper. Desired concentrations of fungal spores (on spore basis) i.e. 2.39 x 10^9 – 2.39 x 10^5 spore/ml were obtained, by serial dilution method.

a) Leaf dip bioassay: The tender cotton leaves were brought from the unsprayed cotton field and were cleaned with 1% sodium hypo-chloride solution and rinsed with distilled water twice. Air-dried cotton leaves were dipped in concentrations of *N. rileyi* for ten seconds with gentle agitation. Leaves were placed on filter paper and allowed to

air dry under ambient conditions. Ten larvae each from 2nd, 3rd and 4th instar larvae of *H. armigera* were released in each Petri dish, individually. Each set was replicated thrice. Control was maintained by dipping leaf in clean water, and all Petri dishes were maintained at 25 ± 1°C and 80 ± 2% RH.

b) Larval bioassay: In direct spray method, larvae of 2nd, 3rd and 4th instar were kept in Petri dishes. One ml of each concentration was directly sprayed at a pressure of 340 g/cm^2 by Potter's tower. The treated larvae were then transferred to separate Petri dishes containing pre-sterilized untreated fresh cotton leaves as food. For control set 1 ml of water under Potter's tower at similar pressure was sprayed on the larvae. Petri dishes with larvae were maintained at constant temperature of 25 ± 1°C and 80 ± 2% RH.

c) Leaf dip + larval bioassay: Leaf dipped in required concentration of fungal spore suspension as mentioned earlier and larvae of 2nd, 3rd and 4th instar, topically treated with 1 ml spore suspension with the help of Potter's tower. The treated larvae were maintained at constant temperature of 25 ± 1°C and 80 ± 2% RH. For each treatment, 10 larvae were treated and three replications were maintained. The larval mortality was recorded every 24 hr up to 240 hrs after treatment. These mortality were then corrected for mortality in control. The log dose probit (LDP) bioassay was carried out to work out median lethal concentration (LC_{50}) and median lethal time (LT_{50}) for various instars of *H. armigera* under study. The mortality data was analysed using computer software "POLO".

RESULTS AND DISCUSSION

Dose-mortality-time response of *N. rileyi* against 2nd instar larvae of *H.armigera:*

The bioassay studies revealed that 83.33 to 46.67, 86.67 to 53.33 and 93.33 to 63.33% mortality observed in leaf dip, larval and leaf dip + larval bioassay at different doses of 2.39 x 10^9 to 2.39 x 10^5 spores/ml (Table 1and Plate 1). Spore concentration for obtaining 50% mortality i.e. LC_{50} for 2nd instar larvae of *H. armigera* was 3.96 x 10^5, 4.29 x 10^4 and 9.96 x 10^3 spores/ml for 2nd instar larvae of *H. armigera* with LT_{50} 119.64 to 206.09 hr, 105.16 to 189.45 hr and 95.53 to 164.43 hr for respective application methods. Leaf dip + larval bioassay combination registered minimum

Table 1. Bio assay study against second instar larvae of *H. armigera*

Characteristics	II instar *H. armigera* larvae dose-mortality-time response				
	Leaf Dip method				
Dose(spores/ml)	2.39 x 10^9	2.39 x 10^8	2.39 x 10^7	2.39 x 10^6	2.39 x 10^5
Mortality (%)	83.33	76.67	66.67	60.00	46.67
LC_{50} value	3.96 x 10^5 spores/ml				
Fiducial limit	7.80 x 10^2 - 3.31 x 10^6 spores/ml				
Slope (±SE)	0.25 (0.079)				
LT_{50} (hr)	119.64	133.89	141.35	171.35	206.09
Fiducial limit (hr)	106.54-132.98	110.20-150.13	115.42-181.70	149.26-205.86	175.84-261.55
Slope (±SE)	3.60(0.41)	3.33(0.41)	2.70(0.38)	2.62(0.38)	2.58(0.41)
	Larval treatment method (Topical application)				
Mortality	86.67	80.00	70.00	60.00	53.33
LC_{50} value	4.29 x 10^4 spores/ml				
Fiducial limit	2.80 x 10^3 - 6.25 x 10^6 spores/ml				
Slope (±SE)	0.26 (0.081)				
LT_{50} (hr)	105.16	118.30	132.70	167.43	189.45
Fiducial limit (hr)	93.103-117.0	103.80-133.72	111.32-158.55	145.44-199.75	161.96-236.45
Slope (±SE)	3.65(0.40)	3.01(0.36)	2.82(0.30)	2.60(0.38)	2.44(0.38)
	Leaf Dip + Larval treatment method				
Mortality	93.33	86.67	83.33	76.67	63.33
LC_{50} value	8.96 x 10^3 spores/ml				
Fiducial limit	1.01 x 10^1 - 3.21 x 10^4 spores/ml				
Slope (±SE)	0.27 (0.090)				
LT_{50} (hr)	92.53	104.43	122.68	139.59	164.43
Fiducial limit (hr)	80.67-104.06	91.72-117.05	107.97-138.53	122.28-160.59	143.88-193.44
Slope (±SE)	3.35(0.32)	3.32(0.37)	3.05(0.37)	2.76(0.36)	2.75(0.32)

SE = Standard error

concentration and minimum time to inflict mortality in *H. armigera* larvae.

Dose-mortality-time response of *N. rileyi* against 3rd instar larvae of *H.armigera:*

Computation of LC_{50} and LT_{50} value for 3rd instar larvae at various fungal spore load is presented in Table 2. The mortality ranged from 83.33 to 46.67% in leaf dip bioassay, 86.67 to 53.33% in larval bioassay while 93.33 to 63.33% in leaf dip + larval bioassay. The LC_{50} values for third instar larvae were calculated as, 1.67 x 10^6 spores/ml, 4.56 x 10^5 spores /ml and 6.11 x 10^4 spores/ml while LT_{50} values were in the range of 132.10 to 203.44 hr, 109.60 to 198.93 hr and 101.16 to 184.28 hr for respective method against concentrations used in bioassays.

Dose-mortality-time response of *N. rileyi* against 4th instar larvae of *H.armigera:*

In leaf dip inoculation method the dose of 2.39 x $10^9$to 2.39 x 10^5 spores/ml were applied to 4th instar larvae to *H. armigera* and recorded 70.00 to 30.00% mortality with LC_{50} value of 2.79 x 10^7 spores/ml with fiducial limit of 3.27 x 10^6 to 2.73 x 10^8 spores/ml and slope value of 0.23, indicating heterogeneity of the culture. (Table 3).

Susceptibility of larvae ranged between 76.67 to 40.00% to the respective dose of *N. rileyi* by larval bioassay method. The LC_{50} values of *N. rileyi* against 4th instar larvae was 1.99 x 10^6 spores/ml with fiducial limit ranged of 9.72 x 10^3 to 1.57 x 10^7 spores/ml with slope value of 0.23. Leaf dip + larval bioassay exhibited highest mean per cent mortality of 4th instar larvae which ranged from 83.33 to 50.00% for the respective doses. The critical dose for obtaining 50 per cent mortality (LC_{50}) was 2.94 x 10^5 spores/ml with fiducial limit of 2.34 x 10^2 to 2.77 x 10^6 spores/ml. The LT_{50} value of 4th instar larvae was in the range of 152.14 to 275.23 hr for leaf dip method, 134.09 to 228.81 hr for larval bioassay and 114.29 to 205.59 hr for leaf dip + larval bioassay method with differential spore load under evaluation(Table 3and Plate 1).

The data revealed that, leaf dip inoculation method required higher concentration to achieve mortality as compared to larval dip and leaf + larval treatment method. Leaf + larval treatment inoculation method exhibited greatest mean mortality in 2nd, 3rd and 4th instar larvae as compared to leaf dip and larval bioassay method. The present findings are

Table 2. Bio assay study against third instar larvae of *H. armigera*

Characteristics	III instar *H. armigera* larvae dose-mortality-time response				
	Leaf Dip method				
Dose(spores/ml)	2.39 x 10^9	2.39 x 10^8	2.39 x 10^7	2.39 x 10^6	2.39 x 10^5
Mortality (%)	76.67	70.00	60.00	50.00	43.33
LC_{50} value	1.67 x 10^6 spores/ml				
Fiducial limit	6.80 x 10^3 - 1.33 x 10^7 spores/ml				
Slope (±SE)	0.23 (0.076)				
LT_{50} (hr)	132.10	150.48	172.00	187.44	203.44
Fiducial limit (hr)	116.37-150.04	132.74-173.00	151.12-202.38	163.5-225.79	170.56-269.55
Slope (±SE)	2.97(0.37)	2.93(0.39)	2.89(0.42)	2.84(0.42)	2.54(0.43)
	Larval treatment method (Topical application)				
Mortality	80.00	76.67	66.67	56.67	46.67
LC_{50} value	4.56 x 10^5 spores/ml				
Fiducial limit	4.85 x 10^2 - 4.09 x 10^6 spores/ml				
Slope (±SE)	0.24 (0.077)				
LT_{50} (hr)	109.60	129.46	157.59	176.71	198.93
Fiducial limit (hr)	95.37-124.38	113.80-147.92	137.16-184.28	153.36-212.71	161.40-281.53
Slope (±SE)	2.89(0.84)	2.81(0.35)	2.68(0.37)	2.64(0.39)	2.24(0.36)
	Leaf Dip + Larval treatment method				
Mortality	90.00	86.67	80.00	66.67	56.67
LC_{50} value	6.11 x 10^4 spores/ml				
Fiducial limit	4.0 x 10^1 - 6.67 x 10^5 spores/ml				
Slope (±SE)	0.29 (0.086)				
LT_{50} (hr)	101.16	112.64	143.23	160.94	184.28
Fiducial limit (hr)	86.67-115.70	97.38-129.00	124.81-166.62	139.73-191.06	158.45-226.78
Slope (±SE)	2.70(0.33)	2.68(0.33)	2.62(0.35)	2.56(0.36)	2.51(0.38)

SE = Standard error

Table 3. Bio assay study against fourth instar larvae of *H. armigera*

Characteristics	IV instar *H. armigera* larvae dose-mortality-time response				
	Leaf Dip method				
Dose(spores/ml)	2.39×10^9	2.39×10^8	2.39×10^7	2.39×10^6	2.39×10^5
Mortality (%)	70.00	60.00	46.67	40.00	30.00
LC_{50} value	2.79×10^7 spores/ml				
Fiducial limit	3.27×10^6 - 2.73×10^8 spores/ml				
Slope (±SE)	0.23 (0.071)				
LT_{50} (hr)	152.14	180.54	202.52	238.21	275.23
Fiducial limit (hr)	136.95-170.31	160.03-210.96	177.88-244.08	198.42-324.41	195.97-336.41
Slope (±SE)	3.64(0.46)	3.22(0.45)	3.22(0.49)	2.53(0.43)	1.64(0.33)
	Larval treatment method (Topical application)				
Mortality	76.67	66.67	60.00	53.33	40.00
LC_{50} value	1.99×10^6 spores/ml				
Fiducial limit	9.72×10^3 - 1.57×10^7 spores/ml				
Slope (±SE)	0.23 (0.076)				
LT_{50} (hr)	134.09	144.00	162.98	195.00	228.81
Fiducial limit (hr)	116.62-155.25	124.70-169.04	140.25-196.48	164.95-251.78	188.20-316.83
Slope (±SE)	2.60(0.34)	2.49(0.34)	2.40(0.35)	2.26(0.36)	2.21(0.38)
	Leaf Dip + Larval treatment method				
Mortality	83.33	76.67	70.00	56.67	50.00
LC_{50} value	2.94×10^5 spores/ml				
Fiducial limit	2.34×10^2 -2.77×10^6 spores/ml				
Slope (±SE)	0.25 (0.079)				
LT_{50} (hr)	114.29	125.69	144.08	175.85	205.59
Fiducial limit (hr)	98.31-131.76	108.30-146.08	124.39-169.96	150.21-217.02	172.69-268.29
Slope (±SE)	2.53(0.32)	2.46(0.32)	2.43(0.33)	2.34(0.35)	2.30(0.37)

SE = Standard error

in agreement with the observation made by Manjuala and Murthy (2005) who reported highest mean larval mortality of *S. litura* when both leaf and larvae treated with *N. rileyi* spore suspension and lowest in leaf dip method. The highest LC_{50} value for the fourth instar larvae clearly indicates the requirement of higher number of spores for inflicting 50% mortality and tolerance by higher larval instars. The second instar larvae are more susceptible than third and fourth instar larvae, and therefore second instar larvae required minimum spore load of *N. rileyi*. The present findings are in confirmation with the work of Ignoffo (1981) who stated that all instars of *Heliothis* are susceptible to *N. rileyi* however; an inverse relationship existed between mortality and larval age. Similar observations were also reported by Vimala (1994) who recorded progressive decrease in susceptibility with advance larval instar of *S. litura*. Therefore, the bioassays of *N. rileyi* with different instars of *H. armigera* clearly suggested that bio-agent should be applied when early instars are predominant in the field for effective management of the pest

Different LT_{50} values were observed in different instars and different bioassay methods. It indicates that LT_{50} values are inoculum load dependent and it decreases with an increase in dose. These results correlates with the work reported by Yong and Dao (1998) where in LT_{50} of *N. rileyi* is reported to increase with the increase in age of *H. armigera* larvae. Our results suggest that entomogenous fungi, particularly *N. rileyi effective* against 2nd and 3rd larval instars of *H. armigera*. Application of entomogenous fungi can be carried out in presence of early larval stages; however, for their effective management, sufficient concentrations of the pathogens are also crucial.

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Distribution Fitting for Pests and Natural Enemies of Soybean (*Glycine max*.)

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Abstract: In the present investigation, trends in population dynamics of major insect pests of soybean crop have been studied through probability model. Among the major insect pests the numbers of larvae of *S. litura, Thysanoplusia orichalce, Spilosoma oblique* Walker and their natural enemies namely *Anisoptera, Coccinellidae* and spider were observed on soybean. The occurrences of the insects were grouped in the form of frequency distribution according to the number of plants. The distribution of *S. litura* using Polya – Aeppli distribution was known to fit well by the method of MPZC(method of proportion of zero cell) and MLE (maximum likelihood) but the distribution of *Thysanoplusia orichalce* using Polya-Aeppli distribution was fitted well by all the three methods of estimation , MPZC, method of moments (MM) and MLE and these methods were not fitted well to describe the frequencies of spiders. These distributions may be used for forecasting of the losses in soybean crop due to major insect pests considered here.

Key Words: Chi-square test, Polya-aeppli distribution, Method of moments, Method of proportion of zero cell Spodoptera, Soybean

Soybean is the major oilseed crop in the world and accounts for 50 per cent of the total area as well as production. It provides approximately 60 per cent of vegetable protein and 30 per cent of oil in the world. *India ranks third in world in respect of area and fifth in terms of production*. Production of soybean in India at the present time is restricted mainly to Madhya Pradesh, Uttar Pradesh, Maharashtra and Gujarat. Keeping in view of the importance of crop, the investigation was planned to study the seasonal abundance of major insect - pests using probability distribution and test the adequacy of the distribution using chi- square test.

MATERIAL AND METHODS

The experiment was conducted during *Kharif* 2011-2012 at the Research Farm of Department of Entomology Adhartal, JNKVV, Jabalpur. The soybean crop was harvested on 13th October 2011 in S-1 trial and 14th October 2011 in S-2 trial, respectively. In order to study the seasonal abundance of major insect-pests on soybean crop, the numbers of larvae of *S. litura*, semilooper, Bihar hairy caterpillar and their natural enemies namely dragon fly, lady bird beetle and spider were counted weekly on each plant. The original counts were then summarized in the form of frequency distribution showing the number of plants containing X=0, 1, 2, 3,…… insect-pests of a given species. If each plant were exposed equally to the chance of containing the major insect-pests during the study period, the probable probability distribution Polya-Aeppli was suggested for describing the inherent variation in the occurrence of major larvae insects and their natural enemies and their parameters were estimated by three methods viz., method of proportion of zero-th cell (MPZC), method of moments (MM) and maximum likelihood estimation (MLE) and then the determination of chi-square values of the respective observed and expected frequencies.

Polya-Aeppli Distribution

This distribution is one of the important continuous distributions and is useful for the situation where events (which are to be counted) occur in clusters and the number of clusters follows a Poisson distribution with expectation è and the number of individuals per clusters follows a geometric distribution with parameter q. The spatial spread of major insect-pests per plant can be described by this distribution. For completeness, this distribution is defined by,

$$P_0 = P[X = 0] = e^{-\theta}$$

$$P_k = P[X = k] = e^{-\theta} p\, k \sum_{j=1}^{k} \binom{k-1}{j-1} \frac{\left(\frac{\theta q}{p}\right)^j}{j!} \; ; (k \geq 1), q = 1 - p \quad ...(1)$$

This distribution consists of two parameters è and q and these are estimated by three methods given below,

(i) Method of Proportion of Zero Cell (method – I)

In this method, the observed proportion of zeroes (n_0/N) and sample mean (m_1') are equated to their corresponding theoretical values. It is given below:

$$e^{-\theta} = \frac{n_0}{N} \;\; \& \;\; m_1' = \frac{\theta}{q}$$

The parameters è and q were estimated from the above relationships.

(ii) Method of Moments (method – II)

In this method, these two parameters were estimated by

equating the observed mean and observed variance with their corresponding theoretical values. It is given below:

$$m_1' = \frac{\theta}{q} \quad \& \quad m_2 = \frac{\theta(1+p)}{q^2}$$

where, m_1' and m_2 are the sample mean and sample variance of the observed data respectively. (Johnson and Kotz, 1969).

(iii) Maximum likelihood (method – III)

Consider a sample consisting of N observation of the random variable X with probability function in which n_0 designates the number of zero observation, n_1 the number of one observation and N the total number of observations. The values chosen as estimates of è and q were those, which

$$L[X_1, X_2, \ldots\ldots, X_N ; \theta, q] \cong \left[\left(e^{-\theta}\right)^{n_0}\left(e^{-\theta}\theta q\right)^{n_1}\left(1 - e^{-\theta} - e^{-\theta}\theta q\right)^{N-n_0-n_1}\right] \quad .....(2)$$

Taking natural logarithms of (2), differentiating with respect to è and q in turn and equating to zero give the estimating equations,

$$\frac{\delta L}{\delta \theta} = -n_0 + n_1 \frac{(1-\theta)}{\theta} + \frac{(N-n_0-n_1)e^{-\theta}(1+\theta q-q)}{(1-e^{-\theta}-e^{-\theta}\theta q)} = 0 \quad ...(3)$$

$$\frac{\delta L}{\delta q} = \frac{n_1}{q} - \frac{(N-n_0-n_1)e^{-\theta}(1+\theta q-q)}{(1-e^{-\theta}-e^{-\theta}\theta q)} = 0 \quad ...(4)$$

where, L is written for InL.

The required M.L. estimates è and q when they exist, will be found by solving simultaneously these two equations (5) and (6). To facilitate their solution, the above equations are reduced to,

$$e^{-\theta} = \frac{n_0}{N} \quad \& \quad q = \frac{n_1\left(1-e^{-\theta}\right)}{N - n_0 e^{-\theta}\theta}$$

Chi- square test

Karl Pearson's chi-square, given by:

$\chi^2 = \sum_{i=1}^{n}\left[\frac{(fi-ei)^2}{ei}\right]$ follows chi – square distribution with n-1 d.f.

Hypothesis: H_0: There is an association between observed frequency and expected frequency.

H_1: There is no association between observed frequency and expected frequency.

RESULTS AND DISCUSSION

S-1 Trial Results:

The, expected frequency which was estimated by the method of MPZC and MLE were very close to the observed frequency of the *S. litura*, as it was non significant by chi-square goodness of fit. For semilooper, all the three methods *viz,* MPZC, MM and MLE were found an association between observed and expected frequencies as it was confirmed by the chi-square goodness of fit (Table 1). All the three methods of estimation showed significant results at 5 per cent and 1 per cent, respectively for *S. litura* and there was no association found, whereas for semilooper, all the three estimation methods found to be best in producing expected frequencies, both observed and expected frequencies found to be associated, which provides the best fitting of Polya – Aeppli distribution (Table 2). But this polya aeppli found to be not worthy in estimating the expected results for the spiders during S-1 trial (Table 5).

S-2 Trial Results:

For *S.litura,* the observed and expected frequencies obtained by the method of MPZC and MLE were found to be associated, whereas for semilooper, the method of MPZC found to be best (Table 3). In Table 4, for *S. litura,* the method of MPZC produced better expected frequencies compare to the other two methods and found to be the best method but for semilooper, all the three methods of estimation provided the expected frequencies which are close to observed frequency of semilooper and which was confirmed by the chi-square goodness (non-significant) of fit test. Polya – Aeppli distribution, in table5, there was a highly significant difference at 5 per cent level of significance by all the three methods of estimation for spiders and found no association.

Results are clearly indicated that for Polya- Aeppli distribution MPZC and MLE found to be best method of estimation in both S-1 and S-2 trials for *S. litura* and semilooper dynamics. The MPZC found to be the best and MLE and MM methods are equally efficient in both the trials.

Polya-Aeppli distribution was found to be adequate for describing the seasonal abundance of major larvae of *S.litura* and semilooper and their natural enemies (spider) population on soybean for S-1 and S-2 trial in after spraying data in comparison to other distributions in the middle stage of the crop (24th September-30th September), and the method of proportion of zeroth cell (Sharma,1988), method of moments and maximum likelihood estimation methods were found to be better method of estimation.

Distribution of *S.litura* using Polya – Aeppli distribution was known to fit well by the method of MPZC and MLE. But distribution of semilooper using Polya –Aeppli distribution was fitted well by all the three methods of estimation *viz.,* MPZC, MM and MLE and these methods (MPZC, MM and MLE) were not fitted well to describe the frequencies of spiders.

Table1. Distribution of observed and expected number of plants according to number of larvae insects on soybean for S-1 trial (24-09-2011) on seven treatments (T_1+T_2+T_3+T_4+T_5+T_6+T_7)

No. of *S. litura*	Observed	Polya-Aeppli Distribution			No. of Semilooper	Observed	Polya-Aeppli Distribution		
	freq.	MPZC	MM	MLE		freq.	MPZC	MM	MLE
0	14	14.00	8.32	14.00	0	44	44.00	41.19	44.00
1	9	12.87	13.86	9.00	1	7	9.14	12.00	7.00
2	11	10.92	14.00	8.04	2	6	4.80	5.84	4.45
3	7	8.39	11.06	6.89	3	4			
4	7	5.95	7.13	5.69	4	2	5.06	3.97	7.55
5^+	15	10.87	8.63	19.38	5^+	0			
Total	63	63.00	63.00	63.00	Total	63	63.00	63.00	63.00
Mean	2.46	-	-	-	Mean	0.61	-	-	-
Variance	3.51	-	-	-	Variance	1.18	-	-	-
Estimates of	è =	1.50	2.02	1.50	Estimates of	è =	0.35	0.42	0.35
Parameters	q=	0.61	0.82	0.42	Parameters	q=	0.57	0.68	0.43
χ^2		3.14	12.41**	2.38	χ^2		0.97	3.31	0.85
d.f.		3	3	3	d.f.		1	1	1

Table 2. Distribution of observed and expected number of plants according to number of larvae insects on soybean for S-1 trial (28-09-2011) on seven treatments

No. of *S. litura*	Observed	Polya-Aeppli Distribution			No. of Semilooper	Observed	Polya-Aeppli Distribution		
	freq.	MPZC	MM	MLE		freq.	MPZC	MM	MLE
0	20	20.00	18.96	20.00	0	43	43.00	41.05	43.00
1	19	15.05	15.65	19.00	1	10	11.97	14.38	10.00
2	6	10.84	11.35	12.29	2	7	4.91	5.14	5.07
3	4	7.13	11.44	6.59	3	3			
4	3	4.35	4.39	3.03	4	0	3.12	2.43	4.93
5^+	11	5.63	1.21	2.09	5^+	0			
Total	63	63.00	63.00	63.00	Total	63	63.00	63.00	63.00
Mean	1.74	-	-	-	Mean	0.52	-	-	-
Variance	3.33	-	-	-	Variance	0.75	-	-	-
Estimates of	è =	1.14	1.20	1.14	Estimates of	è =	0.38	0.42	0.38
Parameters	q=	0.65	0.68	0.82	parameters	q=	0.72	0.81	0.60
χ^2		10.11*	87.78**	42.22**	χ^2		1.21	2.23	1.49
d.f.		3	3	3	d.f.		1	1	1

Treatments description:

S-1 trial:

T_1 : Beauveria bassiana
T_2 : Metarhizium anisopliae
T_3 : Verticilium lecanii
T_4 : Quinalphos 25 EC @ 1.5 l/ha
T_5 : Bacillus thuringiensis var. Kurstaki
T_6 : Spinosad 45% SC @ 73g a.i./ha
T_7 : Control

S-2 trial:

T_1 : EPN 1
T_2 : EPN 2
T_3 : EPN 3
T_4 : EPN 4
T_5 : Check
T_6 : Check
T_7 : Control

Table 3. Distribution of observed and expected number of plants according to number of larvae insects on soybean for S-2 trial (24-09-2011) on seven treatments

No. of *S. litura*	Observed freq.	Polya-Aeppli Distribution			No. of Semilooper	Observed freq.	Polya-Aeppli Distribution		
		MPZC	MM	MLE			MPZC	MM	MLE
0	19	19.00	12.09	19.00	0	39	39.00	36.37	39.00
1	9	12.30	14.83	9.00	1	9	12.28	15.04	9.00
2	7	9.64	12.90	7.57	2	10	6.15	6.83	5.71
3	9	7.14	9.45	6.21	3	4			
4	5	5.04	6.02	4.98	4	0	5.57	4.76	9.29
5^+	14	9.88	7.71	16.24	5^+	1			
Total	63	63.00	63.00	63.00	Total	63	63.00	63.00	63.00
Mean	2.22	-	-	-	Mean	0.7301	-	-	-
Variance	3.76	-	-	-	Variance	1.2130	-	-	-
Estimates of	..	1.19	1.64	1.19	Estimates of	è =	0.47	0.54	0.47
Parameters	q=	0.53	0.74	0.39	Parameters	q=	0.65	0.75	0.48
χ^2		3.81	14.26**	1.60	χ^2		3.34	4.09*	5.20*
d.f.		3	3	3	d.f.		1	1	1

Table 4. Distribution of observed and expected number of plants according to number of larvae insects on soybean for S-2 trial (28-09-2011) on seven treatments

No. of *S. litura*	Observed freq.	Polya-Aeppli Distribution			No. of Semilooper	Observed freq.	Polya-Aeppli Distribution		
		MPZC	MM	MLE			MPZC	MM	MLE
0	16	16.00	8.56	16.00	0	37	37.00	34.12	37.00
1	5	12.37	14.04	5.00	1	10	12.46	15.25	9.41
2	13	10.18	14.01	4.64	2	8	6.67	7.54	6.11
3	8	7.73	10.97	4.27	3	6			
4	7	3.91	4.54	3.89	4	1	6.87	6.09	10.48
5^+	14	12.81	10.88	29.20	5^+	1			
Total	63	63.00	63.00	63.00	Total	63	63.00	63.00	63.00
Mean	2.42	-	-	-	Mean	0.84	-	-	-
Variance	3.48	-	-	-	Variance	1.47	-	-	-
Estimates of	..	1.37	1.99	1.37	Estimates of	è =	0.53	0.61	0.53
Parameters	q=	0.56	0.82	0.22	Parameters	q=	0.63	0.72	0.47
χ^2		7.72	15.34**	28.71**	χ^2		0.93	2.67	1.20
d.f.		3	3	3	d.f.		1	1	1

Table 5. Distribution of observed and expected number of plants according to number of spiders on soybean for S-1 trial (24.09.2011 and 28.09.2011) and S-2 trial (24.09.2011 and 28.09.2011)

S-1 TRIAL										S-2 TRIAL									
24.09.2011					28.09.2011					24.09.2011					28.09.2011				
No. of Spiders	Obs freq	Polya-Aeppli Distribution			No. of Spiders	Obs freq.	Polya-Aeppli Distribution			No. of Spiders	Obs freq.	Polya-Aeppli Distribution			No. of Spiders	Obs freq.	Polya-Aeppli Distribution		
		MPZC	MM	MLE			MPZC	MM	MLE			MPZC	MM	MLE			MPZC	MM	MLE
0	15	15	10.97	15	0	16	16	8.92	16	0	20	20	11.69	20	0	16	16	7.07	16
1	9	15.82	17.19	9	1	5	13.92	15.79	5	1	4	11.68	14.72	4	1	4	12.22	13.75	4
2	20	12.54	15.25	7.94	2	14	11.14	15.46	4.64	2	13	9.15	12.98	3.7	2	7	10.07	14.89	3.77
3	8	19.64	19.59	31.06	3	15	8.07	11.19	4.27	3	7	6.84	9.59	3.41	3	15	7.74	11.97	3.53
4	5				4	7	13.87	11.64	33.09	4	4	4.2	6.13	3.14	4	13	16.97	15.32	35.7
5^+	6				5^+	6				5^+	15	11.13	7.89	28.75	5^+	8			
Total	63	63	63	63	Total	63	63	63	63	Total	63	63	63	63	Total	63	63	63	63
Mean	1.95	-	-	-	Mean	2.15	-	-	-	Mean	2.25	-	-	-	Mean	2.46	-	-	-
Variance	2.39	-	-	-	Variance	2.60	-	-	-	Variance	3.77	-	-	-	Variance	3.07	-	-	-
Estimates	,	1.43	1.74	1.43	Estimates	è	1.3705	1.9545	1.3705	Estimates	è	1.14	1.68	1.14	Estimates	è	1.37	2.18	1.37
of Parameters	q	0.73	0.89	0.41	of Parameters	q	0.63	0.90	0.22	of Parameters	q	0.50	0.74	0.17	of Parameters	q	0.55	0.88	0.18
		7.39**	6.87**	23.00**			12.45**	14.58**	58.04**			8.02*	21.56**	33.96**			14.23**	25.24**	46.08**
X^2 d.f.		1	1	1	X^2 d.f.		2	2	2	X^2 d.f.		3	3	3	X^2 d.f.		2	2	2

**- significant at 1% level
*- significant at 5% level

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Morphometric Analysis of Male and Female Rats Inhabiting South-West Region of Punjab in North India

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***Abstract*:** South-Western region of Punjab is known for its high pesticide use and deteriorated ground water quality mainly caused due to agrochemical processes and extensive use of phosphate fertilizers. The present study was designed to examine the adverse effects of environmental contaminants on biometric parameters, vital and endocrine organs in *Rattus rattus, Tatera indica* and *Bandicota bengalensis* inhabiting South-West region of Punjab in North India. There were significantly decreased length of head, tail, forelimb, hind limb, ear and girth of the field male and female rats as compared to control rats. Significantly decreased weight of kidney, lungs, liver, heart and spleen in male and female rats inhabiting South-West region of Punjab was also observed. The size and weight of the thyroid and parathyroid decreased significantly in field male and female rats of different species as compared to control rats while the weight of adrenal glands did not vary in these rats as compared to control rats except for *Tatera indica* male where it was significantly increased in Bathinda rats as compared to control rats. From present studies we conclude that exposure of multiple pesticides/environmental contaminants for prolonged period has affected the biometrics and health of *Rattus rattus, Tatera indica* and *Bandicota bengalensis* field rats thereby disrupting various metabolic and physiological processes

Key Words: Biometric parameter, Environmental pollutants, Kidney, Liver and Thyroid, Rats

Contamination of natural resources by indiscriminate and hysterical use of pesticides is potential threat to animal and human health. Pesticides are linked to various chronic diseases like cancers, infertility, kidney failure, reproductive problems and nervous disorders in male and female (Agarwal and Sharma 2010). South-Western region of Punjab is known for its high pesticide use and deteriorated ground water quality due to agrochemical processes and extensive use of phosphate fertilizers (Bhalla *et al*. 2011). Acute occupational exposure for pesticides among sprayers was also high as they occasionally use protective devices while spraying (Thakur *et al* 2008; Singh and Kaur 2012). Earlier studies give some indication of increased physiological risks of exposure to pesticides/heavy metals, but the epidemiological evidences do not allow any clear inference to be drawn (Thakur *et al*. 2008, Singh and Kaur 2012, Singh *et al*. 2012). Reproductive health effects have also been detected in male house rats inhabiting South Western region of Punjab (Singh and Sangha 2014). So the present study was designed to investigate the detectable changes in biometric and vital organs of male and female species of rats viz *Rattus rattus, Tatera indica* and *Bandicota bengalensis* inhabiting South-West region of Punjab in North India.

MATERIAL AND METHODS

For this study the male and female rats (*Rattus rattus, Tatera indica and Bandicota bengalensis*) were trapped from the Bathinda district of South-West region of Punjab and also from Punjab Agricultural University, Ludhiana that served as control rats. Approval of Institutional Animal Ethical Committee, Guru Angad Dev Veterinary and Animal Science University (GADVASU), Ludhiana was obtained for the usage of animals. Animals were brought to laboratory and separated according to age, sex and species. Finally the morphometric observation were made after humane scarification of the different species of male and female rats.

Biometric analysis:- Each specimen was weighed and the biometrics measurements were taken (Table 1). Body length was measured from the tip of the nose to the middle of the anus and tail length from the middle of the anus to the tip of the tail. Other parameters such as number of lower teeth, upper teeth, fore digits, hind digits in an animal were also noted in all the rats.

Organ weight:- Following humane sacrifice, the animals were placed on a dorsal recumbency and a mid-line incision were made, starting from the xiphoid cartilage and extending to the pubic symphysis. The peritoneum was reflected and organs were examined in situ and exteriorized. All the vital organ (kidney, lungs, stomach, liver, heart, spleen and brain) and endocrine glands (thyroid, parathyroid and adrenal glands) were also excised cleaned of the adhering tissue and weighed separately.

RESULTS AND DISCUSSION

The head and body length varied non significantly in all the species of female rats *Rattus rattus, Tatera indica* and

Table 1. Biometric analysis of male and female rats inhabiting Bathinda and Ludhiana district of Punjab

Parameters (cm)	*R. rattus*		*T. indica*		*B.bengalensis*	
	Ludhiana	Bathinda	Ludhiana	Bathinda	Ludhiana	Bathinda
Body Mass	111.63±3.74 9	133.14±7.75	128.077±24.580	148.4±14.351	145.00± 11.560	134.67± 7.319
Head Length	3.40±0.135	3.25±0.478	3.66±0.166	4.0±0.158	3.76±0.176	3.23±0.145
	(3.42±0.208)	(3.67±0.727)	(3.83±0.166)	(2.66±0.333 *)	(3.23±0.145)	(3.1±0.264)
Body Length	12.17±0.289	11.70±0.751	11.66±0.166	12.90±0.558	15.16±0.727	11.00±0.578 *
	(11.51±0.167)	(11.33±0.834)	(11.90±1.017)	(9.90±0.953)	(11.00±0.577)	(12.4±3.819)
Tail Length	10.80 ±2.411	16.80±0.435 *	9.66±0.333	15.30±0.972 *	15.16±0.441	11.33±0.882 *
	(17.20±1.001)	(16.5±0.295)	(15.83±1.166	(14.56±1.501)	(11.33±0.881)	(10.83±0.600)
Ear Length	2.07±0.091	1.87±0.125	1.93±0.066	1.90±0.187	1.53±0.088	1.56±0.066
	(1.92±0.348)	(1.67±0.166)	(2.03±0.033)	(1.83±0.166)	(2.03±0.290)	(1.23±0.145 *)
Fore Limb Length	3.17±0.14 4	3.12±0.314	2.26±0.145	1.60±0.292 *	2.26±0.145	3.33±0.285 *
	(3.25±0.167)	(3.50±0.602)	(2.60±0.100)	(1.93±0.233)	(3.33±0.284)	(3.30±0.152)
Hind Limb Length	5.17±0.118	5.00 ±0.353	4.80±0.200	3.80±0.464 *	4.23±0.145	4.20±0.173
	(5.18±0.167)	(4.67±0.118)	(4.50±0.288)	(3.66±0.16 6)	(4.20±0.173)	(4.26±0.317)
Girth(cm)	11.17±0.315	10.13±0.554 *	13.00±0.289	10.30±0.562 *	10.16±2.590	13.50±0.764 *
	(11.38±0.167)	(11.67±0.315)	(13.33±0.726)	(9.50±0.288 *)	(11.83±0.726)	(12.86±0.592)

Values are Mean ± SE,
Figures in parenthesis indicate the values for female rats
*Significant difference at ($p<0.05$) as compared to control

Bandicota bengalensis inhabiting Bathinda region as compared to Ludhiana rats. In male *B. bengalensis* the body length was significantly reduced. Tail length was significantly more in male *R. rattus* and *T. indica* and it was less in *B. bengalensis* inhabiting Bathinda region (Table 1). In all the female rats the tail length vary nonsignificantly (Table 1). Nonsignificant variation in ear length was observed in all male and female rats inhabiting Bathinda and Ludhiana region of Punjab except for *B. bengalensis* where it was significantly reduced (Table 1). Significantly reduction in fore limb and hind limb length was also observed in male and female *T. indica* rats inhabiting Bathinda district as compared to Ludhiana rats. There was no variation in number of upper teeth, lower teeth, fore digits in all the species of male and female rats collected from Bathinda region as compared to control Ludhiana rats.

Significant degrees of variation in morphometric characteristics were also found in Black rat *Rattus rattus* species inhabiting different regions of Tunisia and the pattern of morphometric variation was related with local environmental factors (Faleh *et al.,* 2012). The weight of the vital organs of Bathinda rats was compared with control Ludhiana rats. Kidney, liver, lungs and heart weight was significantly low in all the species of male and female *T. indica* and *B. bengalensis* rats residing in Bathinda district (Table. 2). In 35.71 % male and 30% female *R. rattus* and 20% male and 15.3% female *T. indica,* one to three blisters were observed on the liver (Fig. 2a). In 25% male and 60% female showed extensive deterioration of liver (Table 3; Fig 2b). The weight of spleen and brain was vary nonsignificantly in all the species of male rats. However, in 40% male and female *B. bengalensis* rats the spleen was extraordinary enlarged and weighed three times more than the normal value (Table 3; Fig 2c,d). Stomach weight was more in rats inhabiting Bathinda district as compared to Ludhiana showing significant difference in 25% male and female *B. bengalensis* (Table 2 & 3; Fig. 2e).

Organ weight were recorded a potential indicator of a dietary effect on the organisms. The difference in vital organs especially liver and kidney weight are considered as sensitive risk parameters (Piao *et al.,* 2013). Reduced weight of liver and kidney may be considered as indicators of toxins induced damage (Piao *et al.,* 2013). Adverse changes in liver tissues in test animals also been observed in cypermethrin treated rats as compared to control rats in albino rats (Sangha *et al*., 2011). Heikal *et al.* (2013) reported a significant increase in liver weight of rats treated with chlorpyrifos and their binary mixture as compared to their control. Unpublished data of our laboratory have also revealed pesticide chlorpyrifos and malathion residues in

Table 2. Relative weight of vital organs (g/100 g bw) in different species of male and female rats

Organs	*R. rattus*		*T. indica*		*B. bengalen sis*	
	Ludhiana	Bathinda	Ludhiana	Bathinda	Ludhiana	Bathinda
Kidney	0.352±0.008 (0.350±0.076	0.361± 0.055 (0.491±0.093 *	0.309±0.017 (0.263±0.050	0.266±0.021 * (0.169±0.034 *	0.471±0.051 (0.375±0.101	0.353±0.022 * (0.294±0.014
Lungs	0.416±0.012 (0.364±0.026	0.330 ±0.023 * (0.322±0.116	0.285±0.006 (0.331±0.006	0.226±0.006 (0.199±0.047 *	0.759±0.047 (0.451±0.029	0.782±0.029 (0.631±0.092 *
Stomach	2.141±0.114 (2.313±0.287	2.984±0.505 (2.853±0.283	1.623±0.278 (2.125±0.069	1.705±0.278 (2.063±0.717	1.516±0 .158 (1.811±0.255	2.391±0.077 * (2.330±0.383 *
Liver	4.824±0.389 (5.222±0.105	4.122±0.391 (5.064±0.415	3.613±0.256 (2.751±0.382	2.037±0.256 * (3.584±0.823	5.299±0.750 (5.617±0.829	3.685±0.679 * (3.852±0.276 *
Heart	0.365±0.024 (0.475±0.029	0.371±0. 029 (0.470±0.072	0.380±0.036 (0.288±0.034	0.275±0.036 * (0.327±0.051	0.428±0.051 (0.443±0.083	0.307±0.036 * (0.399±0.044
Spleen	0.326 ±0.025 (0.373 ±0.079	0.262 ±0.028 * (0.242 ±0.066 *	0.288±0.038 (0.280±0.033	0.224±0.038 (0.308±0.099	0.854±0.138 (0.673±0.210	0.607±0.016 * (0.406±0.078 *
Brain	1.731±0.123 (1.580±0.261	1.289±0.041 (1.261±0.063	1.235±0.094 (1.234±0.114	0.973±0.094 (1.246±0.217	1.002±0.021 (1.091±0.061	1.082±0.028 (1.144±0.050)

Values are Mean ± SE
Figures in parenthesis indicate the values for female rats
*Significant difference at ($p<0.05$) as compared to control

Table 3. Percentage abnormalities in various organs of different species of rats collected from fields of South-West region of Punjab

Organ	*R. rattus*		*T. indica*		*B.bengalens is*	
	Male	Female	Male	Female	Male	Female
Liver	35.71	30	20	15.3	25	60
Stomach	44.4	25	40	28.5	25	25
Adrenal	NIL	30	20	NIL	NIL	25
Spleen	NIL	11.1	NIL	NIL	20	60
Kidney	14.2	11.1	NIL	25	25	NIL
Thyroid	14.2	12.5	20	25	NIL	NIL

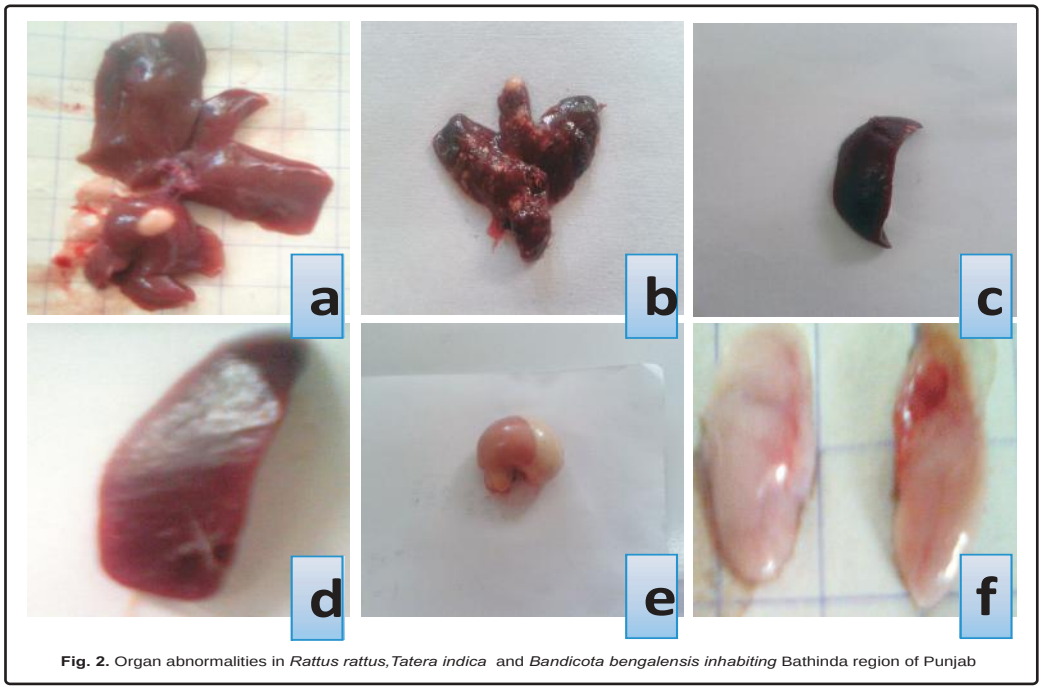

Fig. 2. Organ abnormalities in *Rattus rattus*,*Tatera indica* and *Bandicota bengalensis inhabiting* Bathinda region of Punjab

Organ Abnormalities: -

a.Cyst formation on the liver in *R. rattus* male rats.; b.Liver cirrhosis in *B. bengalensis* female rats.
c.Extra large size of spleen in *B. bengalensis* female rats.; d.Extra large size of spleen in *B.bengalensis* male rats.
e.Abnormal size, shape and colour of stomach *B. bengalensis* male rats.f.Extra large size and weight of thyroid glands in *T. indica* male rats

Table 4. Relative weight of endocrine glands (g/100 g bw) in different species of male and female rats

Organs	*R. rattus*		*T. indica*		*B. bengalensis*	
	Ludhiana	Bathinda	Ludhiana	Bathinda	Ludhiana	Bathinda
Thyroid	0.212±0.014 (0.314±0.033)	0.160±0.022* (0.251±0.065*)	0.135±0 .029 (0.131±0.006)	0.188±0.016 (0.117±0.005)	0.160±0.004 (0.162±0.022)	0.167±0.011 (0.142±0.005)
Parathyroid	0.022±0.004 (0.064±0.011)	0.018±0.002 (0.021±0.005*)	0.024±0.001 (0.091±0.069)	0.014±0.000 (0.041±0.023*)	0.029±0.001 (0.068±0.042)	0.032±0.000 (0.024±0.000*)
Adrenal	0.034±0.005 (0.037±0.008)	0.031±0.007 (0.035±0.006)	0.035±0.006 (0.025±0.002)	0.049±0.008 (0.036±0.009)	0.020±0.001 (0.020±0.002)	0.017±0.000 (0.022±0.001)

Values are Mean ± SE ; Figures in parenthesis indicate the values for female rats
*Significant difference at ($p<0.05$) as compared to control

liver and blood of male and female in *R. rattus, T. indica* and *B. bengalensis* rats inhabiting Bathinda district of Punjab. Enlargement of spleen is indicative of impairment in lymphatic system of exposed rats (Heikal *et al.,* 2013). Low weight of endocrine glands, thyroid and parathyroid was observed in male and female rats all the species residing Bathinda district although few rats had extra large size of their thyroid gland in *R. rattus* and *T. indica* species (Table 4, Fig. 2f). Significant high adrenal gland weight was observed in male and female *T. indica* Bathinda rats as compared to Ludhiana rats (Table 4). The significantly increase in the weight of the adrenals and thyroid in rats might reflect a state of physiological stress in the body of rats (Sangha *et al.,* 2011).

In the present study from all the evidences and literature it is conclude that the environmental contaminants specially pesticide alter the natural make up of the rats. The abnormal range of the morphometric, amount of vital organs and endocrine glands may be due to exposure of environmental contaminants and pesticides in the *R. rattus, T. indica and B. bengalensis* inhabiting Bathinda district of South West region of Punjab in North India.

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CONFLICT OF INTEREST

Authors declare that they have no conflict of interest.

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Effect of Sowing Dates and Abiotic Factors on Infestation of Yellow Mite, *Polyphagotarsonemus latus* (Banks) In Jute

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Abstract: Field trials were conducted during two years (2010-11 and 2011-12) with *olitorius* jute variety, JRO-8432 to observe the effect of dates of sowing on infestation of yellow mite, *Polyphagotarsonemus latus*. The crop was sown in different sowing intervals of 15 days starting from 1st March to 15th June. The earlier date of sowing (second fortnight of March) showed higher infestation of *P. latus*, whereas the later date of sowing (second fortnight of June) invariably had the lowest infestation. The yield was highest in 1st April sown crop in both the cropping seasons. Considering the yield as and mite infestation, the first week of April sowing appeared to be the most suitable. Differences in the infestation of mite as also yield may be attributed to variations in weather parameters.

Key Words: Dates of sowing, Fibre yield, Jute, *Polyphagotarsonemus latus*, Abiotic factors

Jute is an important fibre crop and is grown mainly in eastern part of Indian sub-continent including in the States of West Bengal, Assam, Bihar, Eastern Uttar Pradesh and Odisha. Currently, jute is cultivated in an area of approximately 8.5 lakh ha in India with an average productivity of 25.3 q/ha (Anonymous, 2013). The intensive cultivation of high yielding fertilizer responsive cultivars of jute brought forth the problem of insect pests and mites. Among the pest complex of jute, yellow mite, *Polyphagotarsonemus latus* (Banks) (Acarina: Tarsonemidae) is considered as one of the major pest of the crop (Rahman and Khan, 2006). The fibre yield loss due to this pest has been estimated between 10 and 42% depending upon the level of infestation in jute (Pandit *et al*., 2002).

Changes in agronomic management including change in sowing time, use of short duration cultivar and optimum use of water and nutrients are determined to be important for sustaining crop productivity (Mondal *et al*., 2013). Effect of date of sowing and varieties on the relative abundance of yellow mite, *P. latus* was worked out by many workers in different crops. Very few worker such as Hath and Ghosh (2001) and Hath (2004) conducted experiments in jute crops. Information on time of peak activity of pest, relative susceptibility, influence of variety and abiotic factors to the pest are important prerequisites in formulating mite management programme. However, adequate information is not available in the terai region of West Bengal. It thus, becomes important to evaluate the effect of sowing date on yellow mite infestation in jute. Keeping the problems associated with agro-ecological, socio-economic and plant protection aspects of jute cultivation in view, an attempt has been made to study the effect of time of sowing of jute on relative abundance of pest and fibre yield with an ultimate objective to find out the optimum time of sowing to escape the maximum pest infestation which can be utilized to formulate future IPM programme.

MATERIAL AND METHODS

The experiment was conducted in two consecutive years *viz.,* 2010-11 and 2011-12 *kharif* season in randomized block design (RBD) at Central Research Institute for Jute and Allied Fibres (CRIJAF) Research farm with the variety, JRO-8432. The soil was sandy loam and P^H, 6.5-7.5. Standard agronomic practices were followed except advancing and delaying of sowing dates as required for different treatments and no plant protection measures. The treatment comprised of sowing on 7/8 different dates at 15 days interval beginning with 15th March and continued late upto 15th June during 2010-11 and 2011-12 cropping season. The treatments were termed as very early (Second fortnight of March), early (First week of April), normal-I (Second fortnight of April), normal-II (Last week of April), late (Second fortnight of May), very late (Last week of May) and extra very late (Second fortnight of June) sowing. The per cent infestation of yellow mite was observed at fortnightly intervals starting from 25 days after sowing (DAS). The observations on the infestation of jute yellow mite was as percentage damage of leaves based on symptoms of damage produced on top six leaves from their first appearance. A total of six observations were taken in both the years. The data obtained from two years were pooled together and analysed statistically.

RESULTS AND DISCUSSION

The date of sowing influenced the infestation of yellow mite as indicated in terms of percent damage of plants. There were highly significant differences in infestation among the different dates of sowing during the 2010-11 cropping season, except first, second and third dates of sowing (Table 1). However, the mite infestation in all the dates of sowing was significantly higher in earlier sown crop (15^{th} March to 15^{th} April 2010) as compared to that of the later sown (31^{st} April, 2010 and beyond) crop. The peak infestation of yellow mite was 23.66% during 2010-11 cropping season at 70 DAS during 1^{st} April sown crop while in 15^{th} June sown crop it showed a reduction and was maximum (6.36%) during peak infestation period of 70 DAS. This decline may be due to onset of monsoon. During 2011-12 cropping season, the early sown crop (1^{st} March, 2011) suffered with least infestation of yellow mite however, the peak infestation of 12.87% and 11.50% was observed at 85 and 100 DAS respectively (Table 1). The crop grown after 1^{st}April was infested and the peak infestation of 20.37% was at 70 DAS. The difference in level of yellow mite infestation over time of sowing was significant. Although variation was recorded in yellow mite infestation level among the different dates of sowing, yet the difference was statistically significant.

The pooled data from two years revealed that the effect of date of sowing and yellow mite infestation was significant. Early sown crop suffered higher fibre yield losses due to yellow mite. Significantly lower mite infestation was observed in the late sown crop (second fortnight of April). This finding is in conformity with Hath and Ghosh (2001) and Hath (2004) who found that the infestation of *P. latus* on jute decreased with delayed sowings; highest being on crop sown during 3^{rd} week of April with 32.40% leaf damage. Population growth was faster during early period and peak infestation attained at 55 DAS on very early sown crop (Second fortnight of March) thereafter it followed the decreasing trend.

Delay in sowing time resulted in lower fibre yield (Table 3). During both the cropping season 2010-11 and 2011-12 the highest fibre yield of 29.13 and 30.25 q/ha respectively, was obtained during on 1^{st} April sown crop. Pooled data of both the year showed that, the peak infestation of yellow mite was observed at 70 DAS on early sown crop (last week of March) and least infestation (8.13%) was on late sown crop (mid-June). However, the maximum fibre yield of 29.97, 29.25 q/ha) was observed on early sown and normal-I sown crops respectively. The study was concluded that irrespective of mite infestation at different crop growth stages, the date of sowing had significant positive impact on fibre yield. Hence, the optimum time for sowing jute crop for maximum fibre yield in West Bengal

Table 1. Mean per cent infestation of yellow mite, *Polyphagotarsonemus latus* on different dates of sowing of jute crop different cropping season

Treatments		Date of sowing	Per cent infestation of yellow mite during 2010-11 and 2011-12 at different DAS*									
			25	55	85	100	Fibre yield (q/ha)	25	55	85	100	Fibre yield (q/ha)
T_1	-	01.03.2010	-	-		-	-	0.00 (0.00)	0.00 (0.00)	12.87 (21.02)	11.50 (19.82)	26.61
T_2	Very early sowing	16.03.2010	0.00 (0.00)	10.50 (18.91)	6.10 (14.30)	0.75 (4.97)	28.45	0.00 (0.00)	0.00 (0.00)	8.00 (16.43)	0.00 (0.00)	27.79
T_3	Early sowing	01.04.2010	0.00 (0.00)	3.00 (9.97)	0.50 (4.05)	0.33 (3.29)	29.13	0.00 (0.00)	1.25 (6.42)	0.00 (0.00)	0.00 (0.00)	30.25
T_4	Normal sowing I	15.04.2010	0.00 (0.00)	7.00 (15.34)	2.28 (8.68)	0.12 (1.99)	28.55	0.00 (0.00)	16.71 (24.13)	0.00 (0.00)	0.00 (0.00)	29.72
T_5	Normal sowing II	31.04.2010	1.14 (6.13)	4.11 (11.70)	1.14 (6.13)	0.42 (3.72)	25.94	1.29 (6.52)	2.07 (8.27)	0.00 (0.00)	0.00 (0.00)	27.86
T_6	Late sowing	15.05.2010	1.65 (7.38)	2.69 (9.44)	0.12 (1.99)	1.29 (6.52)	27.80	3.45 (10.70)	0.79 (5.10)	0.00 (0.00)	1.32 (6.60)	23.11
T_7	Very late sowing	30.05.2010	0.90 (5.44)	0.53 (4.17)	1.86 (7.84)	0.63 (4.55)	25.34	0.60 (4.44)	2.42 (8.95)	0.00 (0.00)	0.00 (0.00)	16.66
T_8	Extra very late sowing	15.06.2010	0.72 (4.87)	0.30 (3.14)	1.33 (6.62)	0.45 (3.85)	12.61	0.35 (3.39)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	14.88
CD (P=0.05)		-	8.63	17.64	11.95	5.83	4.95	4.87	7.62	7.75	5.87	4.42

*DAS= Days after sowing, Figures in the parentheses are arc sin transformed values

Table 2. Mean per cent infestation of yellow mite, *Polyphagotarsonemus latus* on different dates of sowing of jute crop (Pooled data of 2010-11 and 2011-12 cropping season)

Treatment		Per cent infestation of yellow mite at different DAS*				
	Date of sowing	25	55	85	100	Fibre yield (q/ha)
T_1	Very early sowing	0.00 (0.00)	15.75 (23.38)	12.19 (20.43)	1.19 (6.26)	28.20
T_2	Early sowing	0.00 (0.00)	4.00 (11.54)	0.56 (4.30)	0.69 (4.76)	29.97
T_3	Normal sowing I	0.00 (0.00)	11.13 (19.48)	3.00 (9.97)	0.19 (2.48)	29.25
T_4	Normal sowing II	2.13 (8.38)	6.31 (14.55)	1.69 (7.46)	0.56 (4.30)	27.20
T_5	Late sowing	4.06 (11.63)	4.31 (11.99)	0.19 (2.48)	2.50 (9.10)	25.65
T_6	Very late sowing	1.56 (7.18)	0.75 (4.97)	3.38 (10.59)	1.31 (6.58)	21.56
T_7	Extra very late sowing	1.00 (5.74)	0.38 (3.51)	2.13 (8.38)	0.63 (4.53)	13.94
CD(P=0.05)	-	8.29	14.59	11.78	4.79	6.22

*****DAS= Days after sowing, Figures in the parentheses are arc sin transformed values

Table 3. Correlation between per cent infestation of yellow mite, *Polyphagotarsonemus latus* with abiotic factors at different days after sowing during 2010-11 and 2011-12

Weather Parameters	Cropping season during 2010-11 and 2011-12				
	25	55	85	100	Fibre yield (q/ha)
Temperature (^{0}C Max.)	0.08	0.40	-0.05	-0.25	0.46
Temperature (^{0}C Min.)	0.62	-0.44	-0.66	-0.21	-0.27
Relative Humidity (%)	-0.07	-0.40	0.04	0.16	-0.41
Rainfall (mm)	-0.25	-0.08	-0.50	-0.38	-0.36
Sunshine (Hrs.)	-0.41	0.34	0.48	-0.13	0.53

situation may be recommended as last week of March to mid-April.

Effect of abiotic factors on yellow mite, P. latus, infestation in jute

A simple correlation co-efficient was worked out between the percent infestation of yellow mite and the weather factors (Table 3). The maximum temperature had a positive effect on yellow mite infestation except at 25 and 100 DAS during 2010-11 and at 85 and 100 DAS at 2011-12 cropping season, but minimum temperature had negative influence at later stages of crop during both the cropping season. Similar observations were also reported by Ahuja (2000), Somchoudhury *et al*. (2008) and Kamruzzaman *et al.* (2014). The relative humidity had little effect on the influence of yellow mite infestation. The present study results were in close agreement with Montasser *et al.* (2011). The correlation studies also revealed that the rainfall mostly had negative effect in both the years. However, bright sunshine hours had a positive effect during 2011-12 cropping season as compared to negative effect in early and late stage of crop during 2010-11 cropping season.

It can be concluded that yellow mite infestation was higher on early sown crop than late sown crop, hence for ensuring higher yield with less pest infestation, jute crop should be sown within the period of first fortnight of April. However, the extent of damage or incidence varied with prevailing abiotic conditions of season. The temperature-humidity combination is an important regulatory factor affecting mite development and that the warm and humid conditions prevailing during cropping period is more suitable for the increase of population densities of *P. latus.*

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Long Term Effect of Manure and Fertilizers on Depthwise Distribution of DTPA-extractable Zn, Cu, Fe and Mn under Rice-Wheat System

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***Abstract*:** Laboratory analysis was made on the soil samples collected (2013) from an on-going long-term field experiment (in progress since *Kharif* 2009-10) at Department of Soil Science, PAU, Ludhiana to investigate the effect of manure and chemical fertilizers in rice-wheat system. The organic manure through bio gas slurry (BGS) @ 6 t ha^{-1} was incorporated along with nitrogen fertilizer (N @ 80 and 120 kg ha^{-1}), phosphorus fertilizer (P @ 30 kg ha^{-1}) and potassium fertilizer (K @ 30 kg ha^{-1}) to the rice crop. It was observed that the DTPA-extractable Zn, Cu and Fe decreased with increase in soil depth, whereas, the DTPA-extractable Mn decreased upto 60-90 cm depth and then its concentration increased upto 120-150 cm soil depth. Higher concentration of DTPA-extractable Zn, Cu, Fe and Mn was found in the treatments where organic manure through BGS was added @ 6 t ha^{-1} along with N @ 80 kg ha^{-1} and K @ 30 kg ha^{-1} to the rice crop. The results of this study were of practical utility since application of manure and chemical fertilizers together increased DTPA-extractable Zn, Cu, Fe and Mn in the surface soil whereas, their concentrations decreased with depth.

***Key W*ords**: Biogas slurry manure, Chemical fertilizers, DTPA-extractable Zn, Cu, Fe and Mn, Rice-wheat system

Rice-wheat is the predominant cropping system, being practiced by majority of farmers in different agro-climatic zones of Punjab with the result, production of food grains is increasing year after year due to intensive cultivation of land thereby depleting a huge amount of macronutrients along with micronutrients. Relatively, over use of macronutrient fertilizers, decreased use of organic manures, reduced recycling of crop residues, and bumper harvests in the past three decades have induced secondary and micronutrient deficiencies in the Indo Gangetic Plains (Agbenin, 2003). In several areas with intensive cropping, zinc deficiency appeared initially and subsequently the deficiencies of iron (Fe) and manganese (Mn) were observed. Application of organic manures resulted in the increase in DTPA-Zn, Cu, and Fe and Mn fractions in the soil. Similarly, FYM reduced the concentration of residual micronutrients and increased the DTPA fractions of micronutrients (Sekhon *et al.,* 2006). In a field study, Varshney *et al.,* (2008) observed that application of zinc sulphate significantly increased the DTPA-extractable Zn in soil but its concentration decreased with subsequent crop removal. Verma *et al.* (2005) reported the effect of decade long fertilizer and manure application on soil fertility and productivity of rice-wheat system in a Mollisol. Kumar and Yadav (2005) reported that a depletion in available Zn, Cu, Fe and Mn content with continuous cropping of rice-wheat-cowpea in fertilized plots at varying sampling stages. Patel *et al.* (2009) reported that addition of FYM increased the concentration of DTPA-extractable Zn, Cu, Fe and Mn in the soil. Elbordiny and Camilia, (2008) conducted an experiment on salt effected soils and observed the effect of different soil properties on DTPA-extractable Zn, Cu, Fe and Mn in soil profile. They reported the positive correlation between Zn, Cu, Fe and Mn with pH values in the surface layer of soil less than 40 cm and greater than 80 cm. Whereas, in between 40-80 cm negative correlation of Zn, Cu, Fe and Mn were found. The significantly positive correlation of Zn, Cu, Fe and Mn and organic matter, clay content, cation exchange capacity and exchangeable sodium was reported in surface (0-15 cm) and subsurface (15-30 cm) layers.

Depthwise distribution of DTPA-extractable Zn, Cu, Fe and Mn under rice-wheat and maize-wheat cropping systems was observed by Sharma *et al.* (2005). They reported that the DTPA-extractable Zn, Cu, Fe and Mn were higher in surface layer than subsurface layer of soil under rice-wheat and maize-wheat cropping systems. The DTPA-extractable Fe (17 mg kg^{-1}) and Mn (10.3 mg kg^{-1}) were reported higher in 87-117 cm depth under rice-wheat cropping system. In maize-wheat cropping system the DTPA-extractable Fe and Mn were higher in 105-120 cm depth. Rice-wheat cropping system showed more content of DTPA-extractable Zn, Cu, Fe and Mn than maize-wheat cropping system.

Various research studies revealed that application of manure in combination with chemical fertilizers supported in building up of the OC level and available Zn, Cu, Fe and Mn

in soil. The information on depthwise distribution of DTPA-extractable Zn, Cu, Fe and Mn with application of manure and fertilizers is meager in rice-wheat system and needs to be investigated. Taking these points into consideration the research has been conducted to study the depth wise variation of DTPA-extractable Zn, Cu, Fe and Mn in soils under rice-wheat system.

MATERIAL AND METHODS

In order to achieve the objectives mentioned earlier, laboratory studies were made on the soil samples collected from an on-going long-term experiment on role of manure and fertilizers in rice-wheat cropping system (in progress since *Kharif* 2009-10) at Department of Soil Science, Punjab Agricultural University, Ludhiana. The soil of experiment field was classified as Typic Ustochrept. The experiment was conducted in a fixed layout since its beginning with treatments combinations mentioned in Table 1. The experiment was laid out in a split plot design with four main and three sub treatments. The organic manure through bio gas slurry (BGS) @ 6 t ha^{-1} was incorporated along with nitrogen fertilizer (N @ 80 and 120 kg ha^{-1}), phosphorus fertilizer (P @ 30 kg ha^{-1}) and potassium fertilizer (K @ 30 kg ha^{-1}) were applied to the rice crop. Whereas in wheat crop, nitrogen fertilizer (N @ 120 kg ha^{-1}), different levels of phosphorus fertilizer (P @ 30 and 60 kg ha^{-1}) and potassium fertilizer (K @ 30 kg ha^{-1}) were applied.

The experiment consists of 12 treatments with three replications under split plot design (Table 1). Biogas manure was applied @ 6 t ha^{-1} before transplantation of rice with different combinations of nitrogen and phosphorus fertilizers were applied to rice and wheat crops. Similarly, profile samples from six periodic depths (0-15, 15-30, 30-60, 60-90, 90-120, 120-150 cm) were collected after harvesting of rice in the month of October, 2013. Soil samples were analyzed for DTPA-extractable Zn, Cu, Fe and Mn.

The pH of the soil was 6.01 and the EC was 0.17 dSm^{-1}. The soil organic carbon was 0.33%, available nitrogen content was 275 kg ha^{-1}, available phosphorus was 23 kg ha^{-1} and available potassium was observed as 184 kg ha^{-1}. The concentration of Zn, Cu, Fe and Mn was noted as 1.76, 0.67, 5.87 and 4.59 mg kg^{-1}.

DTPA-extractable Zn, Cu, Fe and Mn

For determination of DTPA-extractable Zn, Cu, Fe and Mn content, soil samples taken after harvesting of rice were prepared in 1: 2 soil-extractant ratio using DTPA-TEA buffer (0.005 M DTPA + 0.001 M $CaCl_2$ + 0.1 M TEA, pH 7.3) and concentration of these micronutrient cations was measured on Varian Model of atomic absorption spectrophotometer (Lindsay and Norvel, 1978).

RESULTS AND DISCUSSION

Depthwise distributions of DTPA-extractable Zn

The concentration of DTPA-extractable Zn in profile (0-150 cm) soil samples collected after harvesting of rice ranged from 2.08 to 4.02 mg kg^{-1} in all the treatments (Table 2). The higher concentrations of DTPA-extractable Zn were observed in surface soil as compared to the subsurface soil under rice-wheat system (Gurpreet-Singh *et al.,* 2011). Significantly higher concentration of DTPA-extractable Zn has been observed in the treatments where organic manure @ 6 t ha^{-1} was added along with N @ 80 kg ha^{-1} and P_2O_5 @ 30 kg ha^{-1} to the rice crop as compared to the treatments where only N @ 120 kg ha^{-1} and P_2O_5 @ 30 kg ha^{-1} were applied to

Table 1. Treatment detail of long term experiment on rice-wheat cropping system

Treatments	Rice			Wheat
	Manure	N	P_2O_5	P_2O_5
	(t ha^{-1})	(kg ha^{-1})		(kg ha^{-1})
T_1	0	120	0	0
T_2	0	120	0	30
T_3	0	120	0	60
T_4	6	80	30	0
T_5	6	80	30	30
T_6	6	80	30	60
T_7	0	120	30	0
T_8	0	120	30	30
T_9	0	120	30	60
T_{10}	6	80	0	0
T_{11}	6	80	0	30
T_{12}	6	80	0	60

Table 2. Depthwise distribution of DTPA-extractable Zn (mg kg^{-1}) after harvesting of rice

Treatments to rice	Rates of P applied to wheat (kg P_2O_5 ha^{-1})			Mean	Rates of P applied to wheat (kg P_2O_5 ha^{-1})			Mean
	P_0	P_{30}	P_{60}		P_0	P_{30}	P_{60}	
	0-15 cm				60-90 cm			
M_0 N_{120} P_0	3.33	3.19	2.98	3.17	0.38	0.35	0.33	0.35
M_6 N_{80} P_{30}	3.60	3.58	3.35	3.51	0.46	0.44	0.39	0.43
M_0 N_{120} P_{30}	2.65	2.56	2.08	2.43	0.27	0.24	0.24	0.25
M_6 N_{80} P_0	4.02	3.97	3.79	3.93	0.56	0.47	0.46	0.49
Mean	3.40	3.33	3.05	-	0.42	0.37	0.36	-
LSD*(p<0.05)*	R=0.42, W=0.25, RxW=NS				R=0.04, W=0.03, RxW=NS			
	15-30 cm				90-120 cm			
M_0 N_{120} P_0	1.19	1.04	1.00	1.08	0.33	0.32	0.31	0.32
M_6 N_{80} P_{30}	1.35	1.33	1.20	1.29	0.40	0.39	0.35	0.38
M_0 N_{120} P_{30}	0.91	0.81	0.77	0.83	0.31	0.27	0.26	0.28
M_6 N_{80} P_0	2.17	2.03	1.62	1.94	0.48	0.48	0.40	0.45
Mean	1.40	1.30	1.15	-	0.38	0.37	0.33	-
LSD *(p<0.05)*	R=0.45, W=NS, RxW=NS				R=0.06, W=NS, RxW=NS			
	30-60 cm				120-150 cm			
M_0 N_{120} P_0	0.47	0.44	0.42	0.44	0.30	0.29	0.28	0.29
M_6 N_{80} P_{30}	0.49	0.48	0.47	0.48	0.33	0.32	0.31	0.32
M_0 N_{120} P_{30}	0.41	0.33	0.29	0.35	0.24	0.17	0.16	0.19
M_6 N_{80} P_0	0.84	0.64	0.53	0.67	0.40	0.36	0.34	0.37
Mean	0.55	0.47	0.43	-	0.32	0.28	0.27	-
LSD *(p<0.05)*	R=0.18, W=0.09, RxW=NS				R=0.10, W=NS, RxW=NS			

the rice crop without addition of organic manure. Significant higher concentration of DTPA-extractable Zn was in the treatments where organic manure @ 6 t ha^{-1} was added along with N @ 80 kg ha^{-1} without the application of phosphatic fertilizer as compared to the treatments where no organic manure was incorporated but N @ 120 kg ha^{-1} and P_2O_5 @ 30 kg ha^{-1} were applied to the rice crop.

The DTPA-extractable Zn ranged from 2.08 to 4.02, 0.77 to 2.17, 0.29 to 0.84, 0.24 to 0.56, 0.31 to 0.48 and 0.16 to 0.40 mg kg^{-1} in 0-15, 15-30, 30-60, 60-90, 90-120 and 120-150 cm soil depths, respectively. Significantly higher concentration of DTPA-extractable Zn has been observed in the treatments where organic manure @ 6 t ha^{-1} was added along with N @ 80 kg ha^{-1} and P_2O_5 @ 30 kg ha^{-1} were applied to the rice crop in 0-15 cm soil depth. Whereas in the wheat crop, the different levels of P_2O_5 (0, 30 and 60 kg ha^{-1}) were applied and a significant decrease in Zn concentration was observed in the treatments where P_2O_5 @ 60 kg ha^{-1} was applied as compared to the treatments where no phosphatic fertilizer was applied. The interaction between rice and wheat treatments is observed as non significant. Higher content of DTPA-extractable Zn in surface soil was observed which may be due to higher organic matter present in surface soil as compared to subsurface soil. Elbordiny and Camilia, (2008) reported significantly positive correlation between DTPA-extractable Zn and organic matter content in surface and subsurface soils. Similarly, Chhibba *et al.,* (2007) reported a decrease in the DTPA-Zn content with increase in soil depth. Sharma *et al.,* (2005) reported similar results on distribution of DTPA-extractable Zn in the soil profile in Indo-Gangetic plains under rice-wheat system.

Depthwise distributions of DTPA-extractable Cu

The higher concentration of DTPA-extractable Cu was observed in surface (0-15 cm) soil samples collected after harvesting of rice ranged from 0.57 to 0.95 mg kg^{-1} in different treatment combinations (Table 3). Among the different treatments, significantly higher concentration of DTPA-extractable Cu was noticed in the treatments where organic manure @ 6 t ha^{-1} was incorporated along with N @ 80 kg ha^{-1} and P_2O_5 @ 30 kg ha^{-1} to the rice crop as compared to the treatments where N @ 120 kg ha^{-1} and P_2O_5 @ 30 kg ha^{-1} were applied without organic manure application to the rice crop. Significant results were observed for concentration of DTPA-extractable Cu in the treatments where organic manure @ 6 t ha^{-1} was incorporated along with N @ 80 kg ha^{-1} without the application of phosphatic fertilizer as compared to the treatments where no organic manure was incorporated but N @ 120 kg ha^{-1} and P_2O_5 @ 30 kg ha^{-1} were applied to the rice crop. Whereas in the wheat crop, the different levels of P_2O_5 (0, 30 and 60 kg ha^{-1}) were applied, significant response

Table 3. Depthwise distribution of DTPA-extractable Cu (mg kg^{-1}) after harvesting of rice

Treatments to rice	Rates of P applied to wheat (kg P_2O_5 ha^{-1})			Mean	Rates of P applied to wheat (kg P_2O_5 ha^{-1})			Mean
	P_0	P_{30}	P_{60}		P_0	P_{30}	P_{60}	
	0-15cm					60-90 cm		
M_0 N_{120} P_0	0.76	0.74	0.72	0.74	0.45	0.30	0.41	0.39
M_6 N_{80} P_{30}	0.79	0.77	0.76	0.77	0.40	0.43	0.39	0.41
M_0 N_{120} P_{30}	0.72	0.66	0.57	0.65	0.37	0.36	0.38	0.37
M_6 N_{80} P_0	0.95	0.86	0.84	0.88	0.40	0.37	0.47	0.41
Mean	0.81	0.76	0.72	-	0.41	0.37	0.41	-
LSD*(p<0.05)*	R=0.06, W=0.04, RxW=NS				R=NS, W=0.04, RxW=0.08			
	15-30 cm					90-120 cm		
M_0 N_{120} P_0	0.57	0.56	0.55	0.56	0.33	0.32	0.29	0.31
M_6 N_{80} P_{30}	0.67	0.66	0.65	0.66	0.36	0.36	0.36	0.36
M_0 N_{120} P_{30}	0.55	0.53	0.52	0.53	0.38	0.25	0.24	0.29
M_6 N_{80} P_0	0.67	0.67	0.65	0.67	0.38	0.40	0.37	0.38
Mean	0.62	0.61	0.59	-	0.37	0.33	0.31	-
LSD*(p<0.05)*	R=0.07, W=NS, RxW=NS				R=0.03, W=0.03, RxW=0.05			
	30-60 cm					120-150 cm		
M_0 N_{120} P_0	0.49	0.43	0.47	0.46	0.22	0.22	0.21	0.22
M_6 N_{80} P_{30}	0.53	0.54	0.51	0.53	0.26	0.24	0.24	0.25
M_0 N_{120} P_{30}	0.43	0.44	0.41	0.43	0.19	0.18	0.19	0.18
M_6 N_{80} P_0	0.59	0.55	0.54	0.56	0.27	0.25	0.24	0.25
Mean	0.51	0.49	0.48	-	0.23	0.22	0.22	-
LSD*(p<0.05)*	R=0.03, W=NS, RxW=NS				R=0.04, W=NS, RxW=NS			

in concentration of DTPA-extractable Cu has been observed where P_2O_5 @ 30 kg ha^{-1} was applied as compared to the treatments where no phosphatic fertilizer was applied. The DTPA-extractable Cu was found at par with each other where P_2O_5 @ 30 and 60 kg ha^{-1} were applied at 0-15 cm depth. The interaction between rice and wheat treatments is observed as non significant. The increase in DTPA-extractable Cu may be attributed to the chelating action of organic compounds released during decomposition of organic manures, which increased the availability of micronutrients by preventing fixation, oxidation, precipitation and leaching.

Decreasing trend of DTPA-extractable Cu was found with increase in soil depth (Table 4) and the DTPA-extractable Cu ranged from 0.52 - 0.67, 0.41 - 0.59, 0.30 - 0.47, 0.25 - 0.40 and 0.18 - 0.27 mg kg^{-1} at 15-30, 30-60, 60-90, 90-120 and 120-150 cm soil depths respectively. DTPA-extractable Cu decreased normally with increase in soil depth. Hao and Chang, (2002) reported the effect of 25 annual cattle manure applications on soluble and exchangeable Cu in soil. Similar findings were reported by Sharma *et al.,* (2005) for DTPA-extractable Cu. The higher content of DTPA-extractable Cu in surface soil may be due to higher organic matter present in surface soil as compared to the subsurface soil.

Depthwise distributions of DTPA-extractable Fe

The distribution of DTPA-extractable Fe in soil profile (0-150 cm) samples collected after harvesting of rice. The results revealed that higher concentrations of DTPA-extractable Fe were observed in surface soil under rice-wheat cropping system and these concentrations decreased with increase in soil depths (Table 4). Significantly higher level of DTPA-extractable Fe was reported (ranged from 20.24 to 35.28 mg kg^{-1}) in 0-15 cm depth in all the treatments. The data presented in Table 5 illustrated that the concentrations of DTPA-extractable Fe showed significant increase in the treatments where organic manure @ 6 t ha^{-1} has been incorporated along with N @ 80 kg ha^{-1} and P_2O_5 @ 30 kg ha^{-1} applied to the rice crop as compared to the treatments where only N @ 120 kg ha^{-1} was applied without organic manure and P fertilizer application to the rice crop. Significantly higher concentration of DTPA-extractable Fe was also noticed in the treatments where organic manure @ 6 t ha^{-1} was added along with N @ 80 kg ha^{-1} without the application of phosphatic fertilizer as compared to the treatments where N @ 120 kg ha^{-1} and P_2O_5 @ 30 kg ha^{-1} were applied without organic manure addition to the rice crop. Whereas in the wheat crop, the different levels of P_2O_5 (0, 30 and 60 kg ha^{-1}) were applied, a significant response in

Table 4. Depthwise distribution of DTPA-extractable Fe (mg kg^{-1}) after harvesting of rice

Treatments of rice	Rates of P applied to wheat (kg P_2O_5 ha^{-1})				Rates of P applied to wheat (kg P_2O_5 ha^{-1})			
	P_0	P_{30}	P_{60}	Mean	P_0	P_{30}	P_{60}	Mean
	0-15 cm				60-90 cm			
M_0 N_{120} P_0	30.93	27.64	26.71	28.43	3.47	3.19	3.86	3.51
M_6 N_{80} P_{30}	32.96	33.15	31.98	32.70	3.70	3.94	3.61	3.75
M_0 N_{120} P_{30}	26.08	24.85	20.24	23.73	3.13	3.49	2.59	3.07
M_6 N_{80} P_0	34.72	35.28	33.12	34.38	4.88	3.64	3.57	4.03
Mean	31.17	30.23	28.01	-	3.80	3.57	3.41	-
LSD *(p<0.05)*	R=1.51, W=1.08, RxW=2.15				R=0.25, W=0.23, RxW=0.46			
	15-30 cm				90-120 cm			
M_0 N_{120} P_0	11.41	10.97	10.79	11.05	3.52	3.42	2.92	3.29
M_6 N_{80} P_{30}	13.75	12.76	11.42	12.64	3.61	3.84	3.52	3.66
M_0 N_{120} P_{30}	10.89	9.31	9.97	10.05	2.71	3.06	2.89	2.88
M_6 N_{80} P_0	15.90	14.77	14.22	14.96	4.63	4.00	3.91	4.18
Mean	12.99	11.95	11.60	-	3.62	3.58	3.31	-
LSD *(p<0.05)*	R=0.57, W=0.64, RxW=NS				R=0.14, W=0.22, RxW=0.45			
	30-60 cm				120-150 cm			
M_0 N_{120} P_0	4.75	4.66	4.35	4.59	3.40	3.35	3.64	3.46
M_6 N_{80} P_{30}	4.94	4.77	4.65	4.79	3.62	3.44	3.62	3.56
M_0 N_{120} P_{30}	4.54	4.35	4.26	4.38	3.38	3.57	3.42	3.46
M_6 N_{80} P_0	5.37	5.18	4.90	5.15	3.66	3.60	3.48	3.58
Mean	4.90	4.74	4.54	-	3.51	3.49	3.54	-
LSD *(p<0.05)*	R=0.47, W=0.25, RxW=NS				R=NS, W=NS, RxW=NS			

Table 5. Depthwise distribution of DTPA-extractable Mn (mg kg^{-1}) after harvesting of rice

Treatments of rice	Rates of P applied to wheat (kg P_2O_5 ha^{-1})			Mean	Rates of P applied to wheat (kg P_2O_5 ha^{-1})			Mean
	P_0	P_{30}	P_{60}		P_0	P_{30}	P_{60}	
	0-15cm				60-90 cm			
M_0 N_{120} P_0	4.67	4.54	3.69	4.30	2.99	3.07	2.59	2.88
M_6 N_{80} P_{30}	5.45	4.94	4.93	5.12	3.32	3.61	3.37	3.43
M_0 N_{120} P_{30}	3.76	3.61	3.52	3.63	3.60	3.85	3.29	3.58
M_6 N_{80} P_0	5.01	5.12	5.23	5.12	3.43	3.24	3.60	3.42
Mean	4.72	4.55	4.34	-	3.34	3.44	3.21	-
LSD *(p<0.05)*	R=0.49, W=NS, RxW=NS				R=0.22, W=NS, RxW=NS			
	15-30 cm				90-120 cm			
M_0 N_{120} P_0	4.59	4.57	4.41	4.52	3.54	3.16	3.55	3.42
M_6 N_{80} P_{30}	4.73	4.68	4.67	4.69	3.81	4.13	4.53	4.16
M_0 N_{120} P_{30}	4.33	3.61	3.58	3.84	3.85	3.41	2.78	3.35
M_6 N_{80} P_0	5.32	4.94	4.84	5.03	3.45	3.66	3.94	3.68
Mean	4.74	4.45	4.38	-	3.66	3.59	3.70	-
LSD *(p<0.05)*	R=0.28, W=0.19, RxW=NS				R=0.40, W=NS, RxW=0.42			
	30-60 cm				120-150 cm			
M_0 N_{120} P_0	3.56	3.27	2.86	3.23	3.90	3.68	3.51	3.70
M_6 N_{80} P_{30}	3.57	3.51	3.44	3.50	3.67	3.17	3.68	3.51
M_0 N_{120} P_{30}	2.86	2.75	2.80	2.81	3.81	3.08	3.25	3.38
M_6 N_{80} P_0	3.77	3.78	3.67	3.74	3.44	3.15	4.19	3.60
Mean	3.44	3.32	3.19	-	3.44	3.15	4.19	-
LSD*(p<0.05)*	R=0.26, W=0.16, RxW=NS				R=NS, W=0.27, RxW=0.55			

concentration of DTPA-extractable Fe has been observed at these levels. The interaction between rice and wheat treatments is also observed as significant.

The DTPA-extractable Fe was highest in the surface soils and it decreased with the increase in soil depth (Wei *et al.,* 2006). The DTPA-extractable Fe decreased with increase in soil depths 15-30, 30-60, 60-90, 90-120 and 120-150 cm where it ranged from 9.31 to 15.90, 4.26 to 5.37, 2.59 to 4.88, 2.71 to 4.63 and 3.38 to 3.66 mg kg^{-1}. Similar results were observed by Khan *et al.,* (2002), who reported the higher concentration of DTPA-extractable Fe in surface (0-15 cm) as compared to the subsurface (15-30 cm) layer under rice-wheat system. Similarly, Elbordiny and Camilia, (2008) reported significantly positive correlation of DTPA-extractable Fe with organic matter content in surface and subsurface soil. An increase in the availability of Fe in soil with the application of organic manure in rice-wheat cropping system has been reported by Yadvinder-Singh *et al,*. (2000) and Yadav and Kumar, (2000).

Depthwise distributions of DTPA-extractable Mn

Higher concentration of DTPA-extractable Mn was observed in surface soil as compared to the subsurface soil (Table 5). The DTPA-extractable Mn decreased with increased in soil depths. In rice-wheat cropping system, significantly higher concentration of DTPA-extractable Mn in surface soil (0-15 cm) was observed where it was ranged from 3.52 to 5.45 mg kg^{-1} was observed in the treatments where organic manure was incorporated along with chemical fertilizers, as compared to the treatments where only chemical fertilizers were applied without incorporation of organic manure to the rice crop. The DTPA-extractable Mn decreased with increase soil depth upto 60-90 cm. On the other hand, higher level of DTPA-extractable Mn was observed in 90-120 and 120-150 cm soil depths.

The data (Table 6) reported that the concentration of DTPA-extractable Mn showed significantly higher concentration in the treatments where organic manure @ 6 t ha^{-1} was incorporated along with N @ 80 kg ha^{-1} and P_2O_5 @ 30 kg ha^{-1} applied to the rice crop as compared to the treatments where N @ 120 kg ha^{-1} and P_2O_5 @ 30 kg ha^{-1} were applied to the rice crop without organic manure. Significantly higher concentration of DTPA-extractable Mn was also noticed in the treatments where organic manure @ 6 t ha^{-1} was incorporated along with N @ 80 kg ha^{-1} without the application of phosphatic fertilizer as compared to the treatments where N @ 120 kg ha^{-1} and P_2O_5 @ 30 kg ha^{-1} were applied to the rice crop without addition of organic manure. Further, the significant increase was also observed in the treatments where organic manure @ 6 t ha^{-1} was added along with N @ 80 kg ha^{-1} applied to the rice crop as compared to the treatments where only N @ 120 kg ha^{-1} was applied without organic manure to the rice crop.

The DTPA-extractable Mn ranged from 3.58 - 5.32, 2.75 - 3.78, 2.59 - 3.85, 2.78 - 4.53 and 3.08 - 4.19 mg kg^{-1} at 15-30, 30-60, 60-90, 90-120 and 120-150 cm soil depths, respectively (Table 6). Whereas in the wheat crop, the different levels of P_2O_5 (0, 30 and 60 kg ha^{-1}) which were applied, showed non significant response in concentration of DTPA-extractable Fe in surface soil. The interaction between rice and wheat treatments is also observed as non significant. So, DTPA-extractable Mn increased significantly in the plots where organic manure along with chemical fertilizers has been added in combination. An increase in DTPA-extractable Mn may be attributed to the reduction of Mn^{+4} to Mn^{+2} accompanied by an increase in its solubility under submerged conditions and the chelating action of organic manures. DTPA-extractable Mn in soil increased significantly with application of organic manure through BGS in combination with N, P and K fertilizers. Sharma *et al.,* (2005) reported higher levels for DTPA-extractable Mn under rice-wheat cropping system. Similar results were observed by Sharma *et al.,* (2000) and Lu *et al.,* (2004), who reported that the continuous use of rice-wheat cropping system year after year reduced the Mn due to leaching down to lower depth of soil.

Higher concentrations of DTPA-extractable Zn, Cu, Fe and Mn were observed in surface soil as compared to subsurface soil. The DTPA-extractable Zn, Cu and Fe and Mn decreased with increase in the soil depth. Higher levels of DTPA-extractable Zn, Cu, Fe and Mn in surface soil may be due to higher organic matter present in surface soil as compared to subsurface soil. Levels of DTPA-extractable Fe and Mn were significantly higher in surface as well as subsurface soil which may be due higher mobilization of these micronutrient cations.

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Influence of Rice Establishment Methods and Varieties on Soil Properties

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***Abstract*:** Field experiment was conducted during the wet (*Kharif*) season of 2010 at the research farm of the IARI, New Delhi to evaluate the influence of methods of stand establishment and rice varieties on soil properties. Different methods of transplanting significantly affected the concentration and uptake of N and Fe. Fe concentration in grain was 25% higher in SRI than CT. DT also showed nearly 20% increase in Fe concentration in rice grain as compared to CT. Both SRI and DT methods had greater Fe uptake over the CT. However, SRI method showed highest uptake of Fe, which was almost 33% greater than uptake in CT. Available Fe in soil at 60 DAT and at harvest recorded lowest in SRI method but it was at par with CT and DT. Different cultivation methods influenced MBC of soil and SRI recorded significantly higher MBC (182.3) than the other two methods. CT registered the lowest amount of MBC (158.2). Dehydrogenase activity was significantly higher in case of SRI (78.5) as compared to other methods. Among the varieties, 'Pusa Basmati 1401' (68.3) recorded the highest amount of dehydrogenase activity, while lowest activity was recorded in PRH 10. The highest amount of FDA was recorded in SRI (0.84) which was significantly higher as compared to CT and DT. A high level of correlation was recorded between microbial parameters with grain yield, available N and organic carbon status of soil.

Key Words: Rice varieties, SRI, double transplanting, Soil microbial properties

Rice (*Oryza sativa* L.) is the main staple food in Asia, and the crop is typically produced on waterlogged soils. Lowland rice makes a major contribution to global rice supply and rice-rice and rice-wheat system is often cited as an example of sustainable production system (Sahrawat, 2007). The major reason for the maintenance of soil fertility in the lowland rice paddies is the conservation and accumulation of organic matter (organic carbon and nitrogen) under prolonged submerged soil conditions. The preferential accumulation of organic matter in submerged soils as compared to upland systems is primarily caused by slow, incomplete and inefficient decomposition of organic matter under anaerobic (lack of oxygen) condition which results in the net accumulation of soil organic matter (Ceesay *et al*., 2006). On the other hand, the decomposition of organic matter is rapid in presence of oxygen (O_2) under upland crop or lowland rice-upland cropping systems, results in the decline of soil organic carbon (Chapagain and Yamaji, 2010). Hence, submerged or lowland soils differ considerably from their arable counterparts in physical, chemical and biological properties. Unlike submerged soils, in upland soils, the ammonium formed is readily oxidized to nitrate via nitrite (termed nitrification). Rice crop is known to have very low water use-efficiency and under irrigated conditions it consumes 3,000 to 5,000 liters of water to produce one kilogram of rice. Farmers in a number of countries have been able to increase the yields from their current rice varieties with available resources by utilizing what is known as the system of rice intensification (SRI) (Kabir and Uphoff, 2007). Higher productivity is achieved by making certain changes in the management of rice plants and the resources upon which these depend such as soil nutrients, air, water, soil biota, and solar energy.

The agro ecological conditions in Madagascar and similar environments in which SRI has been evaluated are not representative for most intensive rice environments in India. Most of the studies so far have been taken up under different fields having 'traditional' or 'SRI' management practices of rice cultivation with limited data collection and statistical analysis. Work done under different soils and climatic conditions may affect the results due to difference in soil properties and micro-climate. Very little research work has been done in India in on screening rice varieties for SRI method. Double transplanting has been reported as promising method of transplanting especially under summer rice. So there is a need to evaluate this practice also. The objective of this study is **t**o study the root and plant growth pattern along with changes in soil properties under system of rice intensification, double transplanting and traditional transplanting .

MATERIAL AND METHODS

Experimental design and treatments

The experiment was conducted during *Kharif*, 2010 (June-November) at Indian Agricultural Research Institute, New Delhi, situated at a latitude of 28°40' N and longitude of 77°12' E, altitude of 228.6 meters above the mean sea level (Arabian Sea). There was 929.8 mm rainfall during June to November and July, August and September months had 9, 11 and 15 numbers of rainy days, respectively. The experiment

was laid out in factorial randomized block design with nine treatments combinations comprising 3 methods of crop establishment viz., conventional transplanting (CT); system of rice intensification (SRI) and double transplanting (DT) and 3 rice varieties viz., 'Pusa Basmati 1401' 'Pusa 44' and 'PRH 10' and these treatments were replicated four times.

In conventional transplanting (CT), 21 day-old seedlings were transplanted in puddled field with 20 cm x 10 cm spacing and the plots were irrigated to maintain a 3-5 cm depth; hand weeding was done two times; recommended fertilizers were applied @ 120 kg ha^{-1} N, 60 kg ha^{-1} P_2O_5, 90 kg ha^{-1} K_2O. The P and K were applied basally, while N was applied in three splits: 30% basal and 35% each at active tillering and panicle initiation stages. In SRI practice, 12-day-old seedlings were planted at 25 cm x 25 cm and 2 cm irrigation water was applied after hairline cracks appeared in the soil surface up to panicle initiation (PI); then after PI, irrigation was given 1 day after disappearance of ponded water. Inter-cultivation was done two times with a rotary weeder at 10-days intervals. The same recommended fertilizer was applied in SRI as with conventional practice. In double transplanting (DT) 41- days- old seedlings were transplanted at 20 cm x 10 cm spacing in main field under puddle condition. These seedlings were earlier transplanted in secondary field at a closer spacing (7.5 cm x 7.5 cm) when they were 21- days-old and a starter dose of N and irrigation as and when required were given. In double transplanting method water and nutrient management in main field was done as done in conventional transplanting. The gross plot size was 5.0 m × 3.0 m for each treatment. Rotary weeder was used in SRI for weed management and interculture, while in CT and DT manual hand weeding was done. Crop was grown as per recommended practices.

Macro and micronutrient analyses

N concentration in grain of rice samples were determined by modified Kjeldahl method. The Fe in grain of rice crop were determined by rainy-digestion (di-acid digestion) procedure (Prasad *et al*., 2006). The uptake/accumulation of various major and micronutrients in grain of rice were calculated by multiplying the grain yield of rice with their respective concentrations and expressed in kg ha^{-1} and g ha^{-1}. Soil organic C analyzed by rainy digestion method.

Microbiological analyses

Microbial activity in terms of Fluorescein diacetate (FDA) hydrolysis, dehydrogenase activity and microbial biomass carbon were measured before puddling of the main field and at mid season stage (60 DAT) of crop. Soil samples were taken from crop root (0-20 cm soil depth) by core sampler then air dried the sample and kept in freezer until the analysis of the parameters.

Microbial activity in terms of fluorescein diacetate (FDA)

Microbial activity in terms of fluoresein diacetate (FDA) hydrolysis in soil was measured by procedure described by Green *et al*. (2006). FDA hydrolysis was calculated in terms of A490 units" g of Fluorescein released $gram^{-1}$ soil h^{-1}.

Dehyrogenase activity

Dehydrogenase activity was calculated and expressed in terms of g TPF liberated g^{-1} soil h^{-1} or g TPF g^{-1} soil day^{-1}.

Microbial Biomass Carbon (MBC)

Microbial biomass carbon in soil samples was estimated by the method described by Nunan *et al*. (1998). Soil microbial biomass carbon (MBC) was calculated by using the formula given below:

$$\text{µg MBC/g soil (or mg of MBC/kg of soil)} = \frac{\text{O.D. with fumigated sample} \quad \text{O.D. with unfumigated sample}}{17.5} \times 15487$$

Grain yield

Crop was harvested in the first fortnight of October. After harvesting, threshing, cleaning and drying the grain yield was recorded at 14% moisture.

RESULTS AND DISCUSSION

Soil chemical properties

Available N in soil was significantly influenced by cultivation methods. SRI recorded highest available N (187.9 kg ha^{-1}) followed by DT. The possible reason of this increase can be the fact that greater leaching losses of N have taken place in conventional method involving continuous submergence. Also, greater root development might have resulted in more soil microorganism and better N fixation in SRI. CT recorded the lowest (161.6 kg ha^{-1}) N level. DT performed better than CT because of it was planted later in the main field. Among the varieties, 'Pusa 44' recorded the highest amount of available N although 'PRH 10' and 'Pusa 44' were at par. The lowest amount of available N was in 'Pusa Basmati 6' (168.2 kg ha^{-1}). Available N was positively correlated with FDA and dehydrogenase activity (Fig 4). Soil organic carbon level was not significantly influenced by different methods of planting or varieties and was recorded statistically *at par*. It is well established that it takes decades to bring about a change in the organic C status of soil. A positive correlation between organic carbon and microbial activity was also recorded (FIG recommended fertilizers were applied @ 120 kg ha^{-1} N, 60 kg ha^{-1} P_2O_5, 90 kg ha^{-1} K_2O. The P and K were applied basally, while N was applied in three splits: 30% basal and 35% each at active tillering and panicle initiation stages. which illustrates the significance of microorganisms in the maintenance of organic matter of soil. Available Fe in soil at 60 DAT and at harvest recorded lowest in SRI method but it was at par with CT and DT (4.05 mg kg^{-1}). Among the varieties, 'Pusa Basmati1401'and 'Pusa 44' (4.56 mg kg^{-1}) were at par, while significantly lower values were recorded in 'PRH 10'.

Concentration and uptake of nutrients

Different methods of transplanting significantly affected the concentration and uptake of N. Under CT and DT, the concentration of N varied from 1.12 to 1.14 %, and

was statistically at par. With SRI practices concentration of N was 1.31 % in grain. As a result N uptake in grain varied from 50.26 kg ha^{-1} in DT to 65.7 kg ha^{-1} in SRI method. It might be due to favourable soil condition which enhanced nutrient uptake as well as better growth and activity of roots. Alternate wetting and drying microbial a thin film of water that might open the soil for both oxygen and nitrogen activities and promoted the root growth during initial growth stages (Uphoff, 2001). Double transplanting recorded the lowest amount of N uptake in grains. Rice varieties also showed significant difference regarding N concentration and its uptake. The hybrid variety 'PRH 10' recorded significantly higher N concentration (1.21%) in grain than 'Pusa 44' but it was at par with 'Pusa Basmati 6'. Consequently, uptake in grain was also signi?cantly higher in 'PRH 10' (50.03 kg ha^{-1}) than the other two inbred varieties, which were at par. Moreover, it was lowest in 'Pusa 44' (44.4 kg ha^{-1}).

Fe concentration in grain was significantly increased by SRI method. Almost 25% increase was recorded in SRI as compared to CT. This is because of higher root volume in SRI than CT, due to which the amount of siderophores increases, thus increasing the formation of organic chelate formation and finally the uptake of Fe. Uphoff and Randriamiharisoa (2002) also observed that SRI provides soil conditions that are favourable for the mycorhizal fungi and many soil microbes, which enhances the nutrient uptake by rice. DT registered nearly 20% increase in Fe concentration in rice grain as compared to CT. The probable reason is that DT plants were exposed to two types of soil environment during nursery raising, so it might have extracted more nutrients from soil. Rice grown under SRI method recorded highest uptake of Fe, which was almost 33% greater than uptake in CT. DT performed better than CT in Fe uptake in both grain. Although DT also showed nearly 20% increase in Fe concentration in rice grain as compared to CT, both SRI and DT methods led to greater Fe uptake with SRI method recording 33% greater uptake .All the varieties were statistically *at par* regarding Fe concentration in grain. Available Fe in soil at 60 DAT recorded lowest in SRI method but it was at par with CT and DT (4. 05 mg kg^{-1}). It may be due to the fact that in submerged rice field, the reduction of Fe from ferrous to ferric form increases its availability after some weeks of submergence. At harvest, it further increased in CT and DT, which can be attributed to the increased period of submergence. Among the varieties, 'Pusa Basmati a 1401'(4.50 mg kg^{-1}) and 'Pusa 44' (4.56 mg kg^{-1}) were at par 'PRH 10', however recorded significantly lower amount of available Fe in soil, both at 60 DAT and at harvest (Table 1). Differential uptake of Fe in plant body by the three varieties could be a probable reason.

Soil microbial properties

Different cultivation methods influenced MBC of soil and SRI recorded significantly higher MBC (182.3) than the other two methods (Table 1). CT registered the lowest amount of MBC (158.2). Rupela *et al*., (2006) reported that MBC was higher in SRI plots than those of conventional flood rice. Among the varieties, 'Pusa Basmati 1401' and 'Pusa 44' showed at par MBC and they recorded significantly higher MBC as compared to 'PRH 10' (160.5) which recorded the least amount. This may be due to the fact that at mid season stage, both SRI and PRH 10 recorded highest root volumes, among different planting methods and varieties. A high level of correlation was recorded between microbial enzymes with grain yield, soil organic carbon and available N (Fig 2, 3 and 4).

Dehydrogenase activity was significantly higher in case of SRI (78.5) as compared to other methods (Table 1). Among the varieties, 'Pusa Basmati 1401' (68.3) recorded the highest amount of dehydrogenase activity, while lowest activity was recorded in PRH 10. The highest amount of FDA was recorded in SRI (0.84) which was significantly higher as compared to CT and DT. Kranti *et al* (2005) also reported that

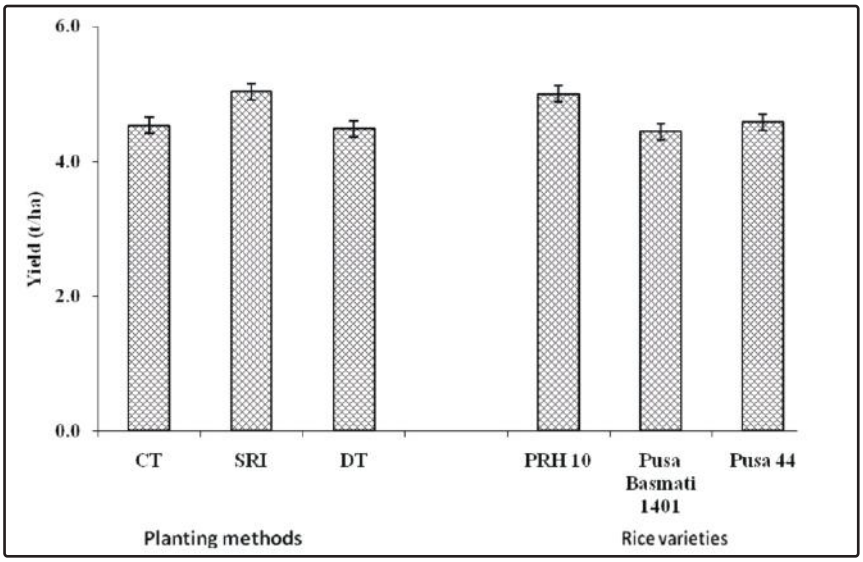

Fig.1. Influence of methods of crop establishment and rice varieties on grain yield

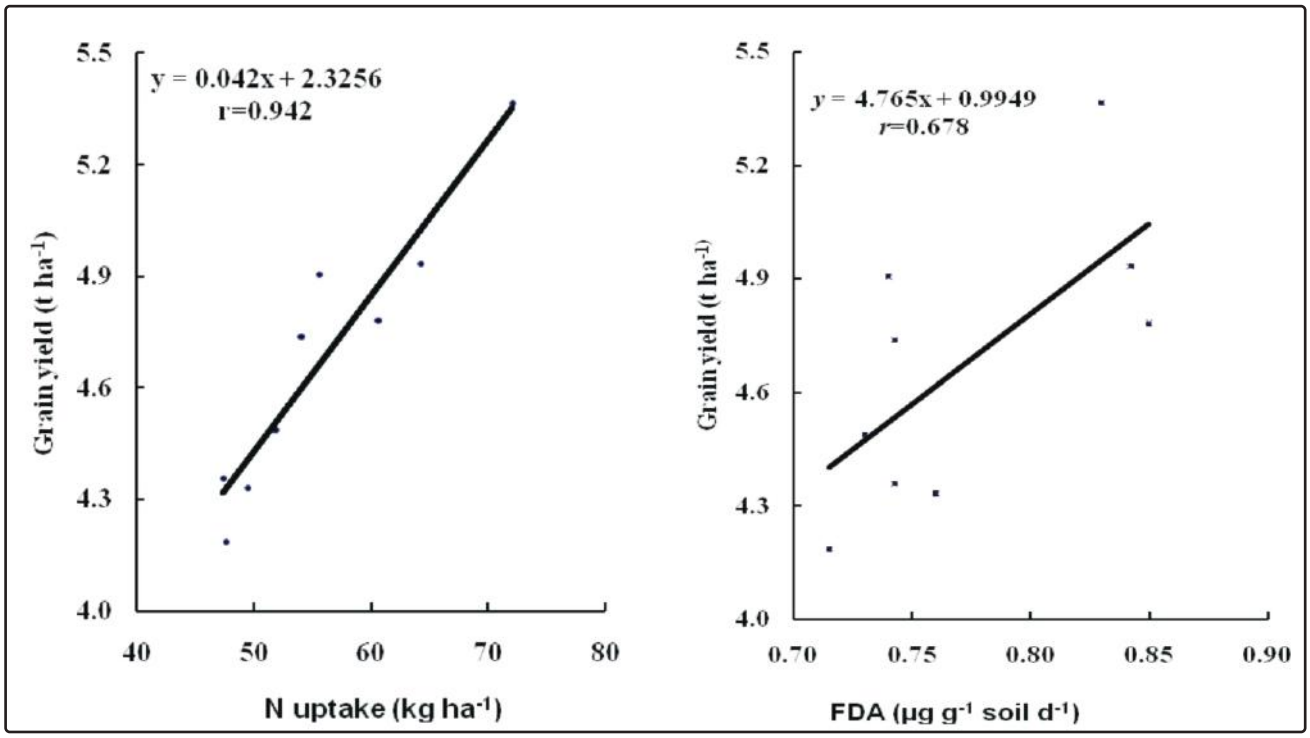

Fig 2. Correlation analyses of grain yield with a. N uptake; b. FDA

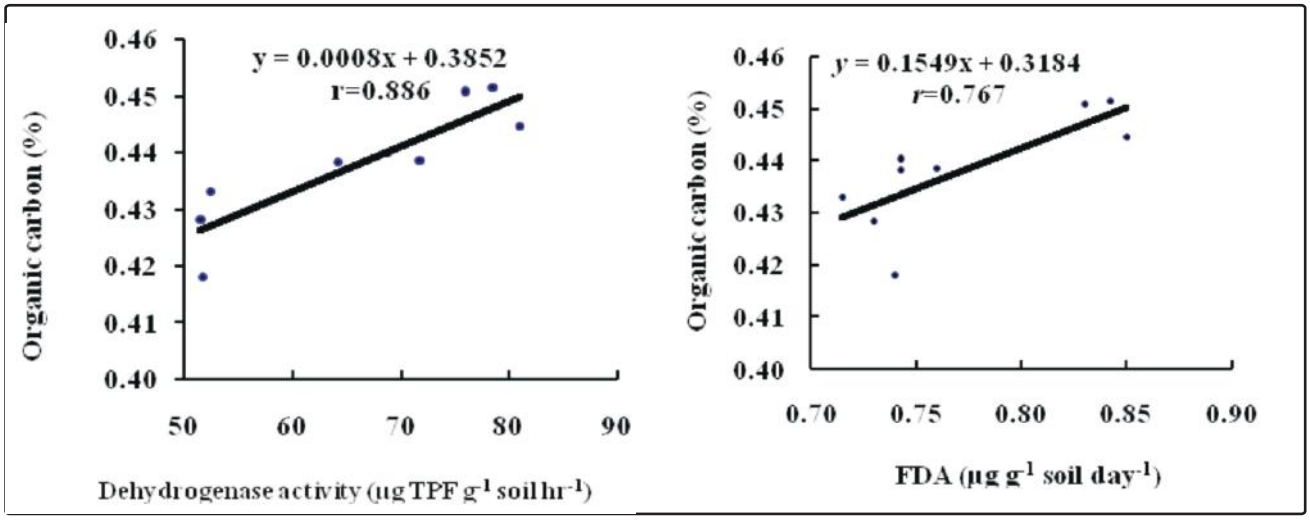

Fig.3. Correlation analyses of Organic carbon with a. Dehydrogenase activity and b. FDA

dehydrogenase activity and FDA was significantly higher in SRI over flooded rice. The possible reason could be that SRI water management practices and recommended weeding with a cono weeder would contribute to the juxtaposition of aerobic vis-à-vis saturated soil and N fixing bacteria are prolific at the interface between these two soil conditions.

Conclusions

Different methods of transplanting significantly affected the concentration and uptake of N and Fe in grain of rice. However, higher concentration and uptake of these nutrients were recorded with SRI over rest of the methods of rice production. All the varieties were statistically *at par* regarding Fe concentration in grain. Available N in soil was significantly influenced by cultivation methods. SRI recorded highest available N followed by DT. Among the different methods of rice crop establishment SRI had higher MBC and FDA. A high level of correlation was recorded between grain yield and microbial enzymes. SRI was found to be most effective in terms of nutrient acquisition in plant and enhancing soil fertility. It can be concluded that SRI practices create conditions for beneficial soil microbes to prosper, for enhancing nutrient availability and increasing grain yield.

Table 1. Effect of methods of stand establishment and varieties on availability and uptake of nutrients in soil and microbial

Parameters	Organic C (%)	Available Fe (mg kg^{-1}) at 60 DAT	Available N (kg ha^{-1}) at harvest	N concentration (%)	N uptake (kg ha^{-1})	Fe concentration (mg kg^{-1} grain)	Fe uptake (g ha^{-1})	FDA (µg g^{-1} soil day^{-1})	Dehydrogenase (g TPF g^{-1} soil hr^{-1})	Microbial biomass carbon (g MBC g^{-1} soil)
Planting method										
Conventional	0.53	4.05	161.58	1.14	51.7	27.37	123.4	0.72	52.8	158.2
SRI	0.54	3.09	187.90	1.31	65.7	37.42	188.5	0.84	78.5	182.3
Double transplanting	0.54	4.05	164.63	1.12	50.3	33.27	149.2	0.75	68.3	162.6
SEm±	0.00	0.04	0.98	0.01	0.62	2.38	11.38	0.01	1.07	1.02
LSD (*P*=0.05)	0.01	0.12	2.85	0.02	1.81	6.96	33.22	0.02	3.13	2.98
Variety										
'PRH 10'	0.54	3.65	171.42	1.21	60.6	32.45	163.2	0.75	64.0	160.5
'Pusa Basmati 1401'	0.54	3.74	168.23	1.17	51.9	29.33	131.3	0.77	68.3	171.5
Pusa 44'	0.54	3.80	174.46	1.20	55.2	36.28	166.6	0.79	67.3	171.1
LSD (*P*=0.05)	NS	0.12	2.85	0.020	1.81	NS	NS	0.02	3.13	2.98
Variety x Method										
LSD (*P*=0.05)	NS	NS	NS	0.04	NS	NS	123.4	0.013	NS	5.15

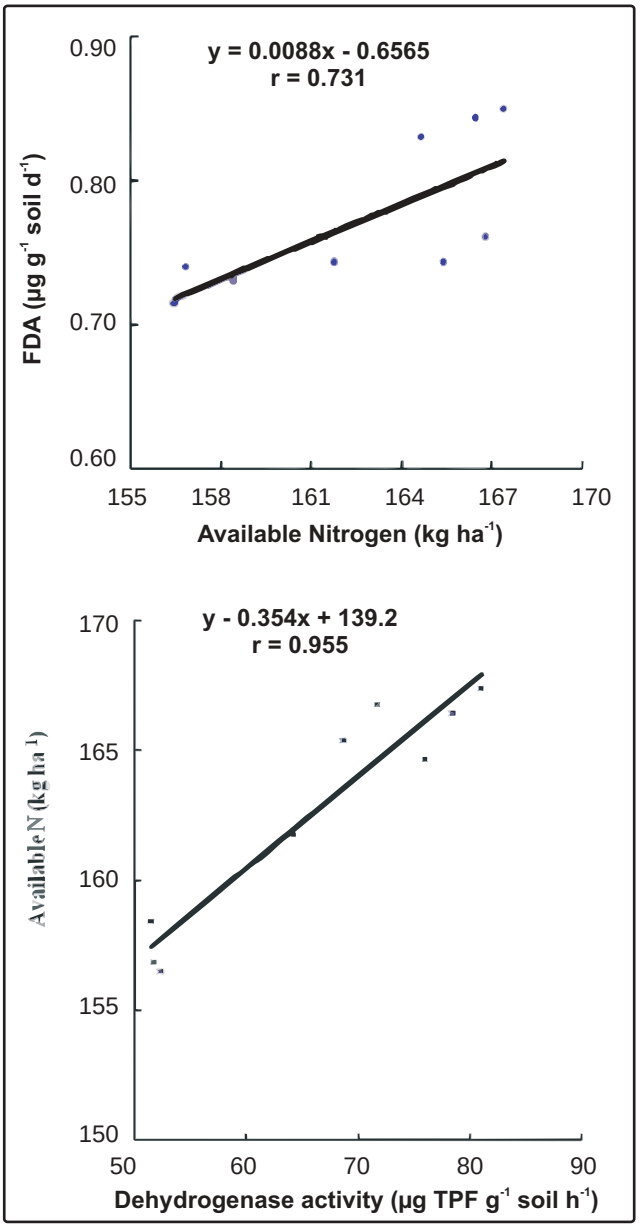

Fig.4. Correlation analyses of a. FDA with Available N; b. Available N with Dehydrogenase activity

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Weeds: An Uncommon Source of Nutrients Used by Tribal Community

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***Abstract*:** The present paper deals with nutritional potential of nine weeds grow naturally and consumed as green leafy vegetable by the tribals of Udaipur district of Rajasthan. Protein content was found to be high in *Melilotus indica* followed by *Cassia tora* and Polygonum glabrum on dry weight basis. Crud fat, ash and crude fiber content are comparable to the conventional green leafy vegetables used commonly. Calcium content varies among analysed weeds from 1935.50 mg/100g in Tribulus terrestris to 66.53 mg/100g in *Marsilea minuta*, whereas magnesium ranged from 54.06 to 134.30 mg/100g in *Marsilea minuta* and Portulaca oleracea respectively. Wide variation was recorded for iron content. The maximum iron and zinc was observed in *Portulaca oleracea* leaves. Copper was ranged from 0.25 mg/100g to 2.78 mg/100g. Beta carotene was found to be maximum in *Cassia tora* leaves (6300.74 µg/100g) whereas Melilotus indica leaves recorded higher ascorbic acid (88.15 mg/100g). Oxalate content ranged from 10.50 (*Marsilea minuta*) to 601.50 mg/100g (*Portulaca oleracea*). *Cassia tora* and *Tribulus terrestris* also had lower content of oxalic acid whereas *Euphorbia royleana* (337.50 mg/100g), *Asphodelus tenuifolius*, and *Melilotus indica* had higher content of oxalic acid was below 100 mg/100 g in five weeds and less than in the remaining weeds. Tannin content ranged between 6.64 g/100g and 10.97g/100 in all weeds.

Key Words: Nutrient and Food security, Tribal, Unwanted plants, Vegetable, Weeds

World over, tribal population still stores a vast knowledge of local plants as food material and other specific uses (Sundriyal and Sundriyal 2004). On the other hand man tries to grow only some selected plants that found useful. Quite a number of plants considered as weeds in modern science have significant value in tribals diet. Many of these naturally growing plants are not really "unwanted" in the light of traditional herbal medicines and diet. Weeds also play an important role in Ayurvedic medicine (Nath *et al.* 2007). Considering the valuable contribution in tribal diet, naturally growing weed plants in tribal, diet naturally growing weed plants in the Udaipur district of Rajasthan were collected and nutritional aspect of these weeds was studied.

MATERIAL AND METHODS

The field survey was conducted in the five tribal *tehsils* i.e. Jhdol, Kotra, Kherwada, Sarada and Salumber of Udaipur district of Rajasthan (Figure. 1). The main tribes of the area are Bheel, Meena, Garasia and Kathodi. In order to collect relevant information an open end proforma with group discussion were used. In each *tehsils* discussion with five to ten group (each group consist of five to ten individuals) were held to find out the availability and usefulness of weeds. For an effective communication, the help of forest guards and *Van Mitra* were also taken.

During the group discussions with tribal, nine weeds were shortlisted on the basis of seasonal availability, feasibility and consumption as green leafy vegetables (Table 1). All the samples were washed thoroughly in running tap water to remove dust and dirt etc. and tender part of stems and leaves were collected for study purpose. Each sample was divided into two portions, one fresh sample was stored till final analysis in seal poly begs at – 18 ± 5 °C for analysis where as another sample was dried at 45 ± 5 °C in hot air oven. They were ground to fine powder in a sieve through 1.0 mm mesh and stored in airtight container for analysis. All the selected green leafy vegetables were analysed for the proximate principle- moisture, protein (N x 6.25), crude fat (ether extraction), ash and crude fiber (NIN, 2003). The carbohydrate, content was calculated by difference, i.e. 100, the sum of the per cent of ash, protein, fat and fiber. Energy value was calculated by multiplying the values obtained for carbohydrate, protein and fat, with 4, 4 and 9 respectively and adding up the values. All selected weeds were analysed for calcium, magnesium, iron, zinc and copper through Atomic Absorption Spectrophotometer (Bishnoi and Brar 1988). Ascorbic acid was analysed by method suggested by the Association of Vitamin Chemist (1966) and â carotene content in the samples was estimated by using HPLC (Chiosa *et al.*, 2005). The oxalic acid (NIN, 2003) and tannin content (A.O.A.C. 2009) was also analysed for the selected weeds.

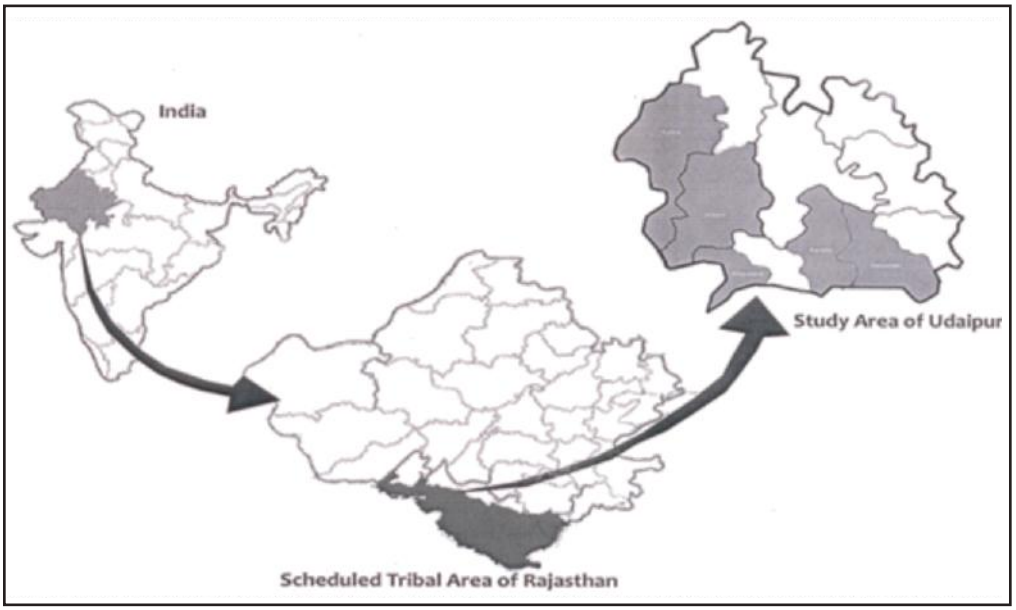

Fig 1. Study Area

Table 1. Details of leafy vegetables identified during group discussions and their utilization pattern

Scientific Name	Family	Local name	Utilization
Asphodelus tenuifolius	Liliaceae	Piyagi/ Wanzooa	Leaves are cooked as vegetable. Decoction of leaves is taken orally by the rural people to cure toxemia and to remove kidney stone. Pastes of leaves are applied externally to cure swelling on any parts of the body
Cassia tora	Leguminosae	Puariya / Punwad	Leaves are cooked as vegetable also stored after sun drying. The fresh leaves cooked with maize-daliya are considered most nourishing vegetable among tribals.
Centella asiatica	Apiaceae	Brahami Buti	Helpful in reliving the mental diseases. Leaves and tender shoots are cooked as vegetables. Leaf juice mixed with palm jiggery is given to tribal women as a tonic during pregnancy period. Decoction of leaves is given to check nervous disorders and also to restore memory.
Euphorbia royleana	Euphorbiaceae	Thor	Leaves of this weed are cooked as vegetable and are poisonous if not cooked properly and it may cause stomach ache. The usual practice is to wash the vegetable, boil it in water then the water is discarded and the boiled leaves are once again washed and cooked like other green leafy vegetables.
Marsilis minuta	Marsileaceae	Jhalod Ri Bhaji	Generally consumed during off season. It is cooked as vegetable, incorporated in *Dhoklas* and *kadhi* preparations.
Melilotus indica	Fabaceae	Pili sangi / Mooda	Grow in winters with wheat and muster crop as weed and is consumes as vegetable. Vegetable is eaten once or twice in a year then the person will not suffer from fever specifically malaria.
Polygonum glabrum	Polygonaceae	Pani vala / Jal Nala	Leaves and tender shoots are cooked as vegetable. Whole plant is purgative. The "*pakories*" made by mixing leaves and tender shoots with '*besan*'. Juice of whole fresh plant is taken orally by the tribals in colic.
Portulaca oleracea	Portulacaceae	Lunakiya	Sour in taste. This is cooked with green chick pea and can cure kidney disease.
Tribulus terrestris	Zygophyllaceae	Gokhru	The leaves are cooked as vegetable and infusion of whole plant orally with milk increase the sexual power to cure gonorrhea.

RESULTS AND DISCUSSION

Moisture content varies among all the analysed weeds and ranged from 93.53 to 70.14 per cent for *Euphorbia nerrifolur* and *Marsilea minuta* respectively. *Marsilea minuta* recorded lower moisture in the present study than Gopalan *et al.*, 2007. This might be due to effect of variation in climatic conditions. Highest protein was observed in *Melilotus indica leaves (*30.45 g/100g) followed by *Cassia tora*, *Polygonum glabrum* and *Marsilea minuta* on dry weight basis. Crude fat content ranged from 1.63 to 9.47 g/100g for *Tribulus terrestris* and *Euphorbia nerrifolur* respectively. The maximum total mineral ash was in *Portulaca oleracea* leaves. Crude fiber

was maximum in *Tribulus terrestris* whereas *Polygonum glabrum, Melilotus indica* and *Polygonum glabrum* had almost similar fiber content. Energy was found to be more in *Euphorbia nerrifolur* and *Melilotus indica*. *Melilotus indica* contained comparatively low fat content but higher protein content. Proximate composition of all the analysed weeds was comparable to the conventional green leafy vegetables (Gopalan *et al*., 2007). Other workers also reported that wild food contained nutrient comparable to the conventional foods (Nazarudeen 2010; Gupta *et al*., 2005).

Mineral content: Wide variation was recorded for mineral composition among all the analysed weeds (Table 3). Calcium was found to be maximum in *Tribulus terrestris leaves (*1935.50 mg/100g*)* and minimum in *Marsilea minuta (*66.53 mg/100g*). Magnesium* ranged from 54.06 to 134.30 mg/100g for *Marsilea minuta* and *Portulaca oleracea r*espectively. Among all the analysed weeds *Portulaca oleracea* leaves was contained highest iron and zinc i.e. 97.06 mg/100g and 42.85 mg/100g respectively. Iron content in *Portulaca oleracea* leaves was similar to previous observations (Gopalan *et al.,* 2007; Sankhla *et al*., 2003). Copper content ranged from 0.42 to 2.78 mg/100g on dry weight basis.

Vitamin: The maximum beta carotene content was in the leaves of Cassia tora leaves i.e. 6300.74 µg/100g followed by *Centella asiatica*. *Marsilea minuta* leaves recorded least beta carotene content *(*491.59 µg/100g*) among all the analysed* weeds (Table 3)*. Melilotus Indica l*eaves recorded highest ascorbic acid 88.15 mg/100g followed by *Centella asiatica (*69.38 mg/100g*), Euphorbia nerrifolur (*68.02 mg/100g*), Asphodelus tenuifolius (*67.84 mg/100g*)* and *Portulaca oleracea* (61.91 mg/100g).

Anti nutritional factors: Oxalic acid is one of the anti nutritional factors, which are widely distributed in plant foods. Oxalic acid is known to interfere with calcium absorption by forming insoluble salts of calcium. Wide variation was recorded for oxalic acid. *Portulaca oleracea and Euphorbia royleana* contained higher amount of total oxalate 601 and 337 mg/100g (Table 3). The rest of the weeds had lower total oxalate content, which was found to be in the range of 10–172 mg/100 g on fresh weight basis. Tannin content among all the weeds were ranged from 6.64 to 10.97 g/100g on dry weight basis. Tannin have antioxidants activity that are much stronger than those of vitamin C and E. Flavonols and flavonones are flavonoids of particular importance because they have been found to possess antioxidant and free radical scavenging activity in vegetable (Amic *et al.,* 2003).

Overall, the study confirms that it is possible to predict nutrient adequacy fairly well through a food variety analysed growing in diverse agro-ecological and socio-cultural settings. It is a useful tool for broader studies of food and nutrition security where it can capture the significance of neglected foods such as wild leafy vegetables.

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Table 2. Proximate composition of weeds per 100gm

Botanical Name	Moisture (gm)	Protein (gm)	Fat (gm)	Ash (gm)	Fiber (gm)	CHO (gm)	Energy (Kcal)
Asphodelus tenuifolius	[illegible]	20.24 ± 0.34	3.67 ± 0.12	10.1 ± 0.1	12.3 ± 0.16	53.7 ± 0.37	328.74 ± 0.85
Cassia tora	84.92 ± 0.05	29.38 ± 1.18	5.67 ± 0.06	11.69 ± 0.81	9.52 ± 0.16	43.71 ± 0.78	343.66 ± 3.05
Centella asiatica	85.71 ± 0.31	19.17 ± 0.17	2.43 ± 0.21	18.27 ± 0.21	10.63 ± 0.12	49.5 ± 0.34	296.56 ± 1.37
Euphorbia nerrifolur	93.53 ± 0.64	11.68 ± 0.29	9.47 ± 0.12	14.15 ± 0.05	9.04 ± 0.14	55.67 ± 0.10	354.58 ± 0.36
Marsilea minuta	70.14 ± 1.82	24.52 ± 0.77	3.17 ± 0.25	8.32 ± 0.13	10.64 ± 0.14	53.29 ± 0.89	340.32 ± 2.39
Melilotus indica	79.57 ± 0.69	30.45 ± 0.61	5.27 ± 0.06	10.58 ± 0.06	7.47 ± 0.41	46.23 ± 0.29	354.13 ± 1.76
Polygonum glabrum	84.86 ± 0.83	28.90 ± 0.29	2.37 ± 0.06	12.44 ± 0.54	7.62± 0.18	48.68 ± 0.79	331.6 ± 2.39
Portulaca oleracea	90.94 ± 0.26	19.26 ± 0.51	3.37 ± 0.15	26.37 ± 0.51	7.47 ± 0.26	43.52 ± 0.49	281.45 ± 2.07
Tribulus terrestris	82.16 ± 0.36	20.92 ± 0.45	1.63 ± 0.21	16.55 ± 0.33	16.6 ± 0.25	44.24 ± 0.63	275.92 ± 1.65

* on dry weight basis, * ± standard deviation

Table 3. Mineral, vitamins and anti nutritional composition in selected weeds per 100g

Botanical Name	Calcium (mg)	Magnesium (mg)	Iron (mg)	Zinc (mg)	Copper (mg)	â-Carotene (µg)	Ascorbic acid (mg)	Oxalic acid (mg)	Tannin (gm)
Asphodelus tenuifolius	853.32 ± 1.26	63.23 ± 0.96	44.33 ± 0.84	11.21 ± 0.70	0.91 ± 0.03	849.38 ± 1.58	67.84 ± 2.23	172.50 ± 2.60	8.08 ± 0.50
Cassia tora	976.63 ± 0.56	72.09 ± 0.82	53.90 ± 0.62	9.73 ± 0.49	0.92 ± 0.03	6300.74 ± 1.54	38.33 ± 0.19	31.50 ± 0.00	9.24 ± 0.50
Centella asiatica	893.40 ± 1.49	72.82 ± 0.86	59.03 ± 0.81	23.74 ± 1.04	1.32 ± 0.16	2890.75 ± 1.57	69.38 ± 0.39	75.00 ± 2.60	6.64 ± 0.50
Euphorbia nerrifolur	793.93 ± 0.98	81.53 ± 0.98	17.00 ± 0.41	13.95 ± 0.63	2.78 ± 0.16	850.71 ± 0.70	68.02 ± 1.93	337.50 ± 0.00	8.08 ± 1.00
Marsilea minuta	66.53 ± 0.67	54.06 ± 0.38	28.10 ± 1.43	4.54 ± 0.15	0.42 ± 0.05	491.59 ± 1.54	33.70 ± 2.36	10.50 ± 2.60	7.79 ± 0.00
Melilotus indica	755.52 ±1.00	71.12 ± 0.81	43.41 ± 0.72	9.85 ± 0.94	1.11± 0.08	960.31 ± 1.12	88.15 ± 0.56	166.50 ± 0.00	8.37 ± 0.50
Polygonum glabrum	719.53 ± 1.70	75.90 ±0.91	53.16 ± 1.38	6.12 ± 0.30	0.25 ± 0.08	849.71 ± 0.59	40.43 ± 2.47	91.50 ± 2.60	9.53 ± 0.00
Portulaca oleracea	799.10 ± 0.53	134.30 ± 0.61	97.06 ± 0.79	42.85 ±1.09	2.54 ± 0.24	940.64 ± 0.65	61.91 ± 1.50	601.50 ± 2.60	7.51 ± 0.50
Tribulus terrestris	1935.50 ± 1.00	93.55 ± 1.87	47.91 ± 1.04	9.73 ± 0.49	0.92 ± 0.03	2100.35 ± 1.15	42.16 ± 1.66	34.50 ± 2.60	10.97 ± 0.50

* â-Carotene, Ascorbic acid and Oxalic acid on fresh weight basis, * Minerals and Tannin on dry weight basis, * ± standard deviation

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Effect of Irrigation Methods and Irrigation Regimes under Different Planting Methods on Crop Productivity in Sugarcane

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***Abstract*:** Conventional planting (planting in 15 cm deep furrows at a spacing of 75 cm followed by planking), single trench (planting in 25 cm deep furrows at a spacing of 75 cm and covered with 5 cm thick soil layer) and paired row trench planting (planting on both sides of a trench 30 cm wide, 30 cm deep, with centre to centre distance of 120 cm between two trenches), two irrigation methods viz. surface drip irrigation and conventional (border) irrigation and three irrigation regimes at IW: CPE ratio of 0.6, 0.8 and 1.0 were tested during 2007-08 and 2008-09. The germination was significantly better in single and paired trench planting as compared to conventional flat planting. In different irrigation regimes germination was significantly higher with irrigation at IW: CPE of 1.0 as compared to irrigation at IW: CPE of 0.6. The yield attributes and cane yield was not significantly influenced by methods of planting and irrigation. However, the cane yield obtained at IW: CPE ratio of 0.8 being statistically at par with that obtained by applying irrigation at IW: CPE of 1.0 was significantly better than irrigation at IW: CPE of 0.6. The drip irrigation resulted in saving of irrigation water by 31.9 and 37.8 % in plant and ratoon crop respectively as compared to conventional (border) irrigation method. The quality parameters like percent Pol in juice, Brix and CCS were not significantly influenced by different planting methods or irrigation methods, though among different irrigation regimes CCS was significantly better at IW: CPE of 0.6 & 0.8 as compared to IW: CPE of 1.0.

***Key Words*:** Cane yield, Drip irrigation, Irrigation regimes, Planting methods, Quality, Sugarcane, W.U.E

Sugarcane is an important cash crop, plays an important role in country's economy, having concern with the industry. The problems faced in sugarcane cultivation are many and vary with a common concern of water management and enhancement in yield. Identification of precise planting technique to improve uniformity in plant population and crop stand is an important issue for improving the sugarcane productivity. The variation in planting techniques in different regions aims to improve the growth and reduce tiller mortality to obtain higher number of millable canes and sugarcane yield. In northern parts of India, spring sugarcane is generally planted on flat beds in single rows at a spacing of 75 cm apart. However planting of sugarcane in paired rows compared with the planting in single rows have proved beneficial.(Yadav *et al*. 1997). Further, planting sugarcane in trenches provide high degree of root anchorage prevents lodging and gives higher yield than flat planting in ratoon crop (Bhullar *et al*. 2008).

Sugarcane being a long duration (12 months under subtropical conditions) and high biomass crop, consumes large amounts of water varied from 150–180 cm. Under present scenario with limited irrigation water resources, there is urgent need to pay attention for adoption of efficient water management technologies in sugarcane cultivation. Furrow irrigation, the most often used irrigation method, can be efficiently used, but non-scientifically designed furrow dimensions with large stream size resulting in only 50% of the water applied actually being used by the crop. Alternative water application methods like drip irrigation allows uniform water distribution with control of the volume of water applied to each plant. With the adoption of drip irrigation technology water can be applied at more frequent intervals in order to maintain optimum soil moisture in the root zone resulting in maximum plant growth. While modern irrigation technology is capable of precise control of water application, there is a lack of information on how to use it. Therefore data are needed to make crucial decisions pertaining to frequency, distribution and quantity of water to be applied to realize maximum cane productivity.

Drip irrigation in sugarcane holds promise to save water in comparison to the furrow irrigation method (Alam and Kumar 2001). The information on irrigation requirements of sugarcane under different methods of planting is not well documented. Therefore, an experiment was conducted to study the response of sugarcane under different planting methods in relation to efficient irrigation methods and irrigation regimes based on IW: CPE.

MATERIAL AND METHODS

A field experiment was conducted to study response of sugarcane plant and ratoon crop as influenced by methods and levels of irrigation under different planting methods during spring season of 2007–08 and 2008-09 in the Department of Soil and Water Engineering, Punjab

Agricultural University Ludhiana, Punjab, India. The planting of cane sets was done in the month of March. The location of the experimental site is 30^0-54´ N latitude and 75^0-48´E longitude and at an altitude of 247 m above mean sea level. The study area comes under semi-arid subtropical climate with very hot and dry summer from April to June, hot and humid conditions from July to September, cold winters from November to January and mild climate during February and March. In summer, maximum temperature rises more than 45ºC and frequent frosty spells are experienced in winter. The total rainfall received during the crop growing season was 500 mm and 1118 mm during 2007-08 and 2008-09 seasons, respectively (Fig.1). The rainfall was well distributed over 36 and 40 rainy days in 2007-08 and 2008-09, respectively during the crop growing season. The soil of the experimental site was loamy sand in texture having pH 8.3 and EC of 0.14 mmhos/cm. It was low in organic carbon (0.36 %), available nitrogen (252 kg/ha), very high in available phosphorus, (65 kg/ha), and medium in available potassium (240 kg/ha)

The treatments comprised three planting methods viz. conventional planting (planting in 15 cm deep furrows at a spacing of 75 cm followed by planking), single trench (planting in 25 cm deep furrows at a spacing of 75 cm and covered with 5 cm thick soil layer) and paired row trench planting (planting on both sides of a trench 30 cm wide, 30 cm deep, from centre to centre two trenches 120 cm apart), two irrigation methods viz. surface drip irrigation and conventional (border) irrigation and three irrigation regimes at IW: CPE ratio of 0.6, 0.8 and 1.0 were tested. The treatments were replicated thrice following factorial split plot design. In conventional planting, 15 cm deep furrows were made with tractor drawn ridger, cane sets were placed end to end and light planking was done after planting, whereas in single trench planting, furrows were opened as in conventional method with a 25 cm depth of trench and then sets were placed and covered with 5 cm soil layer while in paired trench planting, trenches were made with a tractor - drawn paired row trench planter, cane sets were placed in paired rows on either side of the trench and sets were covered with 5 cm soil layer and irrigated immediately. One lakh fifty thousand disease free three budded cane sets of sugarcane variety COJ 88 were used in planting. The planting was done on 24th March, 2007 and harvested on 15th January 2008. The FYM @ 20 t/ha was applied 15 days before planting and nitrogen fertilizer was applied half along the cane rows after germination on 22nd April 2007 and remaining in the month of June. The plant crop after harvesting was ratooned in the following spring season of 2008-09. In case of ratoon crop, one third N was applied in the month of February with first hoeing, one third in April and one third in May. The ratoon crop was harvested on 12th January 2009. The drip irrigation system was operated at 2 day interval (alternate day) based on the cumulative pan evaportaion using lateral (16 mm diameter), spaced 0.75 m apart in conventional and single trench planting and 1.2 m apart in paired trench planting. The drip tape (16 mm dia) with inline emitters (2 lph) were placed on the lateral at 0.3 m interval. The data on germination was recorded at 45 days after planting. Ten canes were randomly selected from each plot to estimate the yield attributes viz. millable canes, cane length, cane weight and juice quality parameters (percent Pol in juice, brix and purity) before harvesting. The percentage of commercial cane sugar (CCS) was calculated by using the farmula {CCS (%) =[S-(B-S) 0.4] × 0.73}, where S= Pol % in juice and B= Brix. The data on cane yield was recorded at the time of harvest of the crop. CCS (%) was multiplied with the cane yield to get sugar yield.

RESULTS AND DISCUSSION

Effect of planting methods

The maximum germination (37.2 %) was in single trench planting which was statistically at par with paired trench planting and both were significantly better than conventional planting (Table 1). The poor germination under flat planting may be due to the greater soil cover over the sets, the longer distance that young shoots has to travel to reach the soil surface. Singh *et al.* (2008) also reported that with increase in depth of soil covering over the sets the number of shoots failed to reach the soil surface and reduced the germination percentage in flat planting.

Planting methods did not significantly influence the cane yield in plant as well as ratoon crop. The yield attributes viz. millable cane length, number of milllable canes and single cane weight were not significantly influenced by the different planting methods viz conventional planting, single trench and paired trench planting in plant as well as ratoon crop (Tabe 1). In plant crop, marginally higher number of millable canes in single trench planting could be due to more number of primary tillers contributing to cane yield, which were heavy in weight, while in case of paired trench planting it could be assigned to the border effect that rows received in form of higher light interception and proper aeration due to wider spacing. Mahendran *et al.* (1995) also reported that millable cane population and cane yields were not affected by normal furrow planting and deep trench planting methods. The quantity of irrigation water applied (Table 2) varied among the methods of planting, more irrigation water 150.3 cm and 123.4 cm was applied in plant and ratoon crop under conventional planting while it was reduced under single

Table 1. Growth, yield attributes and cane yield as influenced by different interventions

Treatment	Germination (%)	NMC (000/ha)		Millable cane length (cm)		Single cane weight (kg)		Cane yield (t/ha)	
	Plant	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon
Planting method									
Conventional	31.3	104.2	94.7	186.6	179.1	0.67	0.64	76.7	67.5
Single trench	37.2	111.2	95.0	190.3	175.4	0.75	0.64	81.5	69.1
Paired trench	35.2	108.2	96.8	192.7	180.7	0.75	0.62	80.9	70.3
CD (p=0.05)	3.49	NS	NS	NS	NS	NS	NS	NS	NS
Irrigation method									
Conventional	34.5	106.4	94.3	188.5	177.0	0.73	0.63	78.8	68.3
Drip	34.7	109.3	96.6	191.2	179.8	0.72	0.63	80.6	69.6
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Irrigation regime (IW: CPE)									
0.6	31.3	93.8	85.2	176.9	164.3	0.70	0.62	68.2	63.3
0.8	34.6	113.6	95.3	193.3	183.1	0.72	0.63	84.2	71.0
1.0	36.0	116.2	105.9	199.4	187.8	0.75	0.65	86.7	72.6
CD (p=0.05)	2.0	3.70	3.67	7.07	5.52	0.03	NS	2.77	1.59

Table 2. Seasonal irrigation water applied and water use efficiency for sugarcane as influenced by different interventions

Treatment	Irrigation water applied (cm)		Water use efficiency (t/ha-cm)		% saving of water	
	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon
Planting method						
Conventional	150.3	123.4	0.51	0.55	--	--
Single trench	143.5	118.1	0.57	0.58	4.7	4.5
Paired trench	136.3	109.3	0.59	0.64	10.3	12.9
Irrigation method						
Conventional	163.1	135.5	0.48	0.50	--	--
Drip	123.6	98.3	0.65	0.71	31.9	37.8
Irrigation regime (IW: CPE)						
0.6	116.7	95.6	0.58	0.66	24.0	41.0
0.8	144.7	120.2	0.58	0.59	16.6	12.2
1.0	168.7	134.9	0.51	0.54	--	--

trench by 4.7 and 4.5 % and in paired trench planting by 10.3, 12.9 % in plant and ratoon crop, respectively. The water use efficiency was also higher under single trench (0.57 t/ha-cm & 0.58 t/ha-cm) and paired row trench planting (0.59 t/ha-cm & 0.64 t/ha-cm) methods in plant and ratoon, respectively. The cane quality parameters (Table 3) viz. percent Pol in juice, brix, commercial cane sugar and sugar yield were not significantly influenced by planting methods in plant as well as ratoon crops. Bhullar *et al.* (2008) also reported that quality parameters viz. percent Pol in juice, brix, CCS and sugar yield were not significantly influenced by conventional or paired trench planting.

Effect of irrigation methods

The irrigation methods viz. drip irrigation and conventional (border) irrigation did not significantly influence the germination percentage. It may be so, because one uniform irrigation was applied immediately after planting by flooding to all the plots. The irrigation methods did not significantly influence the cane yield in both plant as well as ratoon crop. It may be attributed to the reason that rainfall was received in good amount and it was well distributed during grand growth period of the crop (Fig.1). Moreover in this experiment fertilizer was applied as conventional practice and not as fertigation. The marginal differences in cane yield were in conformity with reduction in the yield attributes viz millable cane length and number of milllable canes/ha (Table 1). This was probably due to sufficient receipt of rainfall during the grand growth period of the crop

Table 3. Quality parameters and sugar yield as influenced by different interventions

Treatment	Pol % Juice		Brix %		CCS %		Sugar yield (t/ha)	
	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon	Plant	Ratoon
Planting method								
Conventional	19.36	19.71	21.85	22.17	13.40	13.67	10.27	9.20
Single trench	19.56	19.89	21.95	22.18	13.58	13.83	11.06	9.56
Paired trench	19.54	19.89	21.68	22.09	13.64	13.89	11.01	9.75
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Irrigation method								
Conventional	19.54	19.57	21.92	21.90	13.57	13.60	10.94	9.46
Drip	19.42	20.09	21.73	22.39	13.51	13.99	10.62	9.55
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Irrigation regime (IW: CPE)								
0.6	19.58	20.06	21.86	22.30	13.62	14.00	9.29	8.84
0.8	19.60	19.69	21.92	21.92	13.63	13.72	11.47	9.74
1.0	19.28	19.73	21.70	22.22	13.37	13.67	11.58	9.94
CD (p=0.05)	0.25	NS	NS	NS	0.20	NS	0.41	0.38

(July-Sept), amounting to 500 mm during 2007-08 and exceptionally high i.e. 1118 mm during 2008-09 season. Esther and Gupta (2008) also reported that in plant as well as ratoon crop the yield did not increase with drip irrigation as compared to conventional irrigation. The irrigation application through drip irrigation system resulted in water saving to the tune of 31.9 and 37.8 % in plant and ratoon crop, respectively in comparison to conventional (border) irrigation method (Table 2). The water use efficiency was also higher under drip irrigation 0.65 to 0.71 t/ha-cm as compared to 0.48 to 0.50 t/ha-cm under conventional irrigation in plant and ratoon crop, respectively. The irrigation methods did not significantly influence the quality parameters in both plant as well as ratoon crop, though marginal improvement in quality parameters was observed.

Effect of irrigation regimes

The scheduling of irrigation at IW: CPE of 0.6, 0.8 and 1.0 significantly influenced the sugarcane germination. The irrigations applied at IW: CPE of 0.8 and 1.0 recorded significantly higher germination of 34.6 and 36.0 % respectively than IW: CPE of 0.6 (31.3%), however both the regimes (0.8 and 1.0) were statistically at par with each other. The high water content in the sets was responsible for accelerating the conversion of carbohydrates into reducing sugars, resulting in higher germination percentage (Singh *et al*., 2008)

The irrigation regimes had a significant effect on cane yield (Table 1). The highest cane yield (86.7 t/ha) was obtained with irrigation applied at IW: CPE of 1.0, being 2.9 and 27.1 % higher than that obtained with IW: CPE of 0.8 and 0.6 in the plant crop, while in the ratoon crop this was 2.2 and 14.7 % higher at IW: CPE 1.0 than that obtained with IW: CPE of 0.8 and 0.6 respectively. The reduction in cane yield was in conformity to the reduction in yield attributing characters viz single cane weight, millable cane length and number of milllable canes. Moreover, better nutrient uptake with frequent irrigations might have also contributed to better growth and yield. Under less frequent irrigation regimes, with longer interval between irrigations might have lowered cell turgor pressure and consequently poor proliferation of tillers as reported by Gulati and Nayak (2002). Such type of adverse effects might have occurred in low IW: CPE of 0.6 in which it was found that cane pith was hollow and dry at the time of harvest, which might have resulted in reduced cane weight and hence yield. The irrigation regimes at IW: CPE of 0.8 and 1.0 were statistically at par in terms of cane yield, here scheduling at IW: CPE of 0.8 resulted in water saving of 16.6 and 12.2 % as compared to IW: CPE of 1.0. Further, reduction in irrigation water at IW: CPE of 0.6 though resulted in substantial saving of irrigation water of 24.0 and 41.0 % in plant and ratoon crop respectively, but it also caused significant reduction in cane yield both in plant and ratoon crop. The water use efficiency of 0.58 and 0.66 t/ha-cm was the highest in IW: CPE of 0.6 and it was reduced to 0.51 and 0.54 t/ha-cm at IW: CPE 1.0 with increase in volume of water applied.

The quality parameters viz. percent pol in juice and commercial cane sugar (CCS %) and sugar yield differed significantly among the irrigation regimes (IW: CPE) in plant crop. The irrigation regime with IW: CPE of 1.0 recorded significantly lower pol % in juice and CCS % than IW: CPE ratio of 0.8 and 0.6 in the plant crop, while in ratoon crop all

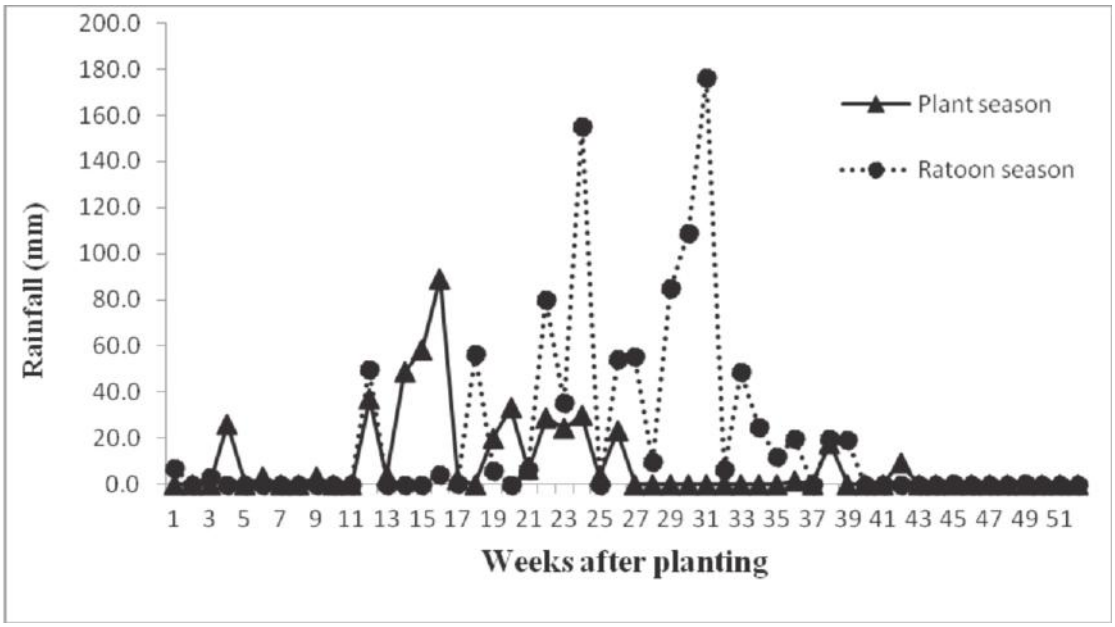

Fig. 1 Seasonal behaviour of rainfall during Plant and ratoon crop

Table 4. Cane yield (t/ha) as influenced by interaction between irrigation method and irrigation regimes (IW: CPE)

Plant crop			
		Irrigation level (IW: CPE)	
Irrigation method	0.6	0.8	1.0
Conventional	73.2	84.2	84.5
Drip	63.1	84.4	88.8
Plant CD (p=0.05) Method x level = 3.91			
Ratoon crop			
		Irrigation level (IW: CPE)	
Irrigation method	0.6	0.8	1.0
Conventional	65.1	72.2	71.4
Drip	61.4	69.9	73.8
Ratoon CD (p=0.05) Method x level = 2.25			

Ratoon CD (p= 0.05) Method x level = 2.25

the three irrigation regimes were statistically at par in all the quality parameters (Table 3). Similarly, Inman (2004) also reported that mild water stress improved the sucrose content in the cane. The sugar yield was significantly higher in irrigation regime with IW: CPE ratio of 0.8 and 1.0 as compared to IW: CPE ratio 0.6 in plant as well as ratoon crop. This could be attributed to differences in cane yield, which was reflected in sugar yield.

Interaction Effects

The interaction effects revealed that in plant crop, drip irrigation at IW: CPE of 0.8 was statistically at par with IW: CPE of 1.0 in conventional method of irrigation (Table 4). Under drip irrigation IW: CPE of 1.0 gave significantly higher cane yield (yield advantage of 5.2 %) over IW: CPE ratio of 0.8 under drip as well as IW: CPE of 1.0 in conventional method of irrigation. Drip irrigated, ratoon crop with irrigation application at IW: CPE of 1.0 recorded significantly higher cane yield (73.8 t/ha) than obtained in IW: CPE of 0.8 (69.9 t/ha), however it was at par with conventional method of irrigation at IW: CPE ratio 0.8. The IW: CPE ratio of 1.0 in drip method yielded significantly higher cane yield than conventional method at IW: CPE ratio of 1.0 (71.4 t/ha). This type of response may be attributed to higher lodging in conventional irrigated plots. The more frequent rainfall events, coinciding with irrigation application caused lodging thereby resulting in yield reduction in ratoon crop.

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Weed Dynamics and Performance of Transplanted Rice (*Oryza Sativa* L.) under Different Water Regimes, Plant Densities and Butachlor in Temperate Conditions

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***Abstract*:** The experiment was conducted to find out the suitable combination of plant population, water levels and different weed management techniques for optimum growth and yield of rice. During the investigation it has been found that plant density of 44 hills m^{-2} proved superior to 55 hills m^{-2} for grain yield, whereas highest straw yield was recorded with 55 hills m^{-2}. Highest grain and straw yield were also recorded with 5 cm water regimes followed by 10 cm compared to 15 cm. Among different weed management practices, application of butachlor provided effective control of weeds and improving rice yield. The combination of 44 hills m^{-2}, 5 cm water regime and butachlor helped to improve grain yield of transplanted rice followed by 44 hills m^{-2}, and 10 cm water regime and butachlor (apart from weed free). Growth parameters like plant height, tillers m^{-2}, leaf area index, dry matter production were significantly favoured by 55 hills m^{-2} as compared to 44 hills m^{-2} with water regimes 5 cm followed by 10 cm as compared to 15 cm. Besides weed free, application of butachlor significantly increased plant height, number of tillers m^{-2}, dry matter production and leaf area index. Weed study like weed count, weed dry matter, weed index and nutrient uptake by weeds significantly reduced with 55 hills m^{-2} than 44 hills m^{-2} and 55 hills m^{-2}, weeds significantly reduced with 15 cm as compared to 10 cm and 5 cm. But 15 cm also proved significantly better measure for recording weed control efficiency.

***Key Words*:** Butachlor, *Oryza sativa L*, Plant density, Water regime**,** Weed index, Weed control,

In India, at the present growth rate, the demand for rice by 2025 AD is expected to be 136 million tonnes indicating that 2.5 million tonnes of enhanced rice production every year. Presently it's occupied around 23.3 per cent of cropped area and provides 43 per cent of total food grain. In India, it is grown on an area of about 36.95 million hectare with the production of 120.60 million tonnes and productivity of 3.32 t ha^{-1} (FAO, 2010). The productivity of rice in Jammu and Kashmir is quite low as compared to national average due to injudicious use of inputs such as water management; time and method of fertilizer application, selection of cultivar, plant density, transplanting seedling age and harvesting schedules. Among these, inappropriate plant population, water regimes, sowing time are the factors responsible for low yield of rice in J&K. Plant density exerts a strong influence on rice growth and grain yield, because of its competitive effect both on vegetative and reproductive development. In case plant densities exceed an optimum level, intra-plant competition for light and nutrients becomes severe. Again, planting densities at sub-optimal level, lead to free space will be occupied by the weed species. So, to find out the optimum plant population of transplanted rice by manipulating the plant spacing in relation to weed management is needed to be examined. Agronomic practices like flooding is one of the most effective techniques for control of many weeds in rice. Water management can also control many weeds and slow down the growth. Weeds are the most competitors in their early growth stages than the later and hence the growth of crops slows down and grain yield decreases (Jacob and Syriac, 2005). Weed free period during the critical period of competition is essential for obtaining optimum rice yield. This can be achieved by removal of weeds by mechanical, cultural or chemical methods or by their combinations. Therefore, integrated methods of weed control like depths of irrigation water and chemical weed control is needed.

MATERIAL AND METHODS

Experimental site: The field experiment was carried out at Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar during 2012, situated at 34º05 N latitude and 74º89 longitudes with altitude of 1587 meters above mean sea level. It is located in mid to high altitude of temperate zone characterized by hot summers and very cold winters. The average annual precipitation is 944.6 mm (average of past 25 years) most of which was received from December to April in the form of snow and rain. Maximum and minimum temperatures during cropping

season ranged between 21.57 to 32.78 ºC and 6.41 to 18.92ºC, respectively. The mean maximum and minimum relative humidity ranged between 70.57 to 93.12% and 41.71 to 64.28%, respectively. The total rainfall received during the experimentation period was 243.3 mm.

Experimental Design and Treatments: The field experiment comprising of three factors *viz*. (plant densities, water regimes and butachlor) was laid out in split plot design and replicated thrice. The treatment were two plant densities as 44 hills m^{-2} (15 cm × 15 cm) and 55 hills m^{-2} (15 cm × 12 cm), three water regimes recommended water level (5 cm ± 1), irrigation after disappearance of pounded water (10 cm ± 1) and farmers practice (15 cm ± 1) and three weed management practices as weedy check, weed free and butachlor 1.5 kg a.i. ha^{-1}. Rice variety 'Jhelum' was sown with gross plot size 3.25 m × 4.30 m = 13.97 m^2 and net plot size 3.0 m × 4.05 m = 12.1 m^2.

Experimental Details and Observations: After harvesting of previous crop (wheat), the experimental field was raised as per recommended package practice (SKUAST-K).Harvesting was done at physiological maturity with 20% moisture content of grain, after excluding border and penultimate rows from all sides of each plot. The growth parameters like plant height, tiller count, leaf area index, dry matter accumulation, weed count, weed dry weight were observed during the experimentation. Weed control efficiency (WCE) for different weed control treatments was worked out with following formula:

$$WCE\ (\%) = \frac{WDC-WDT}{WDC} \times 100$$

Where: WCE= Weed control efficiency
WDC= Weed dry weight in control plot
WDT= Weed dry weight in treated plot

Weed index (WI) for different weed control treatments was worked out with following formula:

$$WI\ (\%) = \frac{YHW-Y}{YHW} \times 100$$

Where: WI= Weed index
YHW= Average crop yield in the hand-weeded plot (Weed free),
Y= Average crop yield in the treatment under study

WI (%)= YHW-Y/YHWx100

RESULTS AND DISCUSSION

Plant height of rice at various growth stages depicted a marked influence with various plant densities (Fig. 1a). Higher plant density (55 hills m^{-2}) recorded significantly taller plants than lower plant density (44 hills m^{-2}) at all growth stages. This could be attributed to the mutual shading at higher densities which has encouraged the plants to grow taller to capture sunshine. Among different water regimes, 15 cm resulted in higher plant height compared to lesser water regimes (Fig.1b). This may be attributed to the fact that, in rice under waterlogged conditions, it has been seen that ethylene increases the response of rice to giberellic acid i.e. giberellic acid becomes more effective as a result of which elongation of rice plant was more under deep water logged conditions i.e. 15 cm water depth. Similar findings were reported by Gun (1999). Perusal of Fig. 1c, among various weed control measures used, apart from weed free treatment, application of butachlor significantly increased the height of rice plants during the course of investigation. This could be ascribed to better weed control with the herbicide resulting in better nutrient uptake by the crop. Hasan *et al*. (2010) also found that weed free in rice resulting in the improvement of plant height next to butachlor. With regard to plant density 55 hills m^{-2} recorded significantly higher tillers m^{-2} at all the growth stages and lowest with 44 hills m^{-2} (Fig. 2a) . It might be due to higher plant population. Similar results of higher number of tillers m^{-2} under closer spacing compared to wider spacing were reported by Bhagat *et al*. (2005). Comparison of Fig. 2b data, among water regimes, 15 cm reduced number of tillers as compared to 5 cm and 10 cm. Because, rice is a semi aquatic plant, it could not tolerate water logging and thus it induces tiller mortality. These results are supported by the findings of Ohe and Mimoto (1999). So far as weed control measures are concerned, apart from weed free, application of Butachlor significantly improved number of tillers of rice at various growth stages than weedy check as shown in Fig.2c. The reduction in weed growth with the herbicide allowed the crop to grow to its potential thereby increased number of tillers m^{-2}. In general, there was linear increase in LAI up to 70 DAT and thereafter, LAI showed decreasing trend. Lowest LAI was recorded at 110 DAT. This could be attributed to shading of lower leaves after flowering stage causing their senescence with advancement in growth. Leaf area index is the major component in determining solar radiation interception thereby influencing yield of crop. Comparison of data presented in Fig.3a, with regard to plant density, significantly higher LAI was recorded in 55 hills m^{-2} at all the growth stages and lowest values were recorded with 44 hills m^{-2}. It might be due to more leaves which occupied the same level area and consequently trapped more light. Namba (2003) also reported higher LAI with closer density of 55 hills m^{-2} in transplanted rice. Among different water regimes, 5 cm recorded significantly higher LAI at all growth stages (Fig. 3b). It might be because of more number of tiller m^{-2}. Similar findings were also made by Subramanyan *et al*. (2007). Among weed control measures apart from weed free treatment, herbicide application of butachlor significantly

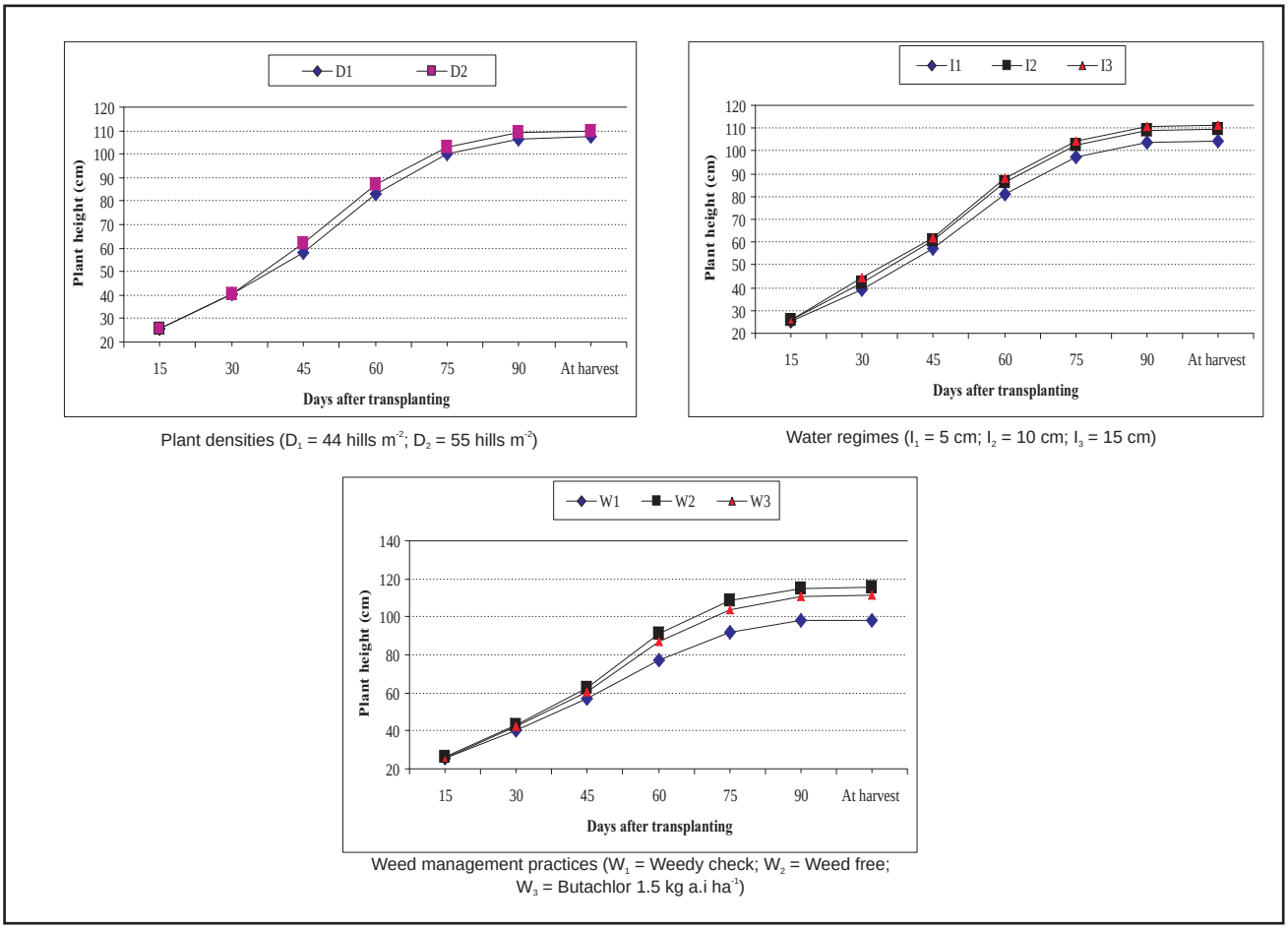


Fig 1. Plant height (cm) of rice as influenced by plant densities, water regimes and weed management practices at different time intervals

increased leaf area index of crop at various growth stages than weedy check (Fig.3c). The reduction in weed growth with the herbicidal application might have allowed the crop to enjoy adequate nutrient supply resulting in higher leaf area index. The optimal accumulation of dry matter by the crop is important as it may be followed by adequate transfer of assimilates to the sink resulting in higher yields. Perusal of data in (Table 1) showed that 55 hills m^{-2} accumulated significantly highest dry matter at each time intervals than 44 hills m^{-2}. This might be due to more leaves and consequently trapped more light and CO_2, resulting in high photosynthesis capacity and producing more dry matter. These findings are confirmed by Salem (2006) in transplanted rice. Among water regimes, highest dry matter accumulation was recorded with 5 cm and lowest was recorded with 15 cm. It is because of increased number of tillers m^{-2} thereby increased dry matter production. Similar findings were reported by Gun (1999). Among different weed management practices, apart from weed free, application of butachlor significantly improved dry matter production of rice at various growth stages than weedy check. The reduction in weed growth with the herbicide allowed the crop to grow its potential, thereby increased dry matter production.

Data in Table 2 reveals that 55 hills m^{-2} significantly reduced weed count and weed dry matter than 44 hills m^{-2}. It might be due to the less space for weeds and greater crop canopy. Further results also indicated that higher plant density with closer spacing significantly reduced weed count and dry matter of weeds (Sindhu, 2009). The data on different water regimes showed that 15 cm significantly reduced weed count and weed dry matter. It might be due to the deep water logged conditions which was unfavourable for weed growth. Among weed control measures, apart from weed free treatment, butachlor reduced dry matter of weeds and weed count than weedy check. This was due to its higher efficiency to control weeds. Out of two plant densities, 55 hills m^{-2} was significantly better measure for recording WCE (Table 2). Further, it reduced weed index than 44 hills m^{-2}. Among water regimes, 15 cm was also significantly better measure for recording WCE, but it remained at par with 10 cm as compared to 5 cm. Also 15 cm reduced weed index followed by 10 cm than 15 cm water regime. It might be due to the

Table 1. Influence of plant densities, water regimes and weed management practices on dry matter accumulation, grain, straw yields and harvest index

Treatment	Dry matter accumulation (q ha^{-1}), Days after transplanting					Yields (t ha^{-1})		
	30	60	75	90	At harvest	Grain	Straw	Harvest index (%)
Plant densities								
44 hills m^{-2}	12.56	70.87	109.99	146.98	149.36	7.11	8.23	45.20
55 hills m^{-2}	14.65	73.38	113.06	150.88	153.15	6.58	8.89	42.51
CD (p=0.05)	1.45	2.01	2.78	3.72	3.67	0.50	0.50	2.32
Water regimes								
5 cm	14.93	74.57	114.75	151.61	155.60	7.35	8.93	44.17
10 cm	13.83	72.17	111.64	149.90	151.36	6.96	8.65	44.11
15 cm	12.04	69.64	108.19	145.30	146.80	6.22	8.09	43.30
CD (p=0.05)	1.78	2.46	3.41	4.55	4.50	0.61	0.61	NS
Weed management practices								
Weedy check	12.89	60.56	80.99	120.00	121.78	4.78	7.53	39.08
Weed free	13.99	80.48	129.10	165.43	168.16	8.01	9.32	46.68
Butachlor @ 1.5 kg a.i ha^{-1}	13.94	75.33	124.47	161.38	163.81	7.75	8.83	45.81
CD (p=0.05)	1.04	4.28	4.04	4.03	4.01	0.27	0.36	1.77

Table 2. Influence of plant densities, water regimes and weed management practices on weed count (m^{-2}), weed dry matter (g m^{-2}) and weed index (on dry matter basis of weed)

Treatment	Weed count		Weed dry matter		Weed control efficiency (%)		DM basis
	Flowering stage	Harvesting stage	Flowering stage	Harvesting stage	Flowering stage	Harvesting stage	Weed index (%)
Plant densities							
44 hills m^{-2}	19.73(3.78)	14.00 (3.09)	46.70 (5.46)	55.90 (6.03)	57.83 (6.43)	56.30 (6.33)	19.60 (3.57)
55 hills m^{-2}	18.90(3.68)	13.03(2.93)	44.07 (5.29)	54.31(5.95)	58.74 (6.49)	57.04 (6.39)	15.98 (3.21)
CD (p=0.05)	(0.10)	(0.14)	(0.16)	(0.08)	(0.05)	(0.04)	(0.35)
Water regimes							
5 cm	22.00 (3.91)	16.83(3.40)	51.58 (5.91)	59.31(6.38)	54.40 (6.23)	52.84 (6.13)	21.22 (3.80)
10 cm	19.44 (3.75)	13.61(3.10)	44.16 (5.23)	56.55 (5.97)	59.87 (6.55)	58.50 (6.48)	17.36 (3.45)
15 cm	16.66(3.49)	10.11(2.53)	40.40(4.99)	49.46(5.62)	60.60 (6.59)	58.67 (6.47)	14.80 (3.14)
CD (p=0.05)	(0.12)	(0.17)	(0.19)	(0.10)	(0.06)	(0.05)	(0.43)
Weed management practices							
Weedy check	43.50(6.59)	33.44(5.76)	109.36(10.43)	128.42(11.32)	0.00 (0.70)	0.00 (0.70)	41.53 (6.43)
Weed free	0.00 (0.70)	0.00(0.70)	0.00 (0.70)	0.00(0.70)	100.0(10.02)	100.00(10.02)	0.00 (0.70)
Butachlor 1.5 kg a.i ha^{-1}	14.61(3.86)	7.11(2.57)	26.79 (5.00)	36.90 (5.95)	74.88 (8.65)	70.02 (8.36)	11.86 (3.26)
CD (p=0.05)	(0.09)	(0.17)	(0.17)	(0.10)	(0.05)	(0.06)	(0.38)

*Values in parenthesis are transformed values $\sqrt{x}+0.5$

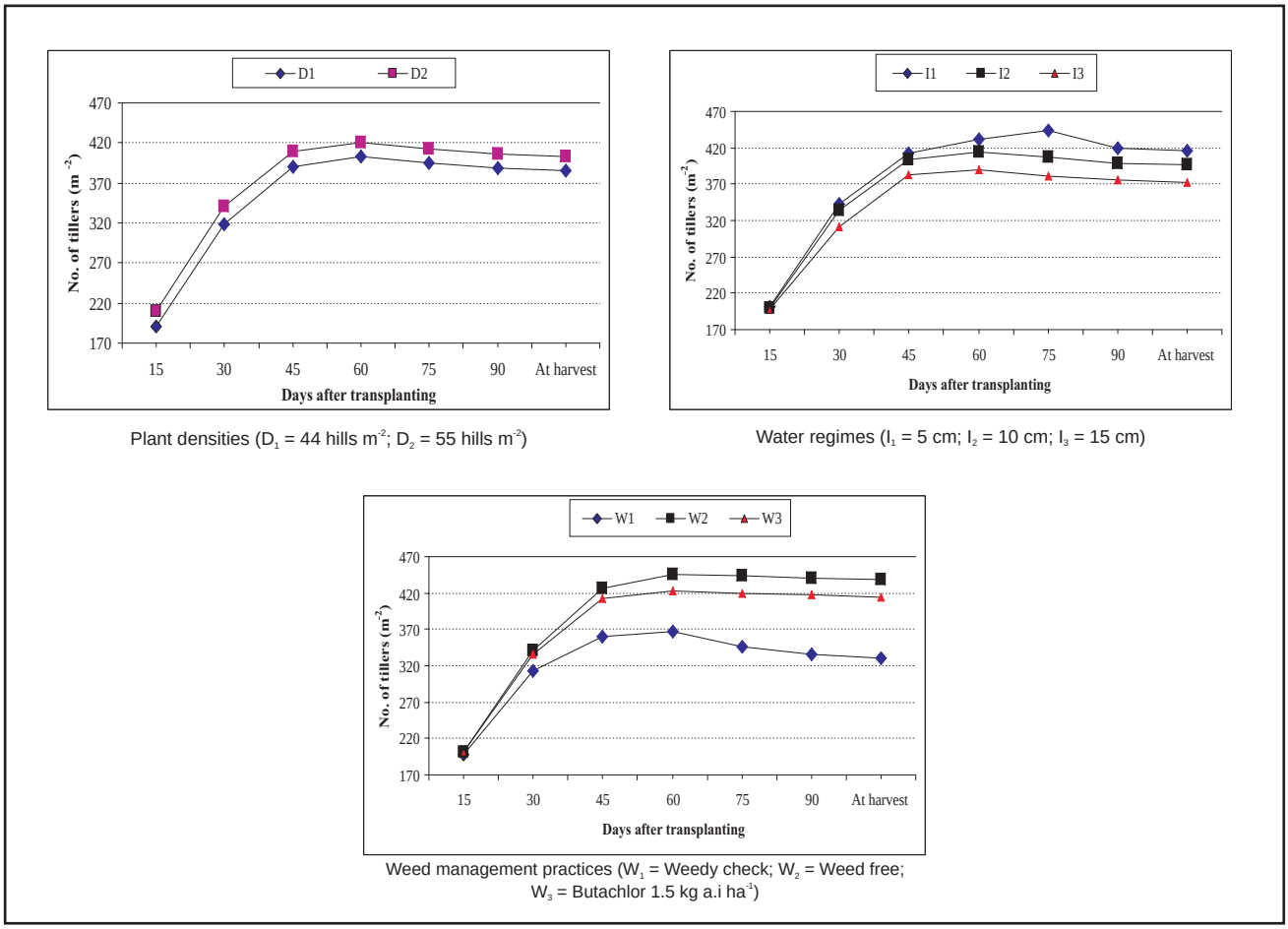


Fig 2. Tillers (m^{-2}) of rice as influenced by plant densities, water regimes and weed management practices at different time intervals

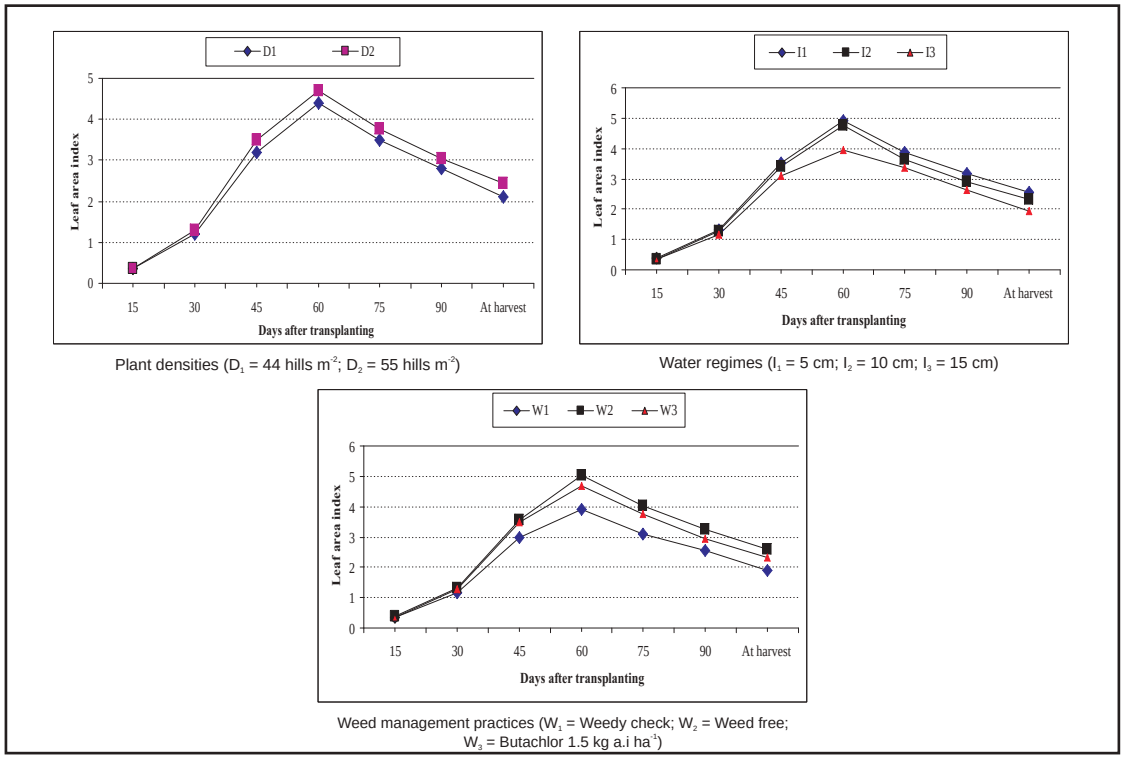
reason that deeper water levels suppressed weed growth. So far as weed control measures are concerned, weed free treatment which showed 100% WCE and application of butachlor proved significantly better measure for recording WCE in view of its efficiency in reducing the growth of weeds. Mukherjee (2006) stated that pre-emergence application of butachlor @ 1.5 kg a.i ha^{-1} supplemented with one hand weeding at 35 DAT showed the highest WCE (81.4%). Among weed control measures, apart from weed free treatment, butachlor reduced weed index than weedy check. During the study, it was found that plant density exerted significant influence on grain yield and straw yield of rice. Plant density of 44 hills m^{-2} gave significantly more grain yield than 55 hills m^{-2}. It is because of wider row spacing (15 cm × 15 cm or 44 hills m^{-2}) increases the performance of individual plants and thus it increases grain yield (Table 1). Lin et *al*. (2006) also reported higher grain yields with lesser plant population (44 hills m^{-2}) while 55 hills m^{-2} gave significantly more straw yield than 44 hills m^{-2}. Reason is being that due to higher plant population and more leaf area index. The study revealed a significant increase in harvest index under 44 hills m^{-2} as compared to 55 hills m^{-2}.Similar findings were reported by Uddin *et al*. (2011). There was a significant increase in the grain and straw yield of rice with 5 cm followed by 10 cm. But, different water regimes failed to bring about any significant change with respect to harvest index. The study further revealed that among different weed control measures apart from weed free treatment, application of butachlor significantly increased grain yield, straw yield and harvest index of rice than weedy check. Higher grain yield with butachlor could be attributed due to significant improvement in all yield attributes with the said treatment. The present investigation revealed that during the course of investigation benefit cost ratio remained highest with treatment combination of 44 hills m^{-2}, 5 cm and butachlor followed by treatment combination of 44 hills m^{-2}, 10 cm and weed free. The results of weed free clearly justify with regard to the significantly highest grain yield as compared to butachlor, but minimum wages in case of butachlor application, which realized highest B: C ratio, when applied in 44 hills m^{-2} and 5 cm water regime followed by butachlor 1.5 kg a.i ha^{-1} when applied in 44 hills m^{-2} and 10 cm water regime (Table 3). In

Table 3. Influence of plant densities, water regimes and weed management practices on relative economics

Treatment	Gross returns (Rs/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C
$D_1I_1W_1$	78081.1	37790	40291.1	1.06
$D_1I_1W_2$	124925.6	44490	80435.6	1.80
$D_1I_1W_3$	123605.6	39490	84115.6	2.13
$D_1I_2W_1$	74625.6	37790	36835.6	0.97
$D_1I_2W_2$	129398.9	44490	84908.9	1.91
$D_1I_2W_3$	122858.9	39490	83368.9	2.11
$D_1I_3W_1$	69582.2	37790	31792.2	0.84
$D_1I_3W_2$	104542.2	44490	60052.2	1.35
$D_1I_3W_3$	101340.0	39490	61850.0	1.57
$D_2I_1W_1$	61600.0	37790	23810.0	0.63
$D_2I_1W_2$	120582.2	44490	76092.2	1.71
$D_2I_1W_3$	108674.4	39490	69184.4	1.75
$D_2I_2W_1$	59710.9	37790	21920.9	0.58
$D_2I_2W_2$	107835.6	44490	63345.6	1.42
$D_2I_2W_3$	117550.0	39490	78060.0	1.98
$D_2I_3W_1$	55174.9	37790	17384.9	0.46
$D_2I_3W_2$	101342.2	44490	56852.2	1.28
$D_2I_3W_3$	114644.4	39490	75154.4	1.90

Cost of seed = Rs. 22 kg^{-1}
Cost of butachlor = Rs. 28 kg^{-1}
Cost of urea = Rs. 540 q^{-1}
Cost of labour = Rs. 125 day^{-1}
Cost of DAP = Rs. 2400 q^{-1}
Cost of grain = Rs. 1100 q^{-1}
Cost of MOP = Rs. 1650 q^{-1}
Cost of straw = Rs. 35 shieve^{-1}
Cost of FYM = Rs. 500 q^{-1}
Cost of mechanics = Rs. 4000 ha^{-1}

D_1 = 44 hills m^{-2}
D_2 = 55 hills m^{-2}
I_1 = 5 cm
I_2 = 10 cm
I_3 = 15 cm
W_1 = weedy check
W_2 = weed free
W_3 = Butachlor 1.5 kg a.i ha^{-1}



Plant densities (D_1 = 44 hills m^{-2}; D_2 = 55 hills m^{-2})

Water regimes (I_1 = 5 cm; I_2 = 10 cm; I_3 = 15 cm)

Weed management practices (W_1 = Weedy check; W_2 = Weed free; W_3 = Butachlor 1.5 kg a.i ha^{-1})

Fig 3. Leaf area index of rice as influenced by plant densities, water regimes and weed management practices at different time intervals

brief periodic plant height, number of tillers, leaf area index, dry matter accumulation of crop were significantly higher in 55 hills m^{-2} but 44 hills m^{-2} produced maximum grain yield (7.11t ha^{-1}) and harvest index (45.2%), with minimum straw yield (8.23 t ha^{-1}). Among water regimes, 15 cm recorded maximum plant height as compared to 5 cm and 10 cm, but 5 cm recorded significantly higher number of tillers m^{-2}, leaf area index, dry matter accumulation and grain yield (7.35 t ha^{-1}), straw yield (8.93 t ha^{-1}) and harvest index (44.17%).

Growth parameters like plant height, tillers m^{-2}, leaf area index and dry matter production were significantly favoured by 55 hills m^{-2} with 5 cm water regimes and weed free condition. Weed study like weed count, weed dry matter and weed index significantly reduced with 55 hills m^{-2} with 15 cm water regimes and butachlor (apart from weed free). Highest grain yield and harvest index was recorded with 44 hills m^{-2} whereas highest straw yield was recorded with 55 hills $m^{-2.}$ with 5 cm water regimes followed by 10 cm compared to 15 cm. However, harvest index did not vary significantly. Grain and straw yield as well as harvest index showed significant improvement with the application of butachlor (besides weed free) compared to weedy check.

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Growth and Yield of Happy Seeder Sown Wheat as Affected by Skip Row Planting and Split Nitrogen Application in Rice-Wheat Cropping System

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Abstract: Field experiment was conducted to determine the effects of skip row planting method and N application time on growth, yield and NPK uptake of wheat sown in the standing stubbles of paddy, sown with happy seeder during 2011–12 and 2012–13. The experiment was laid out in split plot design and had 3 planting patterns, as the main plots and 6 nitrogen application treatments in sub plots. The first planting method in which 3 rows at 20 cm inter-row spacing and 40 cm space between two sets of rows and third planting method in which normal sowing was done at 20cm row spacing produced insignificant ($p<0.05$) grain yield i.e. 53.1 and 50.6 q/ha. Time of nitrogen application also significantly resulted in good yield, when 1/4th of N applied as basal+1/4th of N applied after 1st irrigation+ ½ of N applied after second irrigation. All the growth parameters and NPK uptake was also observed highest under this treatment.

Key Words: NPK uptake, Planting methods, Skip row, Time of N application, Wheat, Yield

The rice-wheat cropping system (RWCS) is the most dominant and profitable system in the Indo-Gangetic Plain region of north-west India. In Punjab, RWCS accounts for more than 2.6 million hectares or 60% of the total net sown area (Singh *et al.,* 2008). Various agronomic manipulations, like planting pattern and application of nitrogen are important factors which influences the grain yield and the quality of wheat. The efficiency of the N applied in satisfying the N demand of the crop depends on the type of fertilizer, timing of application, seasonal trends, etc. (Borghi 2000 and Blankenau *et al* 2002). Ananda (2004) reported that among split application of N, nitrogen applied as half basal + one-fourth at 30 DAS + one-fourth at 60 DAS recorded higher grain and straw yields as compared to N applied as half basal + half at 30 DAS. Wheat sown with happy seeder in north-west India respond better to120kg N/ha as broadcast in two equal splits. This may be due to decreased volatilization of applied urea on mulched treatments as the surface speed and soil temperature would have been lower than on burnt plots (Brar *et al.,* 2010). Keeping in view present scenario for the adoption of resource conservation technologies in wheat, the present investigation was conducted with the objective to study the effect of planting pattern and time of nitrogen application on the productivity of happy seeder sown wheat.

MATERIAL AND METHODS

The experiment was conducted for two seasons (2011–2012 and 2012–2013) at the Punjab Agricultural University, Ludhiana (30?56'N, 75?52'E, 247m ASL), Punjab, India. The experiment fields were under rice-wheat cropping system from last five years. The experimental soil was low in N (228.6-215.6 kg/ha from 0-15 and 15-30 cm) and medium in P and K (18.7-16.9 kg/ha and 188.7-183.5 kg/ha from 0-15 and 15-30 cm,repectively for P and K) and low in organic carbon (0.31-0.29%). The experiment was laid out in a split plot design with 3 planting pattern (M1-3 rows at 20 cm inter-row spacing and 40 cm space between two sets of rows, M2-2 rows at 20 cm inter-row spacing and 40 cm space between two sets of rows, M3-Normal sowing at 20cm row spacing) as the main plots and 6 nitrogen application treatments(T1-Control:; T2- 1/2 dose of recommended N basal+ 1/2 dose of recommended N with 1st irrigation; T3- No basal+ 1/2 dose of recommended N with 1st irrigation + 1/2 dose of recommended N with 2nd irrigation ; T4- 3/4 dose of recommended N basal+ 1/4 dose of recommended N with 1st irrigation; T5- 1/4 dose of recommended N basal+ 3/4 dose of recommended N with 1st irrigation; T6- 1/4 dose of recommended N basal+ 1/4 dose of recommended N with 1st irrigation + 1/2 dose of recommended N with 2nd irrigation) in sub- plots. The experiment was replicated three times. The crop was raised by adopting recommended practices except nitrogen application.

The grain and straw samples from each plot were taken to estimate N, P and K content and N,P, K uptake by wheat grains and straw were calculated by multiplying N, P and K content with grain and straw yield expressed in kg/ ha. NPK energy equivalents were calculated (Devasenapathy *et al.,* 2009 and Gundogmous 2006) as follows;

NPK energy equivalent in grain (MJ/ha) = [{N uptake by grain (kg/ha) }x 60.6 MJ/kg) + {P uptake by grain (kg/ha)x 11.1 MJ/kg} +{K uptake by grain (kg/ha)}x 6.7 MJ/kg}]

NPK energy equivalent = [{N uptake by straw (kg/ha) }x 60.6 MJ/kg)

in straw (MJ/ha) + {P uptake by straw (kg/ha)x 11.1 MJ/kg} +{K uptake by straw (kg/ha) }x 6.7 MJ/kg}]

NPK energy equivalent = NPK energy equivalent in grain + NPK energy equivalent in straw in grain and straw(MJ/ha)

Data were subjected to pooled analysis using the general linear model (GLM) procedures of the SAS software followed by Tukey's Test at P<0.05.

RESULTS AND DISCUSSION

Growth parameters and PAR interception

Based on pooled data of two years, maximum plant height in M2 as compared to the M1 and M3 method (Fig1). It might be due to higher border effect which the M2 methods receive more throughout the growth period. In the N time application treatments the control (T1) had lowest height while all other treatments were at par with each other. Planting methods M1 and M2 had significantly higher leaf area index over the M2 method (Fig 2). Lower value was observed in M2 due to more ground area as compare to the leaf area as in M2 method there was 33% area is unsown while in M1 it was only 25% which was compensated by more tillers in later stages. The nitrogen treatments had significantly higher leaf area index over the control. Higher numeric value was observed in T6 at 90 and 120 DAS. Dry matter accumulation (Fig 3) and PAR interception (Fig 4) also showed same trend as leaf area index. Shaukat *et al.* (1999) also confirmed the same results that skip row planting accounted for significantly higher dry matter production than that of normal without skipping a row sowing.

Yields and Harvest index

Higher the growth rate resulted in higher grain yield in M1 over M2 and M3. Wheat grain yield was significantly affected by the skip row planting methods and time of N-applications. M1 and M3 produced significantly higher grain yield over M2 and were at par with each other. This might be associated with the higher number of productive tillers bearing more number of bold grains (Table1). Das and Yaduraju (2011) obtained higher grain yield by leaving 20% of rows unsown, significantly reduced weed populations and dry weights, and increased the competitiveness of wheat plants through greater leaf area, numbers of ear-bearing tillers, and uptake of N.

Similarly, it was observed that the spilt application of N influence the yield and harvest index. The best results were obtained when nitrogen was applied ¼ at the time of sowing, ¼ dose with 1st irrigation (i.e. CRI stage) and ½ dose with 2nd irrigation (i.e. initiation of stem elongation stage).The results showed the highest grain yield in the these treatments. When nitrogen applied as per T6 treatment as it had 36.1, 4.8, 5.7, 9.7, 5.0 % higher grain yield over T1, T2, T3, T4 and T5. Bellidoa *et al.* (2012) also report an increase in yield when N was applied in two splits especially at CRI and start of stem elongation stage. The straw and biological yield also had the same results. Higher values of grain and biological yield resulted in higher harvest index.

N,P and K uptake

The perusal of the data (Table 2) showed that planting methods had a significant effect on the NPK uptake by the wheat grains, straw. N,P and K uptake observed in M3 was statically showed no difference with M1 but statically higher from M2. Similarly T6 had significantly higher N,P and K uptake than the other T1, T2, T3, T4 and T5 treatments. This might be due to higher biological yield and higher nutrient contents in these treatments. Our results are in agreement with findings of Mattas *et al.* (2011) who reported

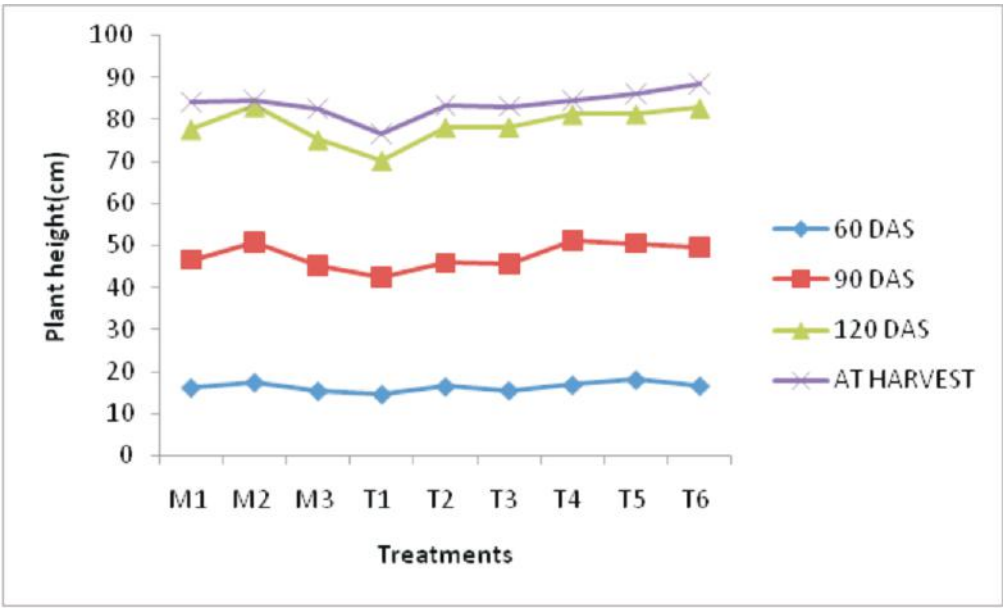

Fig. 1. Effect of skip row planting methods and time of nitrogen application on the periodic plant height

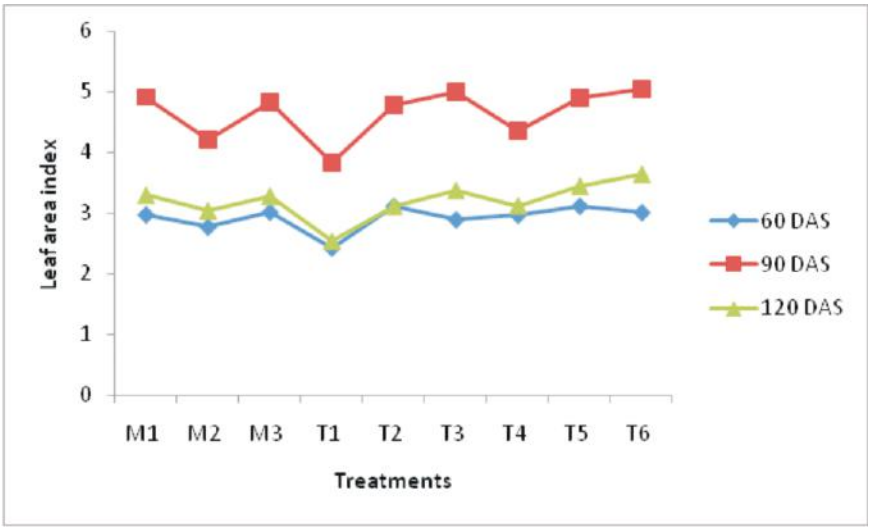

Fig. 2. Effect of skip row planting methods and time of nitrogen application on the periodic leaf area index

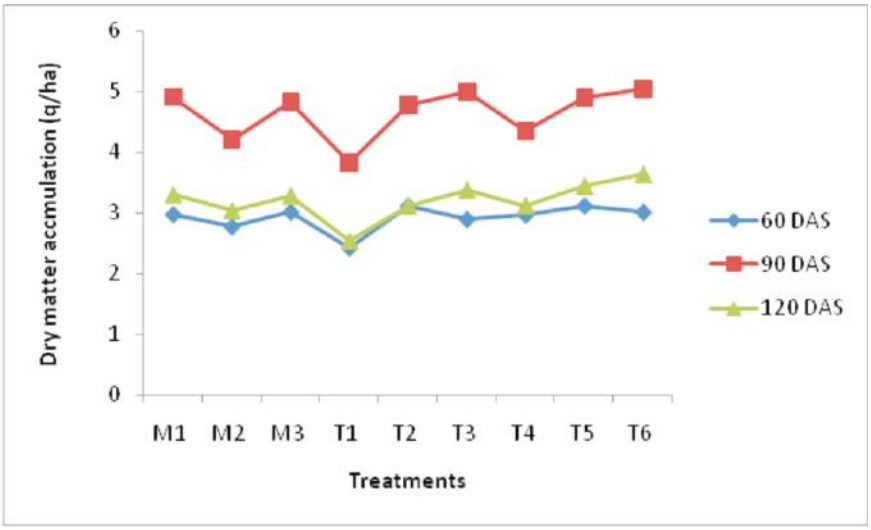

Fig. 3. Effect of skip row planting methods and time of nitrogen application on the periodic dry matter accumulation

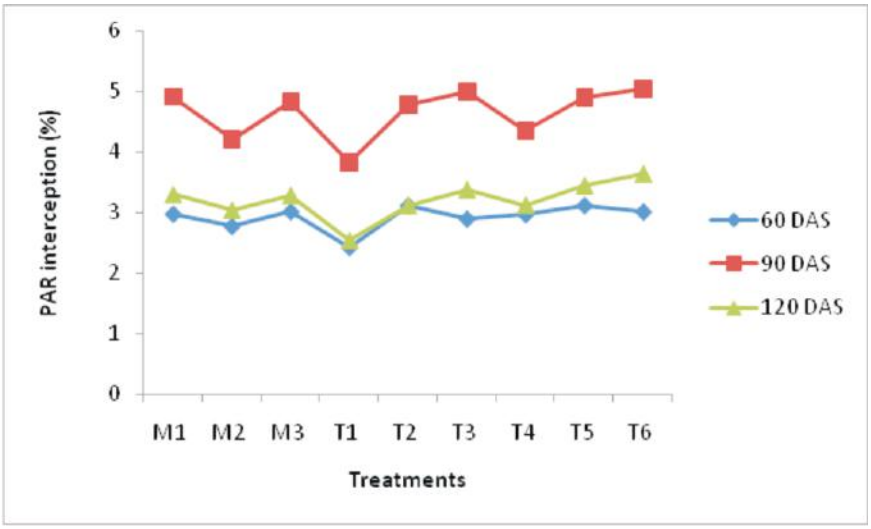

Fig. 4. Effect of skip row planting methods and time of nitrogen application on the periodic PAR interception

Table 1. Effect of skip row planting methods and nitrogen application time on the grain straw and biological yield and harvest index of wheat (Pooled data of two years)

Treatment	Grain yield (q/ha)	Straw yield (q/ha)	Biological yield (q/ha)	Harvest index (%)
		Planting pattern		
M1	53.1 a	41.4a	127.5 a	75.3 a
M2	46.3b	39.0 b	118.1 b	71.9 b
M3	50.6 a	40.1 a	127.9 a	74.4 a
		Split nitrogen application		
T1	35.6c	36.8b	98.7c	60.9c
T2	53.0a	41.2a	128.4a	75.1a
T3	52.5a	40.9a	128.3a	75.5a
T4	50.3b	40.6a	123.1b	73.8b
T5	52.9a	40.8a	128.7a	76.4a
T6	55.7 a	40.6a	139.6a	81.3a
Interaction effects	NS	NS	NS	NS

Means with the same letter are non significant at 5 per cent level of significance

Table 2. Nutrient uptake and NPK energy equivalent as affected by the skip row planting methods and time of nitrogen application in wheat (Pooled data of two years)

Treatments	Total N uptake (kg/ha)	Total P uptake (kg/ha)	Total K uptake (kg/ha)	Energy equivalent for grain (MJ/ha)	Energy equivalent for straw (MJ/ha)	Total Energy equivalent (MJ/ha)
			Planting pattern			
M1	143.1a	34.1a	111.8a	6575.5a	3567.2a	10143.2a
M2	129.5b	31.0b	105.7b	5560.7b	3348.0b	8908.7b
M3	146.5a	35.6a	113.1a	6142.9a	3569.0a	9711.9a
			Split nitrogen application			
T1	86.7d	18.4c	82.1c	3865.9c	2143.9c	6009.8d
T2	143.8b	34.9b	114.1b	6308.2b	3569.5b	9877.7b
T3	147.9b	35.9b	114.9b	6458.3b	3679.8b	10138.1b
T4	139.4c	34.1b	110.8b	6106.3b	3482.6b	9589.0c
T5	151.5b	36.3b	116.0b	6544.6b	3811.7b	10356.3b
T6	168.8a	43.5a	123.3a	7274.8a	4281.9a	11556.8a
Interaction effects	NS	NS	NS	NS	NS	NS

Means with the same letter are non significant at 5 per cent level of significance

that split fertilizer N application improved N uptake in wheat.

NPK energy equivalent

The energy equivalent in grain, straw and biomass varied statically significant in different treatments. M1 method of sowing resulted in highest NPK energy equivalent in grain, straw and total biomass. NPK energy equivalent in M3 was statistically at par with M1 but significantly higher than M2. NPK energy equivalent was significantly influenced by N application time. NPK energy equivalent in grain, straw and biomass recorded significant increase in T6 over T1, T2, T3, T4 and T5 treatment.

It can be concluded that by skipping rows i.e. keeping 25% area unsown help to achieve grain yield equal/higher than the normal sown wheat. N application time in happy seeder sown wheat is quite different from normal cultivated sown wheat, it is profitable, when N applied in three splits i.e. 1/4 dose of recommended N basal+ 1/4 dose of recommended N with 1st irrigation + 1/2 dose of recommend N with 2nd irrigation.

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Investigations on Growth, Fruit Yield and Physico-chemical Attributes of Aonla (*Emblica officinalis* Gaertn.)

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Abstract **:** The investigations on growth, fruit yield and physical and bio-chemical quality attributes conducted on six aonla (*Emblica officinalis* Gaertn) cultivars viz. Chakaiya, Krishna, Amrit, Balwant, Neelum and Kanchan from 2007 to 2010 revealed that Kanchan was most vigorous cultivar with maximum mean tree height, tree canopy and trunk girth. The fruits of cultivar Balwant were the earliest to mature during mid-November. The cultivars Krishna and Neelum also matured in the November. However, the cultivars Amrit, Kanchan and Chakaiya were late maturing. Maximum mean fruit yield (100.69 kg per tree) was recorded in Neelum followed Kanchan. The maximum fruit weight in Balwantwhich did not differ significantly from Krishna, Amrit and Neelum. The fruits of Kanchan were the smallest with 24.30 g fruit weight. The highest pulp percentage (92.16 %) was recorded in Kanchan followed by Chakaiya, whereas, lowest pulp percentage was recorded in cultivar Balwant. The highest TSS content was in Krishna which did not differ significantly from Balwant, whereas, the minimum TSS content was in Neelum. The acidity of fruits did not vary significantly.. The highest vitamin C content (582.98 mg per 100 g pulp) was in Krishna which did not differ significantly Balwant and Chakaiya. Among the cultivars, Balwant, Neelam and Kanchan performed better than other cultivars.

Key Words**:** Aonla, Cultivar, Growth, Quality, Yield

Aonla (*Emblica officinalis* Gaertn) is an important minor fruit crop grown on wide variety of soils under diverse climatic conditions In India, it occupies an area of 1, 08, 060 hectare with an annual production of 1.27 million tons (Anon., 2013). It is one of the richest natural sources of vitamin C. It is valued as an antiscorbutic, diuretic, laxative, alterative and antibiotic. It is also being used in tanning and dyeing industries.

Aonla is a sub-tropical fruit crop but, it can be successfully cultivated in tropical climate. It is evergreen in tropics but, under the subtropical conditions of north India, it shed its determinate shoots and leaves during winters and can grow well on light as well as heavy soils; however, well drained sandy loam soils are best for its cultivation. It can also tolerate semi-arid conditions as well as moderately alkaline soils. Keeping in view the commercial standing of aonla in the central Indian states, six varieties of aonla were introduced at Punjab Agricultural University, Ludhiana to evaluate its commercial potential under Punjab conditions. The present studies were carried out to evaluate the potential and suitability of the aonla varieties under Punjab conditions.

MATERIAL AND METHODS

The present studies were conducted at Fruit Research Farm, Department of Fruit Science, Punjab Agricultural University, Ludhiana during the years 2007 to 2010. The budded trees of six aonla varieties namely Chakaiya, Krishna, Amrit, Balwant, Neelum and Kanchan planted in square system during October 2002 at 7.5 x 7.5m were selected for the investigations. There were four replications with one tree as an experimental unit. The observations on tree growth, fruit maturity, fruit yield and quality were recorded from 2007 to 2010. The vegetative growth in terms of tree height, tree canopy and trunk girth was measured in the peak vegetative growth phase. Tree height was measured with the help of measuring pole in meters. Trunk girth was recorded with measuring tape at the height of 15 cm above the bud union and expressed in centimeters. The tree canopy was calculated with the formula given by Roose et al (1986)

$$V\ (m^3) = 4/6 \eth hr^2$$

Where, h= height (m) of the tree, r = sum of E-W + N-S direction/4

Time of fruit maturity was recorded with respect to changes in physical and chemical characters. A sample of five fruits per replication was collected at weekly interval and changes in fruit weight, size, TSS and acidity were recorded during the fruit growth period. The yield per plant was calculated by adding weight of harvested fruits after each picking in each experimental plant. The pulp percentage was recorded by separating stone from the pulp in each replication. Pulp weight was taken by subtracting the stone weight from the fruit weight and then pulp percentage was calculated. Total soluble solids (TSS) were determined with the help of hand refractometer and then corrected at 20°C

with the help of temperature coefficient chart (AOAC, 1980). The titrable acidity was ascorbic acid content was determined by standard procedures described in AOAC (1980) in which the percent acidity was calculated and expressed in terms of citric acid by using following formula.

$$\text{Acidity (\%)} = \frac{0.0064 \times \text{volume of NaOH used}}{\text{Volume of juice taken}} \times 100$$

Vitamin C content was also determined with the standard procedure described by AOAC, 1980 by using two gram finely chopped pulp of the fruits from each replication of different varieties under investigation and the results were expressed as ascorbic acid mg per 100g of the pulp.

RESULTS AND DISCUSSION

Vegetative characteristics of trees

The data on vegetative growth in terms of tree height, tree canopy and trunk girth (Fig. 1) revealed that among all the cultivars, Kanchan was the most vigorous aonla cultivar with maximum tree height (5.25 m), tree canopy volume (106.66m^3) and trunk girth (63.42 cm). The tree height in cultivar Kanchan was closely followed by Neelum (5.00 m), Balwant (4.81m) and Chakaiya (4.81m). The minimum tree height was recorded in Krishna (3.37m) which was followed by Amrit. The cultivar Krishna also exhibited the least canopy volume (62.18 m^3) followed by Neelum. The canopy volume of Kanchan, Balwant and Chakaiya was significantly higher than other cultivars during 2009, while, there was no significant difference in canopy volume during the other years of investigations. Beside, Kanchan, Balwant and Chakaiya also exhibited vigorous growth than other aonla cultivars. There was no significant difference in the trunk girth of all the cultivars. The maximum trunk girth of 63.42 cm was recorded in cv. Kanchan followed by Krishna and minimum cv. Amrit and Chakaiya. The variation in vegetative growth may be due to differences in genetic makeup of the cultivars. Ghosh *et al* (2003) also recorded maximum plant height and stem girth in Kanchan, however, canopy spread was maximum in Balwant under West Bengal conditions. Meghwal and Azam (2004) at Jodhpur (Rajasthan) conditions recorded significantly larger tree height in Chakaiya and minimum in Krishna. However, Balamohan*et al* (2004) observed maximum tree height in BSR-1 followed by Krishna and Chakaiya, while the girth was minimum in Neelum under sodic soils of Trichy in Tamil Nadu.

Fruit yield and physical quality attributes of fruits

The highest fruit yield of 100.69 Kg/tree was in Neelum followed by Kanchan (Fig.1). During the initial years the fruit bearing exhibited asymmetrical pattern in Krishna and Balwant. The fruit yield in these cultivars was very low during 2007 and 2008, respectively. However, during 2009 and 2010, encouraging yield was recorded in these two cultivars. This shows that Krishna and Balwant had longer juvenile period than the other varieties.

The fruits of cultivar Balwant were the earliest to mature during mid-November from the year 2008 to 2010 (Table 1). The varieties Krishna and Neelum also matured in the month of November. However, the cultivars Amrit, Kanchan and Chakaiya matured late. The cultivar Chakaiya was latest in maturity which matured during the third week of December (Table 1). However, Singh *et al* (1994) classified aonla cultivars Kanchan, Chakaiya and Krishna as early maturing (mid-November to mid-December), Amrit as mid-season (December) and Neelum as late maturing (mid-December – mid-January) varieties under Faizabad (U.P.) conditions.

The maximum fruit weight (30.22 g) was recorded in Balwant followed Amrit and Krishna, respectively. However, the minimum fruit weight was recorded in Kanchan (24.30g). The maximum fruit length was observed inNeelum (3.19 cm) which was statistically at par with Amrit, Krishna and Balwant. The maximum fruit diameter (3.64 cm) was recorded in Balwant followed Amrit and Neelum which did not differ significantly with each other in terms of fruit diameter.

The variations in time of fruit maturity, yield, weight and size of different varieties may be due to differences in their genetic makeup. The present investigations are in line with those reported by Shrivastava *et al* (1997) who recorded the fruit weight, fruit length and fruit diameter in range of 29.5 to 46.4 g, 3.91 – 2.90 cm and 4.50 – 3.50 cm in ten aonla

Table 1. Time of maturity of different Aonla Varieties (2007-2010)

Name of the cultivar	2007	2008	2009	2010
Chakaiya	20-22 Dec.	17-19 Dec.	19-20 Dec.	20-21 Dec.
Krishna	25-27 Nov.	25-27 Nov.	26-28 Nov.	23-25 Nov.
Amrit	17-20 Nov.	30 Nov. -1 Dec.	3 – 4 Dec.	2 – 3 Dec.
Balwant	25-28 Nov.	13-15 Nov.	17-18 Nov.	12-14 Nov.
Neelum	22-24 Nov.	27-30 Nov.	29-30 Nov.	27-29 Nov.
Kanchan	17-19 Nov.	15-18 Dec.	18-20 Dec.	19-20 Dec.

Table 2. Fruit characters of different aonla varieties (2007-2010)

Varieties	Fruit Weight (g)					Fruit Length (cm)					Fruit diameter (cm)				
	2007	2008	2009	2010	Mean	2007	2008	2009	2010	Mean	2007	2008	2009	2010	Mean
Chakaiya	26.32	27.13	27.01	29.18	27.41	2.73	2.72	3.06	2.67	2.80	3.30	3.31	3.2	3.1	3.23
Krishna	33.36	31.52	24.23	29.84	29.74	3.34	3.31	3.03	2.94	3.16	3.88	3.91	2.86	3.17	3.46
Amrit	34.12	33.83	22.46	29.87	30.07	3.30	3.33	2.93	3.11	3.17	3.69	3.67	3.25	3.54	3.54
Balwant	26.46	26.71	33.15	34.56	30.22	2.93	2.84	2.70/	3.19	2.92	3.56	3.43	3.88	3.67	3.64
Neelum	27.51	28.32	25.63	32.15	28.40	3.30	3.24	3.06	3.16	3.19	3.67	3.61	3.29	3.49	3.52
Kanchan	24.22	25.19	21.68	26.12	24.30	2.92	2.84	2.93	2.57	2.82	3.18	3.07	2.74	2.96	2.99
CD (0.05)	2.27	2.09	1.20	2.93	1.92	0.24	0.21	0.19	0.27	0.27	0.23	0.19	0.13	0.21	0.35

Table 3. Fruit quality of different aonla varieties (2007-2010)

Varieties	Pulp (%)					TSS (%)					Acidity (%)					Vitamin C- (mg/100g)				
	2007	2008	2009	2010	Mean	2007	2008	2009	2010	Mean	2007	2008	2009	2010	Mean	2007	2008	2009	2010	Mean
Chakaiya	88.8	90.67	90.93	91.54	90.49	7.72	9	7.67	8.98	8.34	1.54	1.59	1.43	1.61	1.54	514.8	525.7	477.88	530.5	512.2
Krishna	88.3	87.72	84.56	88.20?	87.19	10.22	9.8	10.33	9.71	10.02	1.53	1.56	1.50	1.59	1.55	592.9	597.3	563.5	578.2	582.9
Amrit	89.8	90.13	85.71	90.30?	88.99	8.32	10	6.47	9.94	8.68	1.5	1.59	1.55	1.42	1.42	323.1	529.2	389.79	532.4	443.6
Balwant	85.7	85.44	88.51	88.97	87.16	7.99	10	8.60?	9.98	9.14	1.27	1.37	1.55	1.34	1.38	569.4	572.1	505.19	565.4	553.0
Neelum	87.8	87.89	86..66	89.67	88.01	6.79	8.6	6.80?	9.1	7.82	1.61	1.63	1.41	1.6	1.56	365.2	487.2	533.04	524.4	477.5
Kanchan	92.1	92.74	91.79	92.00?	92.16	8.52	9.2	7.60?	9.4	8.68	1.84	1.77	1.36	1.64	1.65	428.9	495.3	488.53	521.7	483.6
CD (0.05)	2.6	2.73	1.98	2.12	2.13	0.43	0.51	0.28	0.6	1.08	NS	NS	NS	NS	NS	23.7	25.6	22.42	39.3	75.3

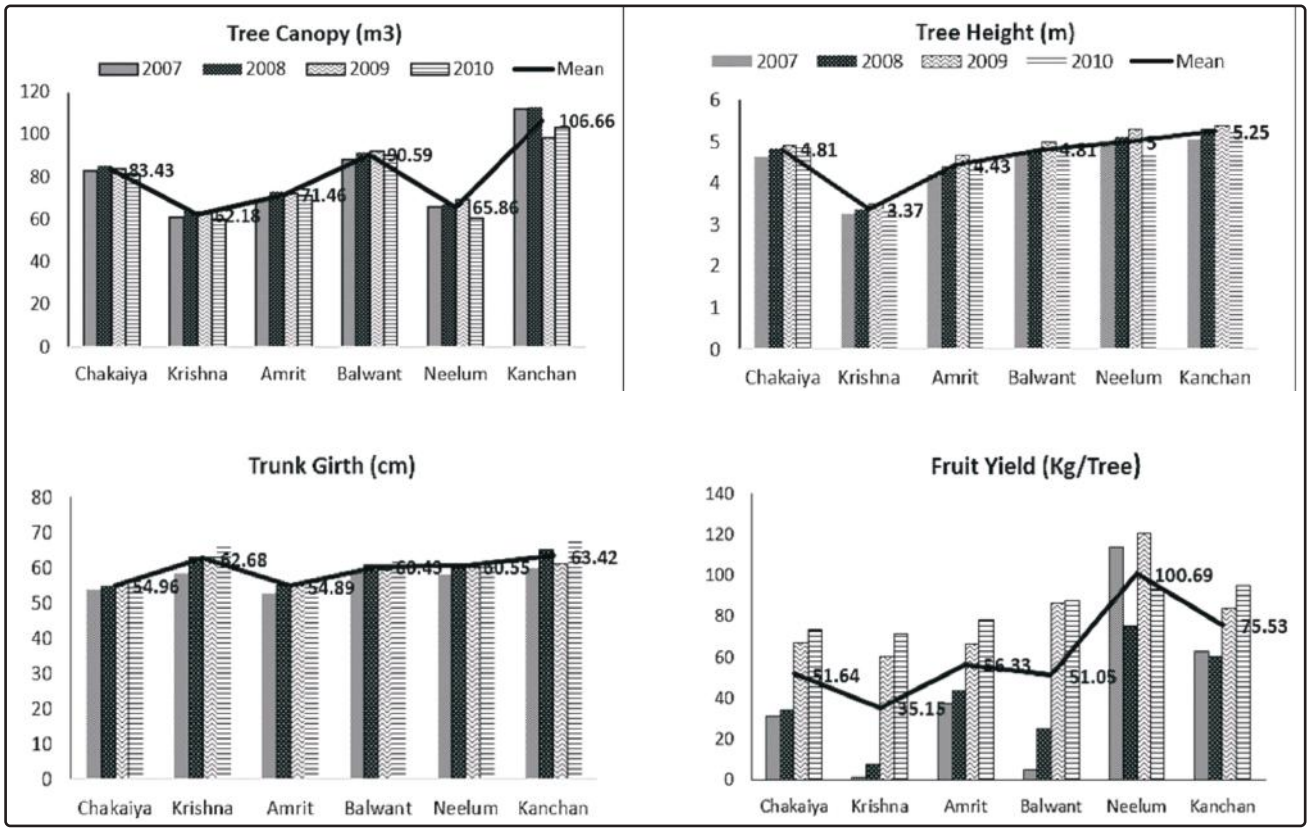

Fig. 1. Tree height (m), tree canopy (m3) truck girth and yield (kg/ tree) of different aonla cultivars

cultivars evaluated under Uttar Pradesh conditions. However, Aulakh *et al* (1997) recorded the largest fruits of 4.1 cm x 3.3 cm in Chakaiya and the smallest fruits of 3.4 cm x 2.7 cm in cv. Banarasi seedling.

The maximum pulp percentage (92.16 %) was recorded in Kanchan followed by 90.49 % in Chakaiya, whereas, minimum pulp percentage of 87.16% was in cultivar Balwant. The variation in pulp percentage among different cultivars may be due to their genetic makeup. Similarly, edible pulp percentage from 92.85 to 94.90 was reported in ten cultivars of aonla evaluated under Faizabad (U.P.) conditions (Kumar and Singh, 2002). Mehta *et al* (2002) also reported that the pulp percentage ranged between 95.44% in Banarasi and 92.71% in local seedlings among five cultivars of aonla evaluated at Hisar, Haryana.

Bio-chemical quality attributes of fruit

The highest TSS content (10.02%) was recorded in Krishna which did not differ significantly from Balwant (Table 3). The minimum TSS content was recorded in Neelum followed by Chakiaya, Amrit and Kanchan which were at par with each other.The vitamin C content was highest in Krishna (582.98 mg in 100 g pulp) which did not differ significantly Balwant and Chakaiya . However, the minimum vitamin C content (443.62 mg per 100 g pulp) was recorded in Amrit followed by Neelum (477.5 mg per 100g pulp) and Kanchan (483.60 mg/100g pulp). The acidity of fruits did not vary significantly during all the years of investigation. The chemical characters may have varied due to differences in the genotype of the cultivars. Singh *et al* (2004) recorded the TSS content of 11.12, 10.96, 10.14, 10.86 and 9.44 percent in Amrit, Neelum, Balwant, Kanchan and Chakaiya, respectively under Faizabad (U.P.) conditions. Singh *et al* (2001) recorded vitamin C content of 600 mg/100 g of pulp under Faizabad (U.P.) conditions in Neelum. Kumar *et al* (2002) reported that the vitamin C content ranged from 305.7 mg/100 g pulp in Amrit to 700 mg/100 g of pulp in Chakaiya among the ten cultivars evaluated at Faizabad, U.P.

It was concluded that aonla cv. Kanchan was most vigorous in respect of tree height, tree canopy and trunk girth. However, maximum yield was recorded in Neelum followed by Kanchan while, the fruit quality was better in Krishna. The cv. Balwant was early in maturity with maximum fruit size.

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Integrated Nutrient Management in Kinnow Mandarin (*Citrus deliciosa* Tenore)

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***Abstract*:** An experiment was carried out at the farmer orchard to evaluate the response of organic nutrients (Vermicompost and FYM) and inorganic manures (NPK) on growth, yield and yield attributes and quality parameters of Kinnow mandarin. Increased plant growth, yield and quality parameters were recorded with main treatment M_2 (Application of FYM at 30 kg per tree per year) and subtreatment S_3(600:250:600 g NPK). However, the TSS (10.13°B) was maximum in S_4 (200:250:200 g NPK), Non reducing sugar (5.85 %) with S_5 (400:250:400 g NPK) and Total sugar (8.75%) with S_2 (400:250:400 g NPK). The interaction between organic manures and inorganic manures on growth, yield and quality of fruits were found non- significant.

Key Words: FYM, Kinnow Mandarin, Integrated Nutrient Management, NPK

Kinnow was evolved as a result of cross between 'king' and 'willow-leaf'. The cross was made by H B Frost, a citrus breeder at the Citrus Research Centre, University of California, USA, in 1951. Both of the parents have Indo-China origins. The name was derived by combining the first and last words of the two parents i.e. 'kin' from king and 'ow' from willow. In India an area of citrus fruit is about 0.84 million hectares with a production of 7.46 million tons (Anon., 2012). Kinnow has been proved promising because Kinnow mandarin has wide adoptability, high bearing potential and good quality fruits. The average yield of citrus in India is about 8.80 t/ha, which is much lower than citrus yield (20-25 t/ha) in other developed countries like Brazil, USA, Japan, China, Spain and Mexico. This low productivity is due to malnutrition and general neglectance of the citrus orchards. Citrus is very much responsive to application of manures and fertilizers (Kumar and Srivastava, 2012). With the hike in fertilizer prices due to decontrol and their adverse effects on ecosystem, it has become imperative to go for integrated nutrient management so as to have increased fertilizer use efficiency with better application technique, use of biofertilizers and organic farming technology. With increasing problem of soil salinity, it is necessary to strike a balance between use of chemical fertilizers and organic manures. The attempts have been made towards standardizing the nutritional requirements of Kinnow mandarin under diverse soil and climatic conditions of Karnataka state, thus necessitates conducting study on integrated nutrient management.

MATERIAL AND METHODS

Studies on integrated nutrient management in Kinnow mandarin (*Citrus deliciosa* T.)" was carried out during 2010-11 in the College of Horticulture, Arabhavi, Karnataka. Four years old uniform healthy Kinnow mandarin trees budded on Jatti Katti root stock at a spacing of 6 × 5 m grown under drip irrigation were selected for the experiment at farmers fields. The experiment was laid out in split plot design and replicated thrice with treatment. The experiment consists of main (M_1: Vermicompost 10 kg and M_2: FYM 30 kg / tree / year) and sub treatment (S_1- 200:250:200 g, S_2- 400:250:400 g, S_3- 600:250:600 g NPK / tree / year applied in two equal split doses. S_4- 200:250:200 g, S_5- 400:250:400 g and S_6- 600:250:600 g NPK / tree / year applied in three equal split doses). Random soil samples were collected and analyzed pH (7.56), EC (0.26 dS/m), organic carbon (0.45 %) and the N,P_2O_5,K_2O before imposition of treatment were 224, 19.8, 192 kg/ha and after imposition of treatment 258, 25.0, 228 kg/ha. The trees were under uniform cultural practices. The data on vegetative growth parameters like plant height and plant spread (NS and EW), fruit yield parameters like number of fruits, yield (kg / tree), yield (tons / ha), fruit weight (g), fruit length (cm) and fruit diameter (cm). Quality parameter like total soluble solids (TSS) with hand refractometer (0-32 scale), the total sugar (%) in the sample by the principle of reducing sugar after inversion, phenols (%) and protein by standard methods were estimated.

RESULTS AND DISCUSSION

All the vegetative parameters *viz*. plant height (cm), plant spread (N-S and E-W) were significantly influenced due to the application of organic and inorganic manures (Table 1). Initial tree height and tree spread (before imposition of

treatments) were found to be non significant among the treatments, indicating the trees uniformity. However, the main treatment (M_2) FYM 30 kg/tree/year recorded high values with respect to tree height (3.23 m), tree spread NS (3.27 m), EW (3.37 m). In the sub treatment (S_3) 600:250:600 g NPK per tree per year applied in two split doses of recorded significantly higher tree height , spread NS , EW after 180 days. Further interaction between main and sub treatment were non significant. From the investigation, it was found that growth parameters particularly tree height and tree spread was increased as the quantity of NPK was increased. This indicates that Kinnow mandarin requires higher nutrition for its growth and productivity.

With respect to yield and yield attributing parameters (Table 2), the main treatment (M_2) FYM 30 kg/tree/year recorded higher number of fruits (526), fruit yield kg / tree (67.05), fruit yield t /ha (22.33), fruit weight (164.68 g), fruit diameter (7.50 cm) and fruit length (6.29 cm). In the sub treatment 600:250:600 g NPK per tree per year (S_3) applied in two split doses recorded significantly higher yield (23.96 tons/ha) and yield attributing parameters like fruits weight (189.1 g), fruit diameter (7.76 cm) and fruit length (6.62 cm). The higher tree height and tree spread in both directions, number of fruits, higher fruit weight, fruit diameter and fruit length might have influenced the fruit yield.

These results are in line with Dalal *et al.* (2009) who reported that the maximum number of fruits was recorded in N and K (800:300:600 g per tree) application in three equal splits *i.e.*, basal, 45, 90 days + 100% P_2O_5 + organics + biofertilizers as basal dose in sweet orange. Shukla *et al.* (2000) reported that combination of 400 g N and 256 g P resulted the fruit yield of 35.78 kg per tree in Kinnow mandarin.

All the fruit juice quality parameters were found significantly influenced by the INM (Table 3). The main treatment (M2): FYM 30 kg/tree/year recorded high with

Table 1 . Effect of INM on tree height and tree spread of Kinnow mandarin

Treatment	Initial tree height (m)*	Tree height (m) at 180 days**	Initial plant spread		Tree spread after 180 days (m)	
			N-S	E-W	N-S	E-W
M_1	2.79	3.15	2.81	2.88	3.22	3.27
M_2	2.77	3.23	2.83	2.90	3.27	3.37
CD p=0.05	NS	0.05	NS	NS	0.05	0.07
		Sub treatment				
S_1	2.82	3.20	2.78	2.89	3.23	3.31
S_2	2.72	3.24	2.83	2.86	3.28	3.36
S_3	2.81	3.29	2.87	2.93	3.32	3.46
S_4	2.76	3.12	2.80	2.89	3.15	3.21
S_5	2.78	3.15	2.85	2.87	3.21	3.25
S_6	2.80	3.19	2.82	2.88	3.25	3.30
CD p=0.05	NS	0.10	NS	NS	0.06	0.06
		M x S Inter action				
M_1S_1	2.79	3.16	2.72	2.86	3.18	3.24
M_1S_2	2.74	3.19	2.80	2.81	3.25	3.30
M_1S_3	2.75	3.24	2.86	2.92	3.27	3.35
M_1S_4	2.81	3.11	2.87	2.90	3.15	3.20
M_1S_5	2.82	3.14	2.89	2.92	3.20	3.24
M_1S_6	2.77	3.18	2.83	2.86	3.24	3.27
M_2S_1	2.85	3.23	2.84	2.93	3.28	3.38
M_2S_2	2.70	3.29	2.86	2.91	3.31	3.43
M_2S_3	2.83	3.35	2.89	2.95	3.38	3.58
M_2S_4	2.71	3.14	2.73	2.89	3.16	3.23
M_2S_5	2.73	3.15	2.82	2.83	3.22	3.25
M_2S_6	2.82	3.19	2.82	2.90	3.26	3.34
CD p=0.05	NS	NS	NS	NS	NS	NS

NS – Non significant; *** -** Before imposition of treatment ** - After imposition of treatment

respect to TSS (9.81 ^{0}B), reducing sugar (2.75 %), non reducing sugar (5.76 %), total sugar (8.81 %), fructose (2.13 %) and protein (1.42 g/ 100g pulp) however, maximum ascorbic acid (70.34 mg/100 g). In the sub treatment 600:250:600 g NPK per tree per year (S_3) applied in two split doses recorded significantly higher with respect to reducing sugar (2.88 %), fructose (2.47 %), ascorbic acid (78.22 mg/100 g) and protein (1.44 g/ 100g pulp), while treatment S_4 showed maximum TSS (10.13 ^{0}B), treatment S_5 recorded higher non reducing sugar (5.85 %), S_2 recorded more total sugars (8.75 %). Total soluble solids was not influenced significantly by the organic manures *viz.*, FYM and Vermicompost and levels of NPK. The interaction between organic manures and different levels of NPK influenced the non reducing sugars, total sugar and fructose significantly. M_2S_5 was recorded higher non reducing sugars (6.30%), higher total sugars (9.25%) and fructose (2.64 g/ 100 g pulp) was recorded in M_2S_3.

The deterioration in quality might be due to increase in fruit yield and consequent dilution of sugars in fruits of Kinnow mandarin. Similar results reported by Kumar *et al.* (1998) who found that effect of NPK on TSS was non significant in Kinnow mandarin. Dalal *et al.* (2009) reported that the maximum total sugar (7.03%), reducing sugar (4.94%) and minimum non reducing sugar (1.98%) were recorded in N and K application in sweet orange. Dalal *et al.* (2009) who reported that maximum ascorbic acid (59.53mg/ 100ml juice) with N and K (800:300:600 g) application in three equal splits *i.e.*, basal, 45, 90 days + 100% P_2O_5 + organics + biofertilizers as basal dose in sweet orange.

From results it can be concluded that basal application of FYM at rate of 30 kg to the soil per tree per year has increased the tree height, tree spread (N-S and E-W), fruit yield per tree and fruit yield per hectare and quality parameters. Inorganic fertilizers dose of 600:250:600 g in two splits per tree per year increased the tree height and spread (N-S and E-W), fruit yield per tree and fruit yield per hectare

Table 2. Effect of INM on fruit yield and yield attributing parameters of Kinnow mandarin

	No. of fruits per tree	Fruit yield (kg/ tree)	Fruit yield (tons/ ha)	Fruits weight (g)	Fruit diameter (cm)	Fruit length (cm)
M_1	518.00	64.89	21.61	155.20	7.22	5.91
M_2	526.00	67.05	22.33	164.68	7.50	6.29
CD p=0.05	6.05	1.34	0.45	7.97	0.18	0.12
			Sub treatment			
S_1	498.00	64.46	21.46	149.44	7.12	5.89
S_2	537.00	66.91	22.28	161.00	7.28	6.23
S_3	559.00	71.94	23.96	189.17	7.76	6.62
S_4	481.00	62.64	20.86	137.11	6.86	5.58
S_5	517.00	63.83	21.26	154.50	7.39	6.00
S_6	543.00	66.04	21.99	168.43	7.72	6.29
CD p=0.05	39.66	2.36	0.79	8.22	0.21	0.18
			M x S Inter action			
M_1S_1	493.00	63.67	21.20	151.67	7.18	5.88
M_1S_2	530.00	65.78	21.90	162.11	7.30	6.29
M_1S_3	557.00	69.89	23.27	176.89	7.50	6.32
M_1S_4	478.00	61.93	20.62	136.11	6.79	5.47
M_1S_5	510.00	63.11	21.02	142.56	7.06	5.62
M_1S_6	542.00	64.97	21.64	161.89	7.47	5.87
M_2S_1	503.00	65.25	21.73	147.22	7.06	5.90
M_2S_2	543.00	68.04	22.66	159.89	7.26	6.16
M_2S_3	562.00	74.00	24.64	201.44	8.03	6.91
M_2S_4	483.00	63.35	21.09	138.11	6.93	5.69
M_2S_5	523.00	64.56	21.50	166.44	7.72	6.38
M_2S_6	545.00	67.11	22.35	174.96	7.97	6.70
CD p=0.05	NS	NS	NS	11.63	0.29	0.26

NS – Non significant

Table 3. Effect of INM on fruit juice quality parameters of Kinnow mandarin

Treatment	TSS (°B)	Reducing sugar (%)	Non reducing sugar (%)	Total sugar (%)	Fructose (g/100 g)*	Ascorbic acid (mg/100 g)	Protein (g/100)
M_1	9.61	2.41	4.98	7.65	1.94	67.39	1.22
M_2	9.81	2.75	5.76	8.81	2.13	70.34	1.42
CD p=0.05	NS	0.28	0.49	0.43	0.15	NS	0.17
			Sub treatment				
S_1	9.60	2.62	5.27	8.16	1.76	59.37	1.17
S_2	9.53	2.70	5.76	8.75	1.89	73.21	1.37
S_3	9.62	2.88	4.76	7.90	2.47	78.22	1.44
S_4	10.13	2.18	5.65	8.13	1.59	61.30	1.19
S_5	9.98	2.49	5.85	8.65	2.05	67.08	1.33
S_6	9.38	2.60	4.92	7.81	2.43	74.04	1.41
CD p=0.05	NS	0.27	0.69	0.68	0.10	6.16	0.19
			M x S Interaction				
M_1S_1	8.80	2.39	4.88	7.53	1.71	56.88	1.13
M_1S_2	9.90	2.50	5.58	8.36	1.88	69.68	1.22
M_1S_3	9.43	2.62	3.74	6.56	2.29	76.76	1.30
M_1S_4	10.33	2.15	5.09	7.51	1.51	60.33	1.12
M_1S_5	9.67	2.37	5.39	8.04	1.98	66.83	1.26
M_1S_6	9.53	2.44	5.17	7.90	2.25	73.88	1.32
M_2S_1	10.40	2.84	5.66	8.79	1.82	61.87	1.22
M_2S_2	9.17	2.89	5.94	9.13	1.90	76.74	1.52
M_2S_3	9.80	3.15	5.78	9.25	2.64	79.67	1.58
M_2S_4	9.93	2.20	6.21	8.75	1.68	62.26	1.26
M_2S_5	10.30	2.62	6.30	9.24	2.12	67.33	1.41
M_2S_6	9.23	2.78	4.68	7.71	2.60	74.20	1.51
CD p=0.05	NS	NS	0.97	0.96	0.14	NS	NS

NS – Non significant ; *100 g of Kinnow mandarin pulp

and quality parameters *viz.* reducing sugar, ascorbic acid, fructose and protein.

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Studies on *in vitro* Regeneration and Acclimatization of Rough Lemon

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Abstract: A complete regeneration protocol was developed for rough lemon, an important citrus rootstock in India. Nodal sections were cultured on Murashige and Skoog (MS) medium supplemented with 6-benzylaminopurine (BAP) and adenine sulphate (Ads) singly or in combination. The highest percentage of explant establishment was observed on MS medium supplemented with BAP (1.0 mg/l) + Ads (1.5 mg/l). Shoot proliferation was undertaken on MS medium supplemented with 1 mg/l 6-benzylaminopurine (BAP) and 0.5, 1.0, 1.5 mg/l kinetin (Kin.). Maximum shoot proliferation was in the explants placed vertically on MS liquid medium containing BAP (1.0 mg/l) + Kin (0.5 mg/l). Earliest root initiation and maximum percentage of rooting was observed on MS liquid media supplemented with 1.0 mg/l IBA and NAA each. Overall effect of acetyl salicylic acid, activated charcoal and abscisic acid on rooting was inhibitory. Maximum survival of micropropagated plantlets was observed on sand followed by burnt rice husk + garden soil + FYM + sand in equal proportion. Among anti-transpirants glycerol resulted in maximum plant survival but ABA had no effect on plant survival.

Key Words: Abscisic acid, Activated charcoal, Acetyl salicylic acid, Glycerol, Liquid medium, Rooting, Shoot proliferation

Citrus fruits have prominent place among fruits of tropical and subtropical climate and are being grown extensively in this region of the world. In India, citrus is the third largest fruit industry after mango and banana and occupies a place of considerable importance in the economy of India. In Punjab, the citrus fruits occupy 65.8 per cent of the total area under fruits, i.e. 76.6 thousand hectares (Anon., 2014). The rough lemon (*Citrus jambhiri* Lush.) has been proved an excellent rootstock for warm, humid areas with deep sandy soil. In such environment, trees on rough lemon grow rapidly, remain productive for longer period and produce high quality fruit (Vij and Kumar, 1990). The propagation of citrus rootstock is normally done by seeds, but propagation through seeds in cross-pollinated species like citrus lead to huge variability. Though seeds, because of their polyembryonic nature give rise to several vigorous and virus free seedlings, which are genetically similar among themselves and to mother tree, but difficulty in elimination of zygotic seedlings necessitates the application of *in vitro* micropropagation (Edriss and Burger, 1984). Micropropagation through tissue culture ensures rapid, true to type and mass multiplication of disease free plants and is one of the highly successful examples of commercial exploitation of tissue culture technology. Therefore, the present study was conducted to establish an efficient protocol for *in vitro* propagation of rough lemon.

MATERIAL AND METHODS

Establishment and multiplication of in vitro shoot cultures

Citrus rootstock, rough lemon was used as explant source for *in vitro* plantlet production, the explants (nodal segments) were obtained from green house grown seedlings. These seedlings were grown in 15cm x 30cm polyethylene bags containing mixture of fresh garden soil and cocopeat in 8:1 ratio. Shoots were excised from actively growing seedlings. Leaves and thorn were removed carefully from the shoots with the help of pruning secateurs. Defoliated shoots were washed thrice with clean water. These shoots were cut for preparing nodal segments of size 2.0 - 3.0 cm each having at least one node. Under aseptic conditions, these nodal segments were surface sterilized with 0.1 per cent mercuric chloride solution (w/v) and shaken continuously for 6 minutes. Then these segments were thoroughly washed with sterile (autoclaved) distilled water before inoculation.

Nodal segments were placed vertically in culture jars containing 50ml of Murashige and Skoog (MS) medium supplemented with 1.0 mg/l 6-benzylaminopurine (BAP), 0.5 mg/l Kinetin (Kin.) and 0.5, 1.0, 1.5 mg/l adenine sulphate (Ads) and solidified with 7 g/l Difco-Bacto agar. The pH of the medium was adjusted to 5.7 before the addition of agar and autoclaved at 121^0C for 20 min. Cultures were incubated at 25^0C under 16 h photoperiod provided by cool-white fluorescent lamps (40 $\mu mol.m^{-2}.s^{-1}$). After bud sprouting shoots were excised and transferred to culture jars containing shoot proliferation media i.e. MS medium supplemented with 1.0 mg/l BAP and 0.5, 1.0, 1.5 mg/l Kinetin (Kin.). The axillary shoots were then excised routinely

and used for multiplication of shoot cultures.

Rooting of in vitro shoot cultures

In vitro regenerated shoots of 1.5 to 2.0 cm length were excised and placed in test tubes (25 x 150 mm) containing 25 ml liquid root induction medium consisting of MS basal medium supplemented with 15 g/l sucrose, and different concentrations of indole-3-butyric acid (IBA) and 1-*naphthaleneacetic* acid (NAA), acetyl salicylic acid (ASA), abscisic acid (ABA) and activated charcoal (AC). Cultures were incubated 25^{0}C under 16 h photoperiod provided by cool-white fluorescent lamps (40 µmol.m^{-2}.s^{-1}). Observations were recorded on days taken for root initiation, rooting percentage, number of roots and length of longest root (cm).

Hardening and transfer of plants to soil / soil less media.

The *in vitro* rooted plantlets were removed from the culture jars and thoroughly washed under running tap water for 1-2 hours. Washing was done to remove the traces of nutrient media from the roots. Dead and decayed parts of the plantlets were removed. The plantlets were than planted in plastic cups containing different substrates viz. sand, saw dust, sphagnum moss, FYM + sand (1:1), burnt rice husk + garden soil + FYM + sand (1:1:1:1) and garden soil + coco peat (4:1) to study the comparative survival of micro-propagated plantlets. The constituents of different substrates were mixed volume/ volume. Bavistin (0.1%) was applied during the first watering of plants transferred to the plastic cups.

Acclimatization with anti-transpirants

Anti-transpirant treatment was given to 30 randomly selected plants. Two different anti-transpirants viz., Glycerol and Abscisic acid were used. The stem and leaves of the plants were dipped into the solution of glycerol for one minute before planting them in plastic cups. Care was taken to avoid dipping of roots in the solution. The ABA was sprayed on the plants with the help of hand sprayer (concentration of glycerol and ABA varied according to treatment).

RESULTS AND DISCUSSION

Establishment and multiplication of in vitro shoot cultures

Results indicate that the establishment of explant was affected by BAP, Kin and Ads concentrations (Table 1). MS_4 medium containing BAP (1.0 mg/l) + Ads (1.5 mg/l) showed maximum percentage of establishment (83.3%) followed by MS_3 and MS_2 containing BAP (1.0 mg/l) + Ads (1.0 mg/l) and BAP (1.0 mg/l) + Ads (0.5 mg/l), respectively. Explant establishment increased with the increase in concentration of Ads (0.5-1.5 mg/l). Higher establishment of explant on MS_4 medium may be due to the synergistic effect of two different types of cytokinin (BAP and Ads) used in media (Bowman, 1994; Baruah *et al.,* 1995). Minimum percentage of establishment (33.3%) was observed on MS_0 (basal) medium without any growth regulator preceded by MS_8 medium (38.3%) containing Kinetin (0.5 mg/l). Less establishment on MS_8 medium may be because Kinetin is a weak cytokinin. Similarly, Chaturvedi and Mitra (1975) reported BAP as highly effective in inducing shoot bud formation.

Table 1. Effect of different level of BAP, Ads and Kin on establishment of explant

MEDIA	Establishment (%)
MS_1: MS + BAP (1.0 mg/l)	46.7
MS_2: MS + BAP (1.0 mg/l) + Ads (0.5 mg/l)	48.3
MS_3: MS + BAP (1.0 mg/l) + Ads (1.0 mg/l)	53.3
MS_4: MS + BAP (1.0 mg/l) + Ads (1.5 mg/l)	83.3
MS_5: MS + Ads (0.5 mg/l)	36.7
MS_6: MS + Ads (1.0 mg/l)	46.7
MS_7: MS + Kin (0.5 mg/l) + Ads (0.5 mg/l)	46.7
MS_8: MS + Kin (0.5 mg/l)	38.3
MS_0: MS Basal	33.3
CD (p=0.05)	12.2

The shoots developed on the establishment medium were transferred to shoot multiplication medium i.e. liquid MS medium fortified with BAP (1.0 mg/l) and Kin (0.5 mg/l). Effect of orientation of explant i.e. horizontal and vertical on shoot multiplication was studied in this experiment. A clump of cotton was put to support the explant and to avoid sinking of explant. Signs of multiplication became evident within 8 -10 days after inoculation. However, minimum mean shoot multiplication (79.0%) was observed with vertical orientation and it was significantly lower as compared to horizontal orientation (84.0%). Dias and Rogers (1992) studied the effect of orientation of explant on shoot initiation in Swingle citrumelo (*Citrus paradisi x Poncirus trifoliata*) and found that only vertically placed stem explants produced shoots. Contrary to this report, in present study, shoot bud initiation occurred on both horizontally and vertically placed explants.

Rooting of in vitro shoot cultures

In vitro regenerated shoots of 1.0 to 1.5 cm height were separated out from shoot clump, obtained during shoot multiplication stage. These shoots were transferred to rooting media. The process of rhizogenesis in the shoots was greatly influenced by the concentration and type of auxin used. The root initiation from the *in vitro* derived shoots of rough lemon started within 13.9 to 14.4 days (Table 2). The percentage of rooted shoots ranged from 46.0 - 62.0 per cent. The highest percentage (62.0%) was obtained on MS medium fortified with NAA and IBA 1.0 mg/l each and the

Table 2. Effect of media and auxin concentration on rooting of rough lemon

Media	Days to root initiation	Rooting (%)	No. of roots / shoot	Length of longest root (cm)
MS + NAA (0.5 mg/l) + IBA (0.5 mg/l)	14.4	46.0	1.21	0.90
MS + NAA (0.5 mg/l) + IBA (1.0 mg/l)	13.9	56.3	1.74	1.54
MS + NAA (1.0 mg/l) + IBA (0.5 m g/l)	14.2	52.4	2.21	2.15
MS + NAA (1.0 mg/l) + IBA (1.0 mg/l)	14.0	62.0	2.41	2.43
CD (p=0.05)	NS	6.2	0.84	0.91

lowest percentage (46.0%) was observed on MS medium fortified with NAA and IBA 0.5 mg/l.

Maximum number of roots per shoot (2.41) was observed on MS medium supplemented with 1 mg/l NAA and IBA each. Length of longest root ranged from 0.90 – 2.43 cm with maximum root length (2.43 cm) on MS medium fortified with 1 mg/l NAA and 1 mg/l IBA. Similarly, Singh *et al.* (1999) observed different rooting response on different rooting media.

The effect of acetyl salicylic acid (ASA) on rooting behaviour of rough lemon on half strength medium fortified with 1.0 mg/l NAA, 1.0 mg/l IBA and 30 g/l sucrose was evaluated. Acetyl salicylic acid was added at 2 and 5 ppm concentration to the medium. ASA had a negative influence on time taken for root initiation. The roots were initiated after 11.6 days on medium free of ASA and root initiation was delayed to 21.3 and 21.6 days on medium supplemented with 2 and 5 ppm ASA, respectively (Table 3). No significant difference in time taken for root initiation was observed between medium supplemented with 2 or 5 ppm. The rooting percentage was lowered by acetyl salicylic acid. The minimum rooting percentage (15.0%) was observed on medium supplemented with 5 ppm ASA preceded by medium fortified with 2 ppm ASA (22.1%). The maximum rooting (60.0%) was observed on medium without ASA. In present study, inhibitory effect of ASA on rooting was observed for rooting and it prolonged root initiation period. The effect of salicylic acid on the physiological processes was found to be variable, promoting some processes and inhibiting others depending on its concentration, plant species, developmental stages and environmental conditions (El-Mergawi and Abdel Wahid, 2004). Beneficial effect of ASA on root number and root length was observed, with maximum number of roots per shoot (5.41) and root length (3.67 cm) on medium with 5 ppm ASA (Table 3). Likewise, in wheat, salicylic acid increased the level of cell division within the apical meristem of seedling roots, which caused an increase in plant growth (Shakirova *et al.*, 2003).

The effect of abscisic acid (ABA) on rooting or rough lemon was studied. Two concentration of ABA i.e. 0.2 ppm and 0.5 ppm were added to the half strength MS medium supplemented with 1.0 mg/l NAA, 1.0 mg/l IBA and 30 g/l sucrose. The addition of ABA to medium was found to delay root induction and the number of days taken for root initiation increased with increase in ABA concentration (Table 4). The earliest root initiation (11.6 days) occurred on medium free of ABA followed by medium containing 0.2 ppm ABA (15.1 days) and 0.5 ppm ABA (17.7 days). The ABA also decreased rooting percentage and decrease in rooting percentage was negatively correlated to the concentration of ABA. The maximum rooting percentage (60.0%) was observed in control followed by media supplemented with 0.5 ppm ABA (39.3%) and 0.2 ppm ABA (44.7%). No significant difference was observed among different treatment i.e. 0.2 ppm ABA, 0.5 ppm ABA and control for number of roots per shoot and length of the longest root. Inhibitory effect of ABA on rooting may be due to the growth retarding nature of abscisic acid, as also observed in Tomato (Hooker and Thorpe, 2004).

Four concentration of activated charcoal i.e. 1,2,3 and 4 g/l along with control (without activated charcoal) were tested, to evaluate the effect of activated charcoal (AC) on rooting of rough lemon in half strength MS medium containing 1 mg/l NAA and IBA each. The activated charcoal delayed the root initiation. Maximum number of days (27.5 days) for root initiation were taken on medium supplemented with 2.0 g/l AC and minimum number of days (19.25 days) were taken on medium having no activated charcoal (Table 5). However, no root initiation occurred in medium fortified with 4 g/l AC and this treatment differed significantly from all other treatments. Percentage of rooting ranged from 0-62.5%. It was maximum (62.50%) on medium with 1.0 g/l AC followed by control (51.3%) and no rooting was observed on medium supplemented with 4 g/l AC. The effect of 2 and 3 g/l AC was also inhibitory to the root formation. The favourable effect of AC on rooting might be due to etiolation resulting from the darkening effect produced by it (Mathew and Phillip, 2000). The negative effect of higher concentration of AC can be attributed to the complete unavailability of auxins for root formation (Maggar *et al*, 2001). The root numbers per shoot decrease with increasing concentration of AC. Besides, no lateral roots were observed on media supplemented with AC. Maximum length of longest root (3.95 cm) was observed on

Table 3. Effect of Acetyl salicylic acid on rooting of rough lemon on MS + NAA (1.0 mg/l) + IBA (1.0 mg/l) liquid medium

Concentration of ASA	Days taken for root initiation	Rooting (%)	No. of roots/ shoot	Length of longest root (cm)
2 ppm	21.3	22.1	4.92	3.17
5 ppm	21.6	15.0	5.41	3.67
Control	11.6	60.0	4.16	2.87
CD (p=0.05)	3.5	4.8	0.75	0.49

Table 4. Effect of abscisic acid on rooting of rough lemon

Concentration of ABA	Days taken for root initiation	Rooting (%)	Number of roots / shoot	Length of longest root (cm)
0.2 ppm	15.1	44.7	4.49	2.97
0.5 ppm	17.7	39.3	4.15	3.16
Control	11.6	60.0	4.06	2.89
CD (0.05)	1.0	4.6	NS	NS

Table 5. Effect of activated charcoal on rooting of rough lemon on MS + NAA (1.0 mg/l) + IBA (1.0 mg/l) solid medium

Concentration of AC	Days taken for root initiation	Rooting (%)	Number of roots/ shoot	Length of longest root (cm)
1 gm/l	24.5	62.5	1.30	3.18
2 gm/l	27.5	37.5	0.69	3.95
3 gm/l	21.0	20.0	0.21	2.25
4 gm/l	0.0	0	0	0
Control	19.3	51.3	3.15	3.69
CD (p=0.05)	9.7	4.3	0.36	1.57

medium containing 2.0 g/l AC and it was significantly higher than obtained on the medium supplemented with 3 g/l AC (2.25 cm) and 4 g/l AC (0.00 cm). Results indicate that AC had negative effect on root elongation. However, contrary to these results, Mathew and Phillip (2000) observed increased root length and attributed it to darkening effect produced by AC.

Hardening and transfer of plants to soil / soil less media.

In order to find a suitable medium ensuring better survival of micropropagated plants on transfer to *ex vitro* conditions, six potting mixtures viz., sand, saw dust, sphagnum moss, FYM + sand (1:1), burnt rice husk + gardan soil + FYM + sand (1:1:1:1) and garden soil + coco peat (4:1) were tried as different substrates to study their relative efficacy in enhancing the survival of micropropagated plantlets. Plantlets transferred to saw dust showed 100 per cent mortality (Table 6). This may be due to some toxic substances present in the saw dust (Dhillon, 2001). The plantlets growing on sand showed maximum survival (60.0%) followed by burnt rice husk + garden soil + FYM + sand (1:1:1:1) (52.5%). High survival on sand can be attributed to high porosity of substrate, resulting in better aeration and drainage. Addition of burnt rice husk improved aeration in substratum, beside it absorbed harmful substances released in soil, this lead to better plant growth (Dhillon 2001). Besides, beneficial effect of sand already described were also available on this substrate. The survival percentage on FYM + sand was better (32.5%) than on sphagnum moss (27.5%) but plants on sphagnum moss were healthier than on FYM + sand. Least survival (22.5%) was observed on garden soil + coco peat (4:1). Substrate nature was found to influence *in vitro* rooting and establishment in soil of citrus plants by Plastira and Karetsos (2003).

Acclimatization with anti-transpirants

This experiment was conducted to study the effect of anti-transpirants viz. glycerol (10, 25, 50 per cent) and ABA (7, 10 and 15 ppm) on *ex vitro* survival of the micropropagated plants. Plantlets were removed from the culture vessels and washed under running tap water to remove media from the roots. These plantlets were dipped in the solution of glycerol. Care was taken not to dip the roots in anti-transpirant solution. ABA was sprayed to the plants with the help of hand sprayer. Among all the treatments 50 per cent glycerol emerged best with maximum plant survival (76.7%) followed by 25 per cent glycerol while ABA 10 ppm showed the least plant survival (30.0%) (Table 7). The direct effect of these anti-transpirants on plantlet survival was found to be promotive. This may be due to closening of stomata or formation of film by the anti-transpirants on leaf and stem surface, resulting in reduction of culticular transpiration, which helps the plant to withstands, stress conditions

Table 6. Relative efficacy of different potting mixture on *ex vitro* plant survival of rough lemon

Potting mixture	Survival (%)
Sand	60.0
FYM + sand	32.5
Sawdust	0.0
Sphagnum moss	27.5
Burnt rice husk + garden soil + FYM + sand (1:1:1:1)	52.5
Garden soil + coco peat (4:1)	22.5
CD (p=0.05)	6.7

Table 7. Effect of anti-transpirants on plant survival

Anti-transpirants	Concentration	Survival (%)
Glycerol	10 %	40.0
	25 %	43.3
	50 %	76.7
ABA	7 ppm	33.3
	10 ppm	30.0
	15 ppm	33.3
Control	--	30.0
CD(p=0.05)		5.7

associated with acclimatization (Dhaliwal *et al.,* 1997 a, b).

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Effect of Intercropping Systems on Fruit Yield and Quality of Kinnow Mandarin in Aridisol

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Abstract: Effect of different field crops on tree performance fruit yield and quality in different Kinnow orchards in aridisol was observed. The tree height, canopy volume ofKinnow shown maximum increase in Kinnow mandarin + soybean followed by desi gram intercropping pattern. The highest Kinnow yield of 41.6 kg/ tree was recorded in the intercropping of Kinnow mandarin + soybean followed by *desi* gram. Fruit quality parameters were superior in Kinnow mandarin + soybean followed by desi gram treatment. The fruit acidity and juice percent were significantly affected by different intercropping patterns. High soil moisture was observed in intercrops of soybean, groundnut and summer moong. Intercropping system of groundnut + soybean or arhar + desi gram in the interspaces of Kinnow mandarin improved the yield as well as sustainability of mandarin.

Key Words: Aridisol, Kinnow, Leguminous, Plant growth, Yield, Intercropping systems

Kinnow orchards grown in aridisol had loamy sand to sandy in soil texture. Soil texture has considerable influence on nutrients and water retention. Sandy soils have poor water holding capacity, high infiltration rate and low nutrient retention capacity. The use of different intercrops provides an effective strategy to obtain additional income during off-season without inducing any stress on soil moisture and soil fertility. The main objective of this investigation is to search for suitable intercropping system near the mandarin root zone area to improve the soil moisture and soil fertility status in long term with emphasis on the health and yield performance of Kinnow trees.

MATERIAL AND METHODS

An extensive survey of 27 bearing Kinnow orchards was carried out with seven intercrops during 2011-2013 in aridisol of Punjab state. The various intercropping treatments were in randomized block design with three replications and six plants per unit. The soil moisture constants for field capacity and permanent wilting point were analysed using pressure plate apparatus (Soil moisture Inc., Santa Barbara, USA). Kinnow mandarin plants were spaced at 6 m with an average canopy area of 23.10- 30.31 m^3. In Kinnow mandarin orchards peas (Punjab 89) sown in 3 m space in between two rows of mandarin spaced at 6 m. In *kharif* season arhar (PAU 881), moong (PAU 911), groundnut (*SG 99*) and soybean (SL 525) whereas, in *rabi* season desi gram (GPF2) and in summer moong (SML 832) and peas (Punjab 89) were sown as intercropped. After sufficient monsoon land attained field capacity the intercrops of *kharif* season were sown. The soil moisture at field capacity was 31.2%, available soil depth 120 cm inKinnow mandarin orchards. From June to September sufficient soil moisture in the main as well as intercrops was maintained due to effective rainfall. Surface flooding was done in intercrops and basin method of irrigation was followed adopting the calendar method of irrigation scheduling. Irrigation was followed when 50% of available water content was depleted. The soil moisture monitoring at 30 cm depth was done at 15 days interval with the help of soil moisture monitoring soil profile probe and soil moisture monitoring meter. The FRP tubes were installed in each treatment for monitoring the soil moisture with profile probe. The experiment was initiated and initial growth parameters were recorded during October. Increase in vegetative growth parameters, i.e. plant height and canopy volume were recorded from 2011to 2013 as per recommended method. Soils were analysed for their physico-chemical properties such as soil texture, soil pH (1:2) (using HNO_3 and $HClO_4$ mixture for digestion) were prepared and analysed for Cu, Fe, Mn and Zn using Atomic Absorption Spectrophotometer "Perkin Elmer" model No.2380 while K using 'Perkin Elmer' Flame Photometer model No.2380 and P by Spectrophotometer "SpectronicbLmbda (ë) 35" using required standard solutions. Available nitrogen in soils and plants were determined using Kjeldahl distillation. The total fruits harvested from each tree were weighed for computing the yield and quality analysis.

RESULTS AND DISCUSSION

Among different intercropping systems soil moisture was lower in no intercrop Kinnow orchards. This may be due to lower row spacing and larger foliage coverage and comparatively higher soil moisture was observed in soybean, desi gram and groundnut intercrops. Moderately

high soil moisture content was recorded in *rabi* season in which soybean followed by desi gram, and groundnut followed by moong bean intercrops were taken.

Lower soil moisture was observed during April-May months and it was due to high temperature and evaporation during summer months. Higher soil moisture content was observed in treatment having Kinnow mandarin with soybean followed by desi gram (24.64% and 29.92%) at 30 cm depth (Table.1). Amongst the intercrops the soybean, desi gram and groundnut has showed significantly higher increase in soil moisture at 30 cm during both the years. The higher soil moisture content below the crop canopy of the intercropping treatments might be due to reduction in soil surface evaporation and weed intensity. The increase in the plant height and canopy volume was comparatively higher in intercropping pattern of Kinnow mandarin along with soybean followed by groundnut and arhar (Table 2). Similar results were reported by Ready *et al.,* (2003). Significant higher fruit yield (41.6kg/tree) was recorded in (T8) intercropping pattern. Similar, results of increased yield due to intercropping were reported in different mandarins as well as other citrus cultivars (Randhawa *et al.,* 1996).

Fertility status of Kinnow orchards

Available nitrogen was observed higher in all intercropped orchards with highest in leguminous crops sown in two years (Fig1a). Available N varied from 110.0-210.0 Kg/ha in different Kinnow orchards of Hoshiarpur district. The highest N content (210 Kg/ha) was recorded in (T_8) Kinnow mandarin + soybean followed by desi gram intercropping pattern while the lowest was (110.0 Kg/ha) in (T_2) no intercropping pattern. The increase is due to addition of organic residues of different intercrops while in no intercrop treatment it remained unchanged. The highest P value 4.0 Kg/ha was found in (T_8) intercropping pattern (Fig 1b). The K content ranged between 105.0-121.0Kg/ha and it was maximum in (T_8) intercropping pattern while minimum in

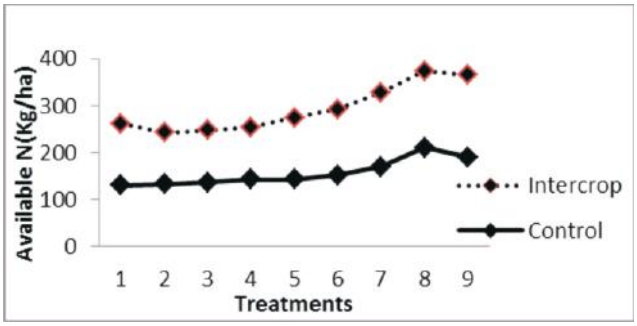
Table 1. Soil moisture status under different intercropping systems in Kinnow mandarin

	2011-12				2012-13			
	June -Sept	Oct-Dec	Jan-March	April-May	June-sept	Oct-Dec	Jan-March	April-May
T_1	29.21	29.07	22.10	20.32	23.89	20.81	21.77	20.11
T_2	29.31	26.81	23.11	21.67	24.62	21.71	23.54	22.03
T_3	28.44	24.91	23.63	21.61	23.21	20.42	20.98	28.35
T_4	29.44	29.10	23.08	20.14	24.81	21.90	23.87	26.75
T_5	30.89	28.09	30.90	24.52	26.13	21.60	24.68	22.83
T_6	28.23	27.90	23.43	22.61	24.91	20.21	24.91	23.31
T_7	27.00	26.81	22.21	20.52	23.71	19.20	26.82	20.41
T_8	32.94	28.01	29.42	24.64	27.91	22.40	29.22	21.92
T_9	32.86	27.60	24.16	21.61	24.21	21.81	29.16	21.84
CD(P=0.05)	0.01	0.04	0.03	0.09	NS	NS	NS	2.2

T_1 - Kinnow mandarin; T_2 - T_1+ pea; T_3 -Kinnow mandarin +soybean;T_4- Kinnow mandarin + desi gram ; T_5-Kinnow mandarin + groundnut; T_6 - Kinnow mandarin+ arhar ; T_7 -Kinnow mandarin + groundnut followed by arhar; T_8-Kinnow mandarin+ soybean followed by desi gram; T_9- Kinnow mandarin + groundnut followed by summer moong

Table 2. Influence of different intercropping systems on vegetative growth, fruit yield and quality of Kinnow

Treatments	Increase in plant height (m)	Canopy volume (m3)	Yield (Kg/tree)	Fruit diameter (cm)	Fruit weight (g)	Juice %	T.S.S (°Brix)	Acidity (%)	Vitamin C (mg/100 ml juice)
T_I	0.93	27.43	32.3	7.10	135.1	43.12	10.40	0.76	21.50
T_2	0.59	24.13	32.7	7.05	132.3	44.14	10.42	0.77	21.70
T_3	0.65	26.18	31.7	6.81	136.7	43.00	10.20	0.76	21.41
T_4	0.63	23.10	37.1	6.91	137.4	43.03	9.81	0.83	22.42
T_5	0.96	26.99	37.8	7.06	137.0	44.12	10.13	0.80	21.63
T_6	1.04	28.07	35.6	7.11	171.1	44.64	10.41	0.78	23.71
T_7	1.09	29.11	38.1	7.21	168.5	45.15	10.32	0.76	23.67
T_8	1.10	30.31	41.6	7.25	175.0	46.32	10.81	0.69	23.74
T_9	0.92	29.42	39.2	7.02	167.2	43.09	10.61	0.71	23.12
CD(P=0.05)	NS	2.56	2.72	NS	0.13	0.05	0.04	0.05	0.08



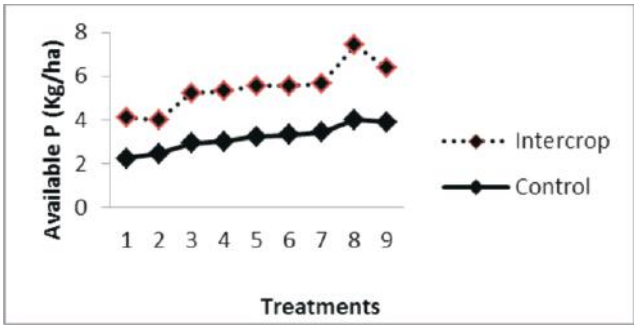
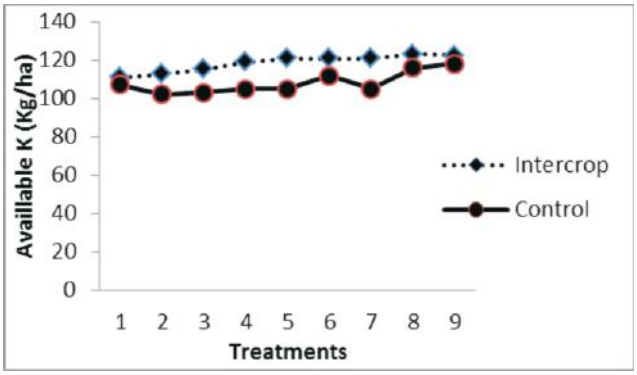
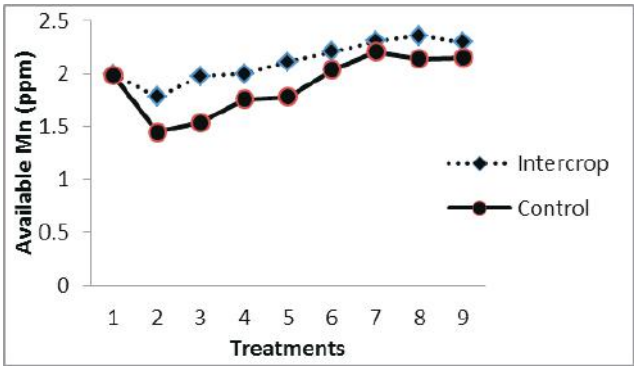
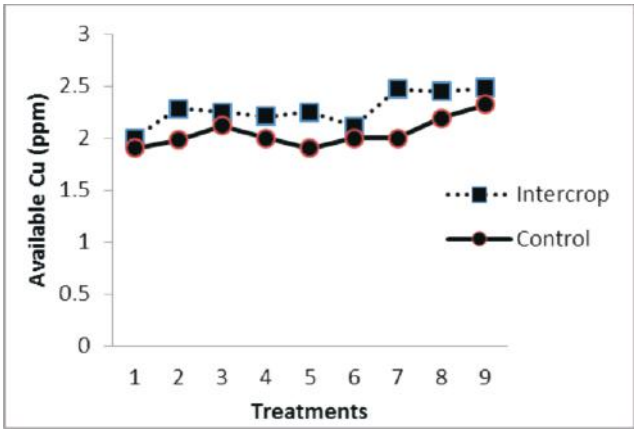
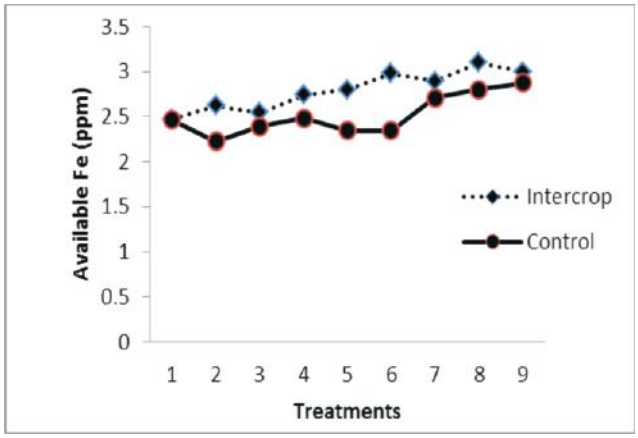


Fig.1a









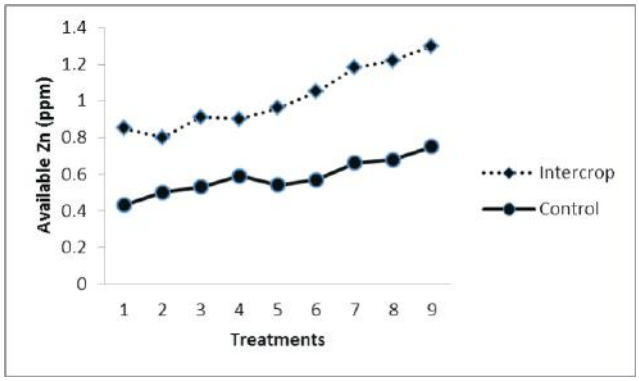


Fig.1. a-g Available nutrients in different intercropping patterns

(T_7) no intercropped Kinnow orchards (Fig 1c). Soil Mn was observed highest (2.36 ppm) and minimum (1.45 ppm) in (T_2) no intercrop pattern (Fig 1d). Soil Cu ranged between 1.90-2.47 ppm and it was (2.47 ppm) in Kinnow mandarin + groundnut followed by arhar (Fig 1e). The Fe content varied from 2.22 to 3.10 ppm (Fig 1f). Soil Zn was recorded highest (0.75 ppm) in Kinnow mandarin + groundnut followed by summer moongand lower (0.30 ppm) in no intercropping pattern (T_2) (Fig 1g).

Fruit quality

The fruit quality of Kinnow mandarin was also greatly influenced by different intercrops (Table 2). Different intercropping patterns conserved in-situ soil moisture during the crop growing period resulted in better fruit weight, yield, juice, total soluble solids, acidity and vitamin C content of the fruits (Table2). Highest fruit juice content (46.32%), total soluble solids (10.81º brix) and lowest acidity (0.69%) was recorded in (T_8) Kinnow mandarin + soybean followed by desi gram intercropping pattern (Table 2). The fruit size (7.25 cm) was maximum in the intercrop of Kinnow mandarin + soybean followed by desi gram intercropping system (Table 2). Similar, results were observed in mandarin (Paslawar *et al.*, 1999). Fruit size was unaffected by various intercropping treatments (Table 2). Vitamin C content was significantly affected with intercropping systems in Kinnow orchards. The highest (23.74 mg/100 ml juice) vitamin C content was recorded in Kinnow mandarin + soybean followed by desi gram intercropping system (Table 2).

Leguminous intercrops crops improving moisture and fertility status of the Kinnow orchards, increasing the fruit yield and quality.

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Effect of Nitrogen Application on Growth of Potted Chrysanthemum in Cocopeat Amended Farm Yard Manure-based Media Mixtures

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Abstract: An experiment was conducted to study the effect of nitrogen (N) application on growth and flowering of potted chrysanthemum. The plants were grown in 8 inch earthen pots comprising four farm yard manure-based growing media mixtures amended with soil:cocopeat (CP) (0:75, 25:50, 50:25, 75:0) on dry weight volume basis. The volume of farmyard manure was kept constant (25%) on dry weight basis in all the media mixture combinations. The growing media mixtures were subjected to 0 (control), 2, 4 and 6 g urea per pot. Plants grown in CP (75%) amended with soil (25%) in FYM-based growing media, subjected to 6g urea per pot were found to exhibit maximum plant height (32.8-30.7 cm) and canopy diameter (36.9-37.1 cm). Number of flowers was found maximum (160.2-151.1) at similar set of treatment for two subsequent years respectively. Flowering duration was observed to increase (32.8-38.2 days) in both the years with increase in proportion of CP and urea level. Slow release of applied N over longer duration, better potassium status in CP and improved physical and chemical root zone environment of CP amended media mixtures were favourable factors for optimum growth of plants.

***Key Words*:** Chrysanthemum, Cocopeat, Chemical properties, Farm Yard Manure, Physical properties

Chrysanthemum is a popular autumn flowering ornamental plant and can be seen grown as a loose flower, cut flower and garden decoration purpose. In North West part of India, chrysanthemum is propagated through terminal cuttings taken from the mother plant during first fortnight of July. Chrysanthemum plants have greater requirement for both nitrogen (N) and potassium (K). Nitrogen is required in sufficient amounts during early seven weeks of its vegetative growth after which its uptake decreases as reported by Yoon *et al.* (2000) and further requirement of N is met from the previous accumulation of nitrate (NO_3-) in stem and petioles There is always a need to supply the exogenous application of N to sustain the growth of plants (MacDonald, 2013). The requirement of P is significantly lower than of N in chrysanthemum (Li *et al.* 2009). The K requirement is generally high which affect the growth of plants and enhance flower colouring (Vanìk *et al.* 2012). Utilization of CP as a growing media mixture at higher proportions may cause immobilization of applied N which is viewed as an unavoidable consequence of biological activity of micro-organisms that consume carbon available in the media (Arenas *et al*. 2002). It is therefore pertinent to supplement additional N in CP amended media mixtures to maintain optimum nutrient status in growing media for satisfactory growth of plants. The present study was therefore undertaken with an objective to study the effect of increasing levels of N application in CP amended FYM-based media mixtures on growth and flowering characteristics of potted chrysanthemum and to generate a logical understanding regarding effect of CP in regulating the physical and chemical root-zone environment.

MATERIAL AND METHODS

The present investigation was carried out at Punjab Agricultural University Landscape nursery during the two consecutive years (2012-13 and 2013-14). The potting media mixture comprising farm yard manure (FYM), cocopeat (CP) and soil was prepared in different ratios and the media mixtures comprised four treatment combinations as follows: T1- FYM:soil:CP (1:3:0), T2- FYM:soil:CP (1:2:1), T3- FYM:soil:CP (1:1:2) and T4- FYM:soil:CP (1:0:3). All the media constituents were mixed on dry weight volume basis based on the volume of 8 inch earthen pot. The experiment was laid out in a completely randomized block design (CRD) with three replications.

The terminal cuttings of chrysanthemum variety 'Mother Teresa' were taken from the mother plants during first fortnight of July for rooting in moist sand beds and were transplanted in pots (one rooted cutting per pot) during first fortnight of August. Each of the media mixtures were subjected to four different fertilizer dose of urea (g per pot) (N0- 0g, control, N2- 2g, N4- 4g and N6- 6g) obtained from urea as top dressing in two splits. First application was provided 3 weeks after transplanting and second 4 weeks thereafter. Pots were irrigated in similar amounts at an interval of 4-5 days during months of August-October and thereafter at weekly intervals due to onset of low temperature and cloudy days. The weekly maximum and minimum

temperature during the entire crop duration (August - December) varied from 13.8-39.9°C and 5.9-26.8°C respectively.

Growing media mixtures were analyzed for physical and chemical properties (Table 1) using standard protocols. The media mixture combinations were analyzed for pH, electrical conductivity (EC), bulk density (Db), water holding capacity (WHC), total porosity and available N, P, K and organic carbon (Jalota *et al.* 2007). The observations on morphological parameters such as plant height (cm), plant spread (cm), above ground and below ground dry biomass weight (g) and floral parameters such as days to bud appearance, days to colour show stage, flowering duration and number of flowers/plant per pot, were recorded. Days to flowering duration were recorded from the appearance of 50% buds showing colour till 50% of the flowers showing withering.

RESULTS AND DISCUSSION

The vegetative characters (plant height, canopy diameter, above ground and root dry weight) and floral characters (days to bud emergence, days to colour break stage, days to flowering duration and number of flowers) showed significant differences among different growing media mixtures at differential N-levels for two subsequent years (2012-13 and 2013-14). However, the interaction between growing media and N-level was found in-significant except for plant height and number of flowers in the first year and plant height, above ground dry weight, days to flowering duration and number of flowers for second year. Mean plant height with respect to growing media mixtures showed a significant increase with subsequent additions of CP. An increase in plant height to the extent of 8.87% and 10.3% respectively was recorded in both subsequent years in FYM:soil:CP (1:0:3) compared to the plants raised in media mixtures without CP. Mean plant height showed a significant increase (31.0% and 33.4% respectively) at highest N-level compared to control in I and II year. Interaction between growing media mixtures and N-level was also found statistically significant. Plant height increased in each of the growing media mixtures subjected to increase in N-level. It showed an increase of 60% at highest CP subjected to highest N-level. However, the increase in the mean plant height was more consistent in II year recording a percent increase of 39.9% with increase in N-level at highest proportion of CP.

Mean canopy diameter was maximum (32.5 cm) in media mixture comprising FYM:soil:CP (1:0:3) with increase of 18.6% compared that recorded in media mixtures without CP. In second year experiment, it showed greater percent increase (23.4%) with increase in proportion of CP. Similarly, at differential N levels, the mean canopy diameter increased by 10.3% and 11.6% respectively for two years subjected to highest N-level compared to control. Increase in plant height and canopy diameter is attributed due to adequate availability of N,P, and K nutrients in FYM besides better physical conditions of the media mixtures using CP were conducive for optimum growth of chrysanthemum. Subsequent additions of CP increased the mean above ground and root dry weight of the plants. It increased to the extent of 67.7% and 64.8% respectively at highest proportion of CP compared to control in both the years. Nitrogen level (N6) showed a significant increase (2-fold) in the mean above ground dry weight compared to control. A significant increase (1.4 and 1.8-fold increase respectively) in root dry weight was observed at highest proportion of CP compared to control in both the years. However, a drastic increase (3.39 times) was recorded at highest N (N6) level in the year I as compared to year II that resulted in 1.6-fold increase in the mean root dry weight. The results obtained for N-uptake by plants revealed that plants fed with increasing fertilizer dose of N had higher mean N-uptake, whereas the mean N-uptake with respect to growing media mixtures was relatively lesser compared to combined effect of fertilizer dose. Nitrogen is essential for building plant biomass in chrysanthemum as well as for the synthesis of enzymes (Liu *et al.* 2010). Increase or decease in dry biomass of plants in media mixtures containing CP have also been reported by several workers (Offord *et al*. 1998, Meerow, 1994, Knight *et al.* 1998).

The increase in plant biomass is evident due to

Table 1. Basic physical and chemical characteristics of growing media mixtures

Treatments (FYM:soil: CP)	Db (Mg/m^3)	Total porosity (%)	WHC (%)	pH*	EC (dS/m)	N (%)	P (%)	K (%)	OC (%)
1:3:0	1.20	48.7	39.40	7.55	0.284	0.54	0.22	1.91	0.68
1:2:1	0.99	52.4	64.50	7.32	0.483	0.50	0.28	3.27	1.61
1:1:2	0.75	62.5	103.00	7.10	1.170	0.42	0.36	3.42	3.24
1:0:3	0.31	80.1	300.00	6.85	2.310	0.31	0.44	4.43	6.04

*pH was computed in (1:5) suspension of growing media mixtures and water
Db- Bulk density, WHC- Water holding capacity, EC- Electrical conductivity,
N- Total nitrogen, P- Available phosphorus, K- Available potash, OC- Organic carbon

better retention of moisture at higher proportion of CP that in-turn maintained adequate supply of nutrients for accumulating maximum plant biomass. Urea-N applied to CP amended media is mineralized slowly and released gradually for the plant N uptake. This is due to the tendency of CP to slow down the nitrification process due to the presence of tannins and phenols (Prabhu and Thomas, 2002). As a consequence, there is inhibition in rapid conversion of NH_4^+ to NO_2^- and subsequent conversion of NO_2^- to NO_3^- thus leading to slow mineralization of applied N. It has been reported that an optimal plant growth is achieved when N (NH_4^+) is used at a rate of 50 per cent of the total amount (Muniz *et al.* 2009).

The days to bud emergence and days to colour break stage increased by 4.97% and 8.34% respectively in the plants raised in media mixture amended with highest proportion of CP. Similar increase was noticed at highest N-level (N6) that recorded 6.38% and 4.58% increase respectively (Table 2). During next year, more number of

Table 2. Effect of differential urea-N application in FYM-based media mixtures on vegetative and floral characters of chrysanthemum (2012-13)

Media mixtures (FYM:soil:CP) (v/v)	Urea(g/pot) N0	N2	N4	N6	Mean
		Plant height (cm)			
1:3:0	21.6	23.2	25.9	27.6	24.6
1:2:1	23.0	24.9	26.3	27.4	25.4
1:1:2	24.5	26.5	27.8	28.1	26.7
1:0:3	20.2	24.6	31.4	32.8	27.2
Mean	22.3	24.8	27.8	29.0	
CD (p=0.05)		Media mixtures(M)=1.746 ; Nitrogen level (N)=1.746 ; M x N=3.493			
		Canopy diameter (cm)			
1:3:0	24.3	26.3	28.3	29.0	27.0
1:2:1	26.7	28.5	30.0	32.1	29.3
1:1:2	28.7	30.3	31.9	33.1	31.0
1:0:3	28.0	30.9	34.0	36.9	32.5
Mean	26.9	29.0	31.1	32.8	
CD (p=0.05)		Media mixtures(M)=2.243 ; Nitrogen level (N)=2.243 ; M x N=NS			
		Above ground dry weight (g)			
1:3:0	13.5	17.5	23.2	33.2	21.8
1:2:1	15.6	19.5	24.9	33.4	23.3
1:1:2	18.8	22.5	29.5	40.4	27.8
1:0:3	25.9	29.3	39.6	52.2	36.7
Mean	18.4	22.2	29.3	39.8	
CD (p=0.05)		Media mixtures(M)= 1.881; Nitrogen level (N)=1.881 ; Mx N=NS			
		Root dry weight (g)			
1:3:0	1.1	2.4	4.7	8.4	4.2
1:2:1	3.0	4.2	5.6	9.1	5.5
1:1:2	2.7	4.2	6.5	9.4	5.7
1:0:3	3.7	4.9	6.9	8.6	6.0
Mean	2.6	3.9	5.9	8.9	
CD (p=0.05)		Media mixtures(M)=1.016 ; Nitrogen level (N)=1.016 ; M x N=NS			
		Days to bud emergence			
1:3:0	70.1	71.7	72.3	74.0	72.0
1:2:1	71.9	74.2	75.0	77.3	74.6
1:1:2	73.0	74.2	75.0	77.7	75.0
1:0:3	73.8	75.1	76.2	77.6	75.7
Mean	72.2	73.8	74.6	76.7	
CD (p=0.05)		Media mixtures (M)=1.289 ; Nitrogen level (N)=1.289 ; M x N=NS			
		Days to colour show stage			
1:3:0	90.4	93.3	96.4	97.8	**94.5**
1:2:1	94.1	95.5	97.5	96.2	**95.8**
1:1:2	97.8	97.8	101.4	102.0	**99.8**
1:0:3	101.5	101.8	103.1	105.3	**102.9**
Mean	**96.0**	**97.1**	**99.6**	**100.3**	
CD (p=0.05)		Media mixtures (M)=3.199 ; Nitrogen level (N)=3.199 ; M x N= NS			
		Days to flowering duration			
1:3:0	26.0	28.2	30.4	33.1	**29.4**
1:2:1	29.4	30.1	30.5	32.9	**30.7**
1:1:2	30.8	33.7	36.3	36.7	**34.4**
1:0:3	38.1	37.8	38.7	38.2	**38.2**
Mean	**31.1**	**32.5**	**34.0**	**35.2**	
CD (p=0.05)		Media mixtures (M)=2.257 ; Nitrogen level (N)= 2.257; M x N= NS			
		Number of flowers			
1:3:0	84.0	94.3	102.8	112.1	**98.3**
1:2:1	70.6	98.7	120.1	130.4	**105.0**
1:1:2	65.0	121.3	134.7	145.6	**116.7**
1:0:3	59.3	129.7	146.5	160.2	**123.9**
Mean	**69.7**	**111.0**	**126.0**	**137.1**	
CD (p=0.05)		Media mixtures (M)=3.504 ; Nitrogen level (N)=3.504 ; M x N=7.009			

N0 (0g urea, control), N2 (2g urea per pot), N4 (4g urea per pot), N6 (6g urea per pot)

days to bud emergence (9.90%) and days to colour break stage (7.38%) with respect to additions of CP were recorded. However, unlike in year I, increase in CP proportion and N-levels recorded more (10 days) days for the buds to appear and also for the buds to show colour (3.7 days) at highest N-level (Table 3).

Better retention of moisture in CP as evident from high water holding capacity amended media mixtures might lead to delay in days to bud emergence and subsequent colour break stage. Chrysanthemum uptakes N to the maximum extent 3 days after application and accumulate as NO_3^- form in stems and petioles to be utilized in later stages during reproductive development (Mac Donald, 2013). However, due to better CEC of CP amended media mixtures and more exchangeable sites for P there is gradual release of nutrients in particular P for entire crop duration leading to dominance of vegetative growth (due to enhanced root proliferation) over the reproductive growth (Scagel, 2003).

Table 3. Effect of urea-N application in FYM-based media mixtures on vegetative and floral characters of chrysanthemum (2013-14)

Media mixtures (FYM:soil:CP)	Urea (g/pot)				
	N0	N2	N4	N6	Mean
(v/v)		Plant height (cm)			
1:3:0	18.4	22.8	25.4	27.2	23.4
1:2:1	22.5	23.8	24.2	24.3	23.7
1:1:2	27.7	30.0	32.8	28.5	29.7
1:0:3	22.7	25.0	28.5	30.7	26.7
Mean	22.8	25.4	27.7	27.7	
CD (p=0.05)		Media mixtures(M)=1.63; Nitrogen level (N)=1.63 ; M x N=3.26			
		Canopy diameter (cm)			
1:3:0	13.0	21.3	30.0	28.7	23.3
1:2:1	14.4	26.0	34.7	27.7	25.7
1:1:2	19.8	25.0	30.7	29.0	26.1
1:0:3	16.7	31.3	36.0	31.0	28.8
Mean	16.0	25.9	32.9	29.1	
CD (p=0.05)		Media mixtures(M)=2.37; Nitrogen level (N)=2.37 ; M x N=NS			
		Above ground dry weight (g)			
1:3:0	13.2	22.6	25.3	28.7	22.5
1:2:1	13.8	14.6	30.9	32.2	22.9
1:1:2	15.2	16.3	17.9	23.8	18.3
1:0:3	22.7	38.9	39.1	47.7	37.1
Mean	16.2	23.1	28.3	33.1	
CD (p=0.05)		Media mixtures(M)=1.79; Nitrogen level (N)=1.79 ; M x N=3.58			
		Root dry weight (g)			
1:3:0	6.5	8.5	8.6	11.7	8.8
1:2:1	6.5	7.3	9.5	12.6	9.0
1:1:2	9.0	10.0	9.7	11.0	9.9
1:0:3	11.0	17.0	17.8	20.5	16.6
Mean	8.3	10.7	11.4	14.0	
CD (p=0.05)		Media mixtures(M)=1.66; Nitrogen level (N)=1.66 ; M x N=NS			
		Days to bud emergence			
1:3:0	79.2	80.1	81.1	82.2	**80.7**
1:2:1	80.3	81.1	82.2	83.2	**81.7**
1:1:2	81.1	83.3	85.0	89.1	**84.6**
1:0:3	87.1	88.3	89.3	90.2	**88.7**
Mean	**81.9**	**83.2**	**84.4**	**86.2**	
CD (p=0.05)		Media mixtures (M)=1.96; Nitrogen level (N)=1.96; M x N=NS			
		Days to colour show stage			
1:3:0	97.6	98.4	99.2	100.1	**98.8**
1:2:1	99.1	101.5	102.2	102.7	**101.4**
1:1:2	102.5	103.2	103.9	104.1	**103.4**
1:0:3	104.3	105.4	106.8	107.9	**106.1**
Mean	**100.9**	**102.1**	**103.0**	**103.7**	
CD (p=0.05)		Media mixtures (M)=3.02; Nitrogen level (N)=NS; M x N=NS			
		Days to flowering duration			
1:3:0	30.1	30.7	31.2	31.3	**30.8**
1:2:1	30.9	30.2	31.5	32.0	**31.2**
1:1:2	30.0	30.9	31.2	33.7	**31.5**
1:0:3	29.1	30.7	32.2	32.8	**31.2**
Mean	**30.0**	**30.6**	**31.5**	**32.5**	
CD (p=0.05)		Media mixtures (M)=NS; Nitrogen level (N)=0.55; M x N=1.10			
		Number of flowers			
1:3:0	56.7	96.7	78.5	90.0	**80.5**
1:2:1	82.0	90.7	84.7	102.6	**90.0**
1:1:2	92.3	118.0	114.2	120.1	**111.2**
1:0:3	115.0	121.1	134.5	151.1	**130.4**
Mean	86.5	106.6	103.0	116.0	
CD (p=0.05)		Media mixtures (M)=4.88; Nitrogen level (N)=4.88 ; M x N=9.77			

N0 (0g urea, control), N2 (2g urea per pot), N4 (4g urea per pot), N6 (6g urea per pot)

The nutrients applied prior to onset of reproductive phase had little or in-significant effect over further crop growth. Therefore, these slow and continuous releases of nutrients lead to prolonging of onset of reproductive stage in plants relative to those raised in media mixtures without any amendment with cocopeat.

Days to flowering duration also recorded a significant increase both with respect to growing media mixtures (29.6%) and differential levels of N (13.9%) each at highest proportion of their constituents (CP and N) in the first year. However, differences were found in-significant with respect to media mixtures in second year. Significant differences were observed with differential levels of N (N0-N6) recording percent increase of 4.16% in mean number of days to flowering duration. Interaction among the media mixtures and N-levels also showed statistically significant difference in second year. Number of flower recorded a significant increase (27.1% and 46.1% respectively) at highest proportion of CP compared to control for both the years. However, there was a drastic increase (2-fold) noticed at highest N level that ultimately would yield highest average fresh flower weight per plant per pot. Similar trend was observed for the second year, where differential N-levels showed 1.44 times increase in mean flower number at highest dose of N. The interaction between media amendment and N-level also resulted in significant difference. Flower number increased to the extent of 1.37-2.72 times for the first year and 1.36-1.39 times for the second year at highest proportion of CP respectively at highest N-level. However, the increase was more significant in media mixture without CP in the second year. Greater flower number had a positive correlation with K content in the CP. Increased N-levels in media mixture also resulted in greater flower count. Treder (2008) also reported effect of availability of N and K on better flowering of oriental lily.

Utilizing cocopeat as an amendment in FYM (3:1) was observed is an ideal pot growing media mixture for optimum growth and flowering of chrysanthemum. Plants were observed to be well anchored even at highest proportion of CP and exhibited excellent quality of flowers. Immobilization of applied N by CP and its gradual release over longer periods has been observed to be beneficial to meet the N demand by the chrysanthemum, particularly during the initial growth stages. Increased K content in CP along with improved physical root-zone environment was found favourable for better proliferation of roots and subsequent nutrient uptake for optimum growth of plants.

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Effect of Different Levels of NPK on Growth , Nutrient Uptake and Biomass Yield in *Melia dubia* Cav.

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Abstract: A field experiment was conducted to study the effect of different levels of NPK on the nutrient uptake pattern and biomass yield in *Melia dubia.* Higher content and uptake of N,P and K in plant were markedly influenced by the application of 250:150:150 g N,P & K plant^{-1}. The LAI was higher at 2,4 & 6 months after planting (0.61, 1.33 & 2.40, respectively) due to influence of 250:75: 150 g NPK plant^{-1}. The leaf area duration was higher due to application of 250:150:150 g NPK plant^{-1} and registered 59.02 days, followed by 250:75:150 g NPK plant^{-1} with a value 58.06 days. The biomass yield was also altered by different levels of N, P and K and it was significantly influenced due to application of 250:150:150 g NPK plant^{-1} followed 250:75:150 g NPK plant^{-1}.

Key Words*:* Biomass, Growth, *Melia dubia*, NPK, Uptake

Depletion of forest areas in the country has badly hit the supply of fibrous raw material to the industry and hence great importance has been given to raise fast growing species for use as raw material for paper and cellulose industries. Under such circumstances *Melia dubia* has been identified as one of the potential pulpwood species. (Parthiban *et al.,* 2009). Global demand for wood is increasing at an annual rate of 1.7 per cent (South, 1999). At the same time, planted forest resources are insufficient to meet current demand. The scope of expansion of forested areas is limited (Gregory *et al.,* 2002). This trend creates economic pressure that encourages the commercial exploitation of natural forests, unless supply can be increased through the establishment of high yield plantations. The use of fast growing elite trees enable early harvest and thereby it helps to improve yield. *Melia dubia* is one such fast growing tree species. This species has become popular among both public and private sector tree growers. The most obvious challenge in the forestry sector is to meet growing demand for forest products and enhance the quality of environment. The tree crop taken for investigation currently yields 250 t ha^{-1} with calorific vale of 5043 kcal kg^{-1} and to increase the productivity potential of the tree, the scheduling of nutrients is a paramount importance. Hence, the effect of different doses of NPK fertilizers on growth, nutrient uptake pattern and biomass yield in *Melia dubia* was studied in the present investigation.

MATERIAL AND METHODS

The experiment was conducted in village Mathampalayam of Coimbatore district which is located in Western zone of Tamil Nadu. The geographical location is at 11°11'32 N latitude and 76°57'17 E longitudes with an altitude of 398 m mean sea level. The average annual rainfall of the experiment site is 915 mm. The mean maximum temperature ranges from 32.0 to 36.3°C and the mean minimum temperature ranges from 16.1 to 22.1°C. The soil is red sandy loam, non-calcareous, neutral in reaction with low in nitrogen and phosphorus medium in available potassium. The experiment was laid out in randomized design replicated three times. Treatments consisted of three levels of nitrogen (150, 250 and 350 g N plant^{-1}), two levels of phosphorus (75 and 150 g P plant^{-1}) and two levels of potassium (150 and 300 g K plant^{-1}) were tried to standardize the fertilizers schedule for the tree crop taken for investigation. Field preparation was done as per recommended practice.

The *Melia dubia* seedlings which attained the age of six months were planted (two numbers per treatment) and Leaf area index (LAI) and Leaf area duration (LAD) were recorded. Leaf area index was estimated by analyzing

$$LAI = \frac{LA}{P}$$

LA = Leaf area

P = Unit area i.e., space occupied by plant.

Leaf area duration (LAD)

Leaf area duration is the integral of the LAI over growing seasons. LAD was calculated from LAI as per the formula and expressed in days.

$$Li + (Li+1) \times (t_2 - t_1)$$

$$LAD = \frac{\text{---------}}{2}$$

Li =LAI at i^{th} stage

Li+1 = LAI at i+1 stage

(t_2-t_1) = time interval between Li and Li+1 stages.

To study the influence of treatments on the nutrient content in the tree samples *viz.,* leaf, stem, and root at 6 MAP, the samples were collected by destructive method and oven dried at 60°C in an electric oven. Tree samples were powdered in a willey mill and processed for chemical analysis. The plant samples were analysed for its nutrient composition *viz.,* N, P and K by following standard procedures

The nutrients uptake at 6 MAP computed treatment wise by multiplying total respective dry matter production (DMP) with nutrient content and expressed in kg ha^{-1}.

RESULTS AND DISCUSSION

Leaf area index: LAI was affected by different levels of N,P and K at all the three stages *viz.,* 2, 4 and 6 MAP and was higher at 2 MAP. It was significantly influenced by application of 250:150:150 g NPK $plant^{-1}$ 2 4 and 6 MAP with respective values of 0.62, 1.35 & 2.41 (Table 1). This was followed by the application of 250:75:150 g NPK and 150:75:300 g NPK. The minimum value of 0.40, 1.03 and 1.48, respectively was obtained in control with no supplementary fertilizer application. The increased LAI might be due to application of optimum quantity of NPK fertilizers, further application of N might influenced the chlorophyll formation in the plants, which lead to improve the photosynthetic activity resulted in vigorous vegetative growth and development of plant Mutanal (1998).

Leaf Area Duration: The LAD was affected by NPK levels at 60-120 and 120-180 days after planting (DAP). The LAD is increased progressively from 60-120 and 120-180 DAP. In both the stages, NP and K levels had significant influence over LAD values. The LAD was higher due to application of 250:150:150 g NPK $plant^{-1}$ and it was significantly superior over the rest of the treatments at both the level of measurement. The plants, which did not receive any nutrients resulted lesser value of 42.92 and 75.19 days at 60-120 and 120-180 DAP, respectively.

Total biomass: Application of 250:150:150 g NPK $plant^{-1}$ recorded 2983 kg ha^{-1} of biomass followed by the application of 250:75 :150 g NPK $plant^{-1}$ and 150 :75 :300 g NPK $plant^{-1}$ and are on par whereas the treatment T_{13} which did not receive any fertilizers registered 1236 kg ha^{-1} of biomass (Table 1). The increase in biomass was reflected from the favourable growth of tree crop promoted by the application of NP and K at optimum levels. These results are in tune with many other workers who also revealed that application of fertilizer increase the total dry matter production.

N content and uptake of nutrients on seedling growth: The N content of the plant ranged from 3.27 to 3.69 per cent. The application of 250:150:150 g NPK $plant^{-1}$ registered the highest value and it was at par with the application of 250:75:150 g NPK $plant^{-1}$ and 150 :75 :300 g NPK $plant^{-1}$. The treatment T_{13} received no nutrients registered lesser value of 3.27 per cent (Table 2).The higher level of NPK might have improved the nutrient content in the plant.

These results are in accordance with Ian Hunter (2000) who reported that the above ground biomass and nutrient uptake of three tree species (*Eucalyptus camaldulensis,Eucalyptus grandis* and *Dalbergiasissoo*) is affected by irrigation and fertilizer. Pant *et al.* (1995) and Koul *et al.* (1995), reported that fertilizer on survival and growth of *Cassia siamea* of five months old seedlings, application of fertilizer dose of 75: 75: NP g $plant^{-1}$ registered increased the available N (181 kg ha^{-1}) and the content of N was increased by 2.52 per cent in *Bauhinia variegata*, due to the application of fertilizer dose of 60: 40 N P kg ha^{-1} respectively

The highest uptake of N was associated with the application of 250:150:150g NPK $plant^{-1}$ recorded the N uptake of 110.1 kg ha^{-1}. The higher biomass evinced in this treatment might be the reason for the increased uptake of NP and K. The nutrient utilization by fast growing, short rotation tree species like *Melia dubia,* is rapid but restoration of nutrient cycling is not enough. The excess of any element in the soil may interfere with the metabolism of plants and would lead to the abnormal development of plants. Singh (2001) confirmed that application of fertilizer dose of 200: 100: 50 NPK kg ha^{-1} applied to *Populus deltoides* of 11 months old trees, registered increased the uptake of N (171.5 kg ha^{-1}).

Phosphorus content and uptake: The P content of the plant ranged from 0.34 to 0.50 per cent (Table 2). The application of 250:150:150 g NPK $plant^{-1}$ registered the highest P content (0.50 per cent) followed by the application of 250 :75 :150 g NPK $plant^{-1}$ and 150:75:300 g NPK $plant^{-1}$ and were at par. Sharma *et al.* (1994), concluded that nutrition of *Robiniapseudacacia* of seven months old seedlings as influenced by phosphorus and molybdenum, application of fertilizer dose of 60 P kg ha^{-1} resulted in increased P content of 0.24 per cent.

The different treatments registered a significant effect on the phosphorus uptake by the plant. The highest uptake of P was found to be associated with the application of 250:150:150 g NPK $plant^{-1}$ registering of 14.9 kg ha^{-1} followed by the application of 250:75:150 g NPK $plant^{-1}$ (Table 2). The

Table 1. Effect of NPK onthe leaf areaindex and leaf area durationat different growth stages of *Melia dubia* (month after planting)

Treatments/g plant (NPK)	Leaf area index			Leaf area duration (days)		Total biomass (kg ha^{-1})
	2	4	6	2-4	4-6	6
150 :75 :150	0.60	1.25	2.13	55.61	101.56	2706
150 :150 :150	0.60	1.26	2.14	55.83	101.80	2812
250 :75 :150	0.61	1.33	2.40	58.06	111.77	2915
250 :150 :150	0.62	1.35	2.41	59.02	112.94	2983
350 :75 :150	0.55	1.25	1.81	53.96	91.65	2012
350 :150 :150	0.55	1.24	1.79	53.78	91.12	1987
150 :75 :300	0.61	1.26	2.14	56.05	102.11	2910
150 :150 :300	0.60	1.26	2.13	55.83	101.77	2892
250 :75 :300	0.60	1.32	2.39	57.69	111.28	2756
250 :150 :300	0.60	1.31	2.39	57.33	110.89	2698
350 :75 :300	0.46	1.13	1.67	47.79	84.00	2008
350 :150 :300	0.46	1.11	1.65	47.09	82.79	1982
Control	0.40	1.03	1.48	42.92	75.19	1236
CD(P=0.05)	NS	NS	NS	0.19	0.24	145

Table 2. Effect of NPK on the nutrient content (%) and nutrient uptake (kg ha^{-1}) of *Melia dubia* (6 month after planting)

Treatments/g plant (NPK)	Nutrient content (%)			Nutrient uptake (kg ha^{-1})		
	N	P	K	N	P	K
150 :75 :150	3.48	0.41	3.17	94.2	11.1	85.8
150 :150 :150	3.50	0.44	3.19	98.4	12.4	89.7
250 :75 :150	3.64	0.48	3.24	106.1	14.0	94.4
250 :150 :150	3.69	0.50	3.25	110.1	14.9	96.9
350 :75 :150	3.49	0.43	3.18	70.2	8.6	64.0
350 :150 :150	3.42	0.42	3.16	67.9	8.3	62.8
150 :75 :300	3.60	0.47	3.22	104.8	13.7	93.7
150 :150 :300	3.51	0.41	3.18	101.5	11.9	92.0
250 :75 :300	3.47	0.44	3.19	95.7	12.1	87.9
250 :150 :300	3.32	0.40	3.17	89.6	10.8	85.6
350 :75 :300	3.33	0.38	3.15	66.9	7.6	63.3
350 :150 :300	3.31	0.36	3.13	65.6	7.1	62.0
Control	3.27	0.34	3.10	40.4	4.2	38.3
CD(P=0.05)	0.14	NS	0.05	6.55	1.04	5.02

treatment, where no fertilizer was applied resulted in minimum uptake of P (4.2 kg ha^{-1}). Adalarasan (2002) observed increase in total P uptake by 125 per cent at 150 DAT with integrated application of 54 kg of P_2O_5 and 27 kg of K_2O to *Casuarina equisetifolia*.

Potassium content and uptake: The K content of plants was also enhanced due to application of 250:150:150 g NPK plant^{-1} registering of 3.25 per cent followed by the application of 250:75:150 g NPK plant^{-1} and 150:75:300 g NPK plant^{-} whereas, the unfertilized plants resulted in lesser uptake of K (3.10 per cent). These results corroborated with Ray and Thomas (2012), who confirmed that application of fertilizer dose of 300 K kg ha^{-1} applied to teak registered increased available K (426.7 kg ha^{-1}). The K uptake of plant was also significantly influenced by the various treatments of fertilizer application. The highest uptake of K was found to be associated with the application of 250 :150 :150 g NPK plant^{-} followed by the application of 250 :75 :150 g NPK plant^{-1}, 150 :75 :300 g NPK plant^{-1} and 150 :150 :300 g NPK plant^{-1}. The application of potash increases assimilation of carbon dioxide, uptake of water and utilization of nitrogen as a result of which rate of growth and vigour of the tree is improved.

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Do Fresh Water Swamps of the Central Western Ghats Differ in their Species Composition Across Latitude?

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Abstract: Study was conducted in three geographically isolated clusters of fresh water swamps of the Central Western Ghats *viz*. Northern, Central and the Southern regions to understand differences in the species composition of different latitudes. A checklist of all the plant species was prepared by running a line transect along the main stream of every swamp. Total of 129 plant species belonging to 104 genera and 49 families were recorded. Swamps of central region were more specious (73) than southern latitudes swamp (48). Species categorized as exclusive swampy and evergreen species were predominant in central swamp where as invaded species are more in Southern Swamp. However, when typical swamp species were compared, northern and central swamps shared 50% species, while northern and southern swamps were similar only for about 30%. Further, central and southern swamps were more similar (37%); suggesting a gradual change in the typical swamp species across latitudes.

Key Words: Central western ghats, Fresh water swamps, Latitude, similarity index

The study of plant communities at a different geographical gradients such as latitude, longitude and altitude scale is thus an important to understanding the ecological complexity of an area in terms of resource allocation, coexistence, competitive exclusion, speciation, dominance, etc, which enables the complex interplay of chance and evolutionary history. The formation of a climax community through a number of ecological processes (e.g. resource allocation, niche differentiation, coexistence, and/or competitive exclusion) depends mainly on the abiotic gradients prevailing in an area (Joseph et al. 2008). The most important characteristics of the tropical and subtropical humid forests are their species richness, heterogeneity and complex community organization. These forests, found all over tropical and subtropical belt, harbour maximum diversity of plant species found on the earth (WCMC 1992).

The Western Ghats form a more or less continuous mountain chain over a distance of about 1600 km along the west coast of India. Various ecological and climatologically conditions which enables the formation of diverse ecosystems in this region along the latitudinal gradients. The fresh water swamps are one of the finest ecosystems which distributed all along the Western Ghats harbours special and unique type of species composition of plants as well as faunal assemblages (Pascal et al. 2004). These swamps are also called as *Myristica* swamps because of larger presence of tree species belong to Myristicaceae family. *Myristica* swamps are critically endangered ecosystems in the Central Western Ghats. Fresh water swamps perform numerous valuable environmental services such as recycling of nutrients, purifying water, recharging ground water, augmenting and maintaining stream flow apart from providing habitat for a wide variety of flora and fauna. Fresh water ecosystems are also the sources, sinks and transformers of chemical, biological and genetic materials.

Myristica swamps support characteristic vegetation on account of specialized edaphic conditions, as influenced by free water accumulation. Latitude is one of the strong gradients determining the edaphic conditions and hence influences the species diversity as well. Unfortunately characteristic changes in species composition of a swamp that occur across latitudes have not been reported. To know the distribution and variation of plant species in response to three different latitudinal gradients for the better management and conservation of these unique habitats in the central Western Ghats is the prime objective of the study.

MATERIALS AND METHODS

Study Area

The study was conducted in following three clusters of fresh water (Fig. 1).

Northern cluster: This swamp is lies in Siddapur taluk of Uttara Kannada district. Swamp occurs along perennial stream and comprises an area of about one hectare at 14° 16' 803'' N latitude and 74° 46' 757'' E longitude at an altitude of 586m. This is one of the finest habitat of *Semecarpus kathalekanensis*, a recently identified critically endangered endemic evergreen tree species of Central Western Ghats (Dasappa and Swaminath, 2000). The major plant species of this swamp are *Gymnacranthera canarica, Myristica fatua* var. *magnifica, Semecarpus kathalekanensis, Pinanga dicksonii* etc.

Central cluster: This is a typical Myristica swamp found in Hosanagar taluk of Shimoga district at 13° 43' 093'' N latitude and 74° 59' 843'' E longitude at an altitude of 517m. This swamp comprises an area of about one hectare. The major plant species in this swamp includes *Gymnacranthera canarica*, *Holigarna arnottiana*, *Myristica fatua* var. *magnifica*, etc.

Southern cluster: This cluster of small fresh water swamps present around Sringeri taluk of Chikmagalur district. The total area of all these swamps is about one hectare. All these swamps are almost similar in their species composition and lies between 13° 35' 364'' N latitude 75° 17' 716'' E longitude and 13° 21' 651'' N latitude 75° 11' 753'' E longitude at an average altitude of 658m. The major species found in these swamps are *Mastixia arborea, Alstonia scholaris, Calophyllum apetalum, Garcinia gummi-gutta* etc.

Sampling methods

A check list of the all the plant species were recorded by running a line transects of 5 meter breadth covering a total area of one hectare along the main stream of the every swamp in each cluster. During the floristic survey GBH at 30 and above 30 cm were considered as growing stock and below 30 cm GBH were recorded in numbers. The data obtained from the sampling were analysed for number of species, stand density, basal cover per hectare and diversity indices and dominance. The plants species occur in these swamps were grouped into three categories such as typical swamp species, adopted evergreen species and invaded species. Plants that occur more frequently (>80% individual) in the swampy habitat are considered as 'Typical swamp species'. Species which have established in swamps because of disturbance are considered as 'Invaded species'. Species similarity among the swamps was computed using Sorenson's index (1957):

$$I = 2J/A+B.$$

Where, I=similarity, J=Common species of both the series a and series b. A=Total number of species in series a and = Total number of species in series b.

RESULTS AND DISCUSSION

The pooled over data of all the clusters of swamps recorded 129 plant species spread over 104 genera and 49 families. Among them, 87 were trees, 13 shrubs, 12 climbers and 17 were herbs. Of the 10 dominant species of all the swamp clusters, *Lophopetalum wightianum*, *Dimocarpus longan* and *Mastixia arborea* were common species suggesting the commonality among the clusters.

Of the 129 plant species pooled over all the localities, about 22 (17%) were typical swamp species, 16 (12%) were invaded species, 77 (60%) evergreen species and 4 (11%) facultative species found both under swampy and non-swampy conditions. The central swamp at Hulikal and Northern swamp of Thorme recorded the highest number of typical swampy species with 11 species each respectively where as 'invaded species' was highest in southern swamp (16.6%) and least in northern swamp (4%) (Table 1). Though the typical swampy condition in the southern swamp but there is absence of typical swampy tree species like *Gymancranthera canarica*, *Myristica fatua* var. *magnifica* etc., may be due to the attributes like disturbance and also climate change which support many invasive species by spreading into new ranges putting more pressure on fragile communities including swampy species. With regards to the percentage variation of different type of

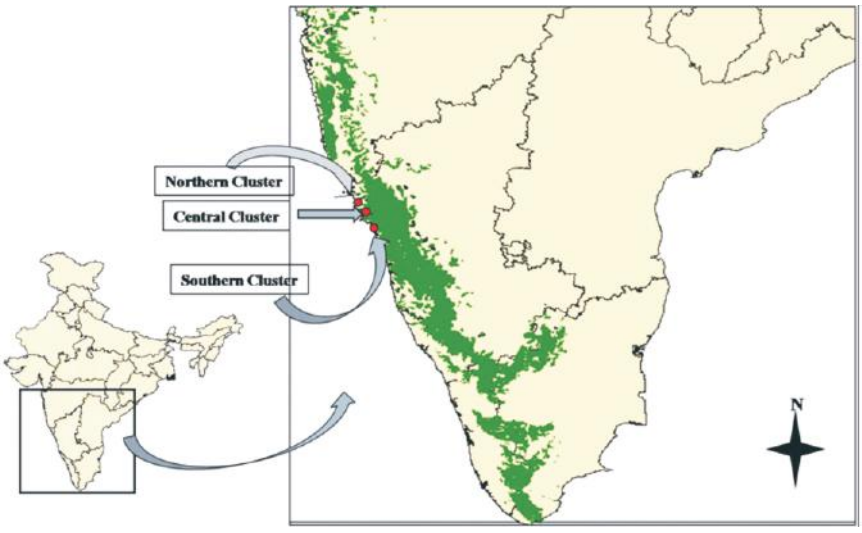


Fig. 1. Locations of study area in Central Western Ghats

Table 1. Distribution of different categories of species

Categories of species	Number of species			
	Northern Swamp	Central Swamp	Southern Swamp	
Evergreen species	33 (62%)	44 (60%)	24 (50%)	77 (60%)
Typical Swamp Swampy species	11 (21%)	11 (15%)	08 (16.6%)	22 (17%)
Facultative Swampy species	07 (13%)	12 (16.4%)	08 (16.6%)	04 (11%)
Invaded species	02 (04%)	06 (8%)	08 (16.6%)	16 (12%)
Total	53	73	48	129

species across the swamps, there is not much variation in typical swamp species but as the percentage of evergreen species decreases from northern swamp to southern swamp however, the percentage of invaded species increases.

Latitudinal gradients analysis

The highest values of richness and diversity index were recorded in Central swamp (Hulikal) and least was in Southern swamps (Sringeri). Highest stand density and basal area were also recorded for central and northern swamps than the southern swamps. Undisturbed nature, perennial source of water availability with better edaphic conditions may be the probable reason for the high species richness (Table 2). However, Srivastava and Mehrotra, (2013) have stated that, the increased seasonality temperature and also change in latitude are also might be the strong reason in species richness and diversity. In general, there was only 30 % similarity in species composition with respect to all the species (Table 3). No latitudinal gradient was observed for pooled species as well as for evergreen species. However, when considering the typical swamp species, northern and central swamps shared 50% of species, while northern and southern swamps were similar only for about 30%. Further, central and southern swamps were more similar (37%) suggesting a gradual change in the typical swamp species across latitudes (Fig. 2). However, it is very cleared that latitudinal gradient of increasing richness with decreasing latitude (Willing, 2001). It was also observed that the edaphic conditions and duration of stream flow which widely reflects the occurrence of typical swampy species however, the flow of southern swamps decreases due to high disturbance in the catchment area which enables to change in species composition by invading non-swampy species in the longer period. Joseph et al. (2008) observed similar results with regards to the various climatic topographic gradients which plays a significant role in the resource partitioning and niche differentiation. Climate is also other striking features for change in forest types and its species composition with respect to change in the global climate scenario. Further, variation in the rainfall pattern along the latitude *i.e.,* from South to North also another possible factor for dissimilarities in species composition however, this was proved in case of distribution of bat species in different latitudes of Western Ghats (Korad et al. 2007). Rekha and Dinakaran (2013) have affirmed that lateral interactions between streams and geographical distribution may play a major role in stream ecosystems which strongly influence the tropic structure in case of Caddisflies distribution in southern Eastern Ghats. Another strong reason for highest sharing of species in the central swamp from southern and northern swamp is due to its central location where a bio-geographical transition takes place between the northern and southern Western Ghats. However, this region forms the northern limit of the geographic range for several species of plants and animals (Chandran, 2003). One hundred and twenty nine plant species were recorded from fresh water swamps of different latitudinal gradients of Central Western Ghats.

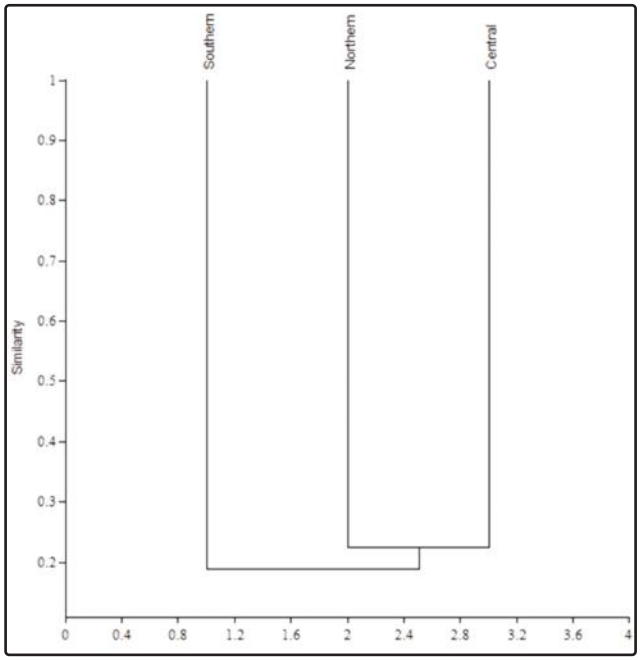
Table 2. Cluster-wise phytosociological analysis of swamps in central Western Ghats

Attributes	Swamp clusters		
	Northern Swamp	Central Swamp	Southern Swamp
Species richness	53	73	48
Stand density/ha	280	524	259
Basal area/ha	140.9	83.1	29.4
Shannon's index (H')	3.55	3.82	3.52
Dominance	0.04	0.03	0.04
Dominant species			
1.	*Elaeocarpus*	*Myristica fatua*	*Calophyllum tuberculatus apetalum*
2.	*Lophopetalum*	*Holigarna arnotiana*	*Dimocarpus longan wightianum*
3.	*Semecarpus*	*Ochlandra rheedii*	*Lophopetalum Kathalekanensis wightianum*
4.	*Gmnacranthera*	*Lophopetalum*	*Hopea ponga canarica wightianum*
5.	*Ochlandra Pinanga dicksonii*	*Holigarna arnottiana rheedii*	

Table 3. Species similarities among three different latitudinal gradients of swamps in the central Western Ghats

Species Types (Swamps)	Sorenson's Index
All species	
Northern Vs Central	0.362
Central Vs Southern	0.297
Northern Vs Southern	0.333
Evergreen species	
Northern Vs Central	0.337
Central Vs Southern	0.304
Northern Vs Southern	0.382
Typical Swamp species	
Northern Vs Central	0.5
Central Vs Southern	0.375
Northern Vs Southern	0.307

Fig. 2. Dendrogram showing the relationship among different clusters drawn from similarity of plant species diversity



Northern and Central swamps are having more number of species compare to Southern swamp. Invaded species were more in southern swamp; however, these swamps are disturbed than others. Typical swamp species are more in Hulikal swamp (Central swamp) suggesting the typical swampy conditions with less disturbance. As these swamps are located at geographical regions of different latitudinal gradients, factors such as climatic as well as anthropogenic pressure across the latitude may influence on their species composition, and structure. However, similarity study was resulted the strong evidence for change in the species composition across the latitude. If only typical swamp species are considered, there is a considerable decrease in similarity between northern swamp and southern swamp, and it is more evidenced in northern and central swamps. These patterns may be very useful to classify and categorize fresh water swamps across latitudes and thereby giving an idea of the speciation in these swamps and rather it is more important to know the pattern of changes in species composition across the latitude and it would be more important in managing and conserving the habitat as well as its unique flora.

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Evaluation of Management Practices for Rice-Wheat System Under On-farm Condition for Low Hill Zone of Himachal Pradesh

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***Abstract*:** On-farm experiment was conducted in sub-montane and low hills sub-tropical zone of Himachal Pradesh to study the impact of application of recommended dose of nutrients and full package of practices with and without farm yard manure (FYM) along with farmers' practice in rice-wheat cropping sequence under irrigated conditions for four consecutive cropping seasons during 2007-08 to 2010-11. The single intervention of applying recommended fertilizer nutrients over the existing farmer's practice increased the overall grain yields of rice and wheat by about 18.1 and 21.9%, respectively. The application of recommended package of practices further increased rice and wheat yields by about 8.1 and 10.2%, respectively and rice grain equivalent yield and net returns by about 30.4 & 40% over the farmer's practice. Both crops also responded to the application of FYM which significantly increased rice and wheat grain and straw yields, rice grain equivalent yield and gross and net returns over the other treatments.

Key Words: Farmers' package, Nutrients, Rice-wheat cropping sequence, Scientific package

Rice (*Oryza sativa* L.), wheat (*Triticum aestivum* L.) and maize *(Zea mays* L). provide two-thirds of all energy in human diets and greatly affect the livelihood and health of the urban and rural poor in India Rice-wheat is the most important cropping system in India (Prasad 2005) and occupies 10.5 m ha productive lands in Indo-Gangetic plains. It contributes about 25% of the national food production (Ladha *et al.*, 2000). But now the productivity of both the crops have stagnated (Yadav 1998) and factor productivity is declining year after year because there is great difference in actual and achievable yield. This is due to use of low yielding traditional varieties, imbalance and inadequate use of fertilizers, sub-optimal plant stand and heavy weed infestation, use of inadequate irrigation and improper plant protection measures. Apart from this, lack of knowledge about the non-monetary inputs is the major constraint which influences the productivity level. As the system is very exhaustive, there is greater drain on the native soil fertility, depletion in soil organic matter and losses of nutrients emphasizing balanced application of nutrients to sustain the productivity. In Himachal Pradesh, this system covers more than 80 thousand hectares with average productivity of 3.07 t/ha (Anonymous, 2013) as against the national average of 5.70 t/ha .The low productivity in the state needs immediate attention for the efforts to be geared in this endeavor. It is therefore, necessary to study the effect of proper nutrient management and recommended package for rice-wheat system on the farmers' fields.

Keeping in view these considerations, present study was undertaken on farmer's fields to demonstrate appropriate production technology for increasing productivity of rice –wheat cropping system.

MATERIAL AND METHODS

Field investigation to evaluate appropriate production technology for increasing the productivity of rice-wheat cropping system was undertaken under the On-Farm Research Programme of 'All India Coordinated Research Project on Integrated Farming Systems', Project Directorate of Farming System Research, Modipuram, Meerut (ICAR) for four years (2007-08 to 2010-11).

Experimental trials on cultivators' fields were conducted in Una, Hamirpur & Kangra districts all within NARP Zone I of Himachal Pradesh. During 2007-08 & 2008-09, two centres viz; Nandpur and Kalruhi in district Una, one centre viz; Rangas in district Hamirpur and one centre viz; Khabli in district Kangra were identified for the purpose and eight locations (two at each centre) per year in all the three districts were selected for conducting trials. During 2009-10, four centres (Jawali, Rehan, Tripal and Silh-Dehri) whereas during 2010-11, six centres (Jawali, Rehan, Tripal Silh-Dehri,Dehrian & Fatehpur) all falling within NARP Zone I in district Kangra were selected and at each centre two trials were laid down. The soils of the experimental locations were inceptisols having soil texture loamy sand to silty clay loam Soil pH at different locations varied from 6.6 to 8.4 and 5.5 to 6.8 in Farming situation I and Farming situation II, with mean value of 7.7 and 6.1, respectively. The total annual precipitation recorded was 795 mm, 1479 mm, 1141 mm, and 1841 mm during 2007-08, 08-09,09-10 and,10-11,respectively, whereas mean maximum and minimum temperature of the test sites varied from 27.2 to 29.1 °C and 14.3 to 16.9 °C respectively throughout the period of study.
Rice variety Kasturi Basmati and wheat varieties PBW-343 and HPW-184 were sown during the period under study.
The following treatments were implemented in farmers' field:
T_1: Farmers practice (application of FYM @ 5 t/ha, N @ 40% of recommended dose of

N, no criteria of seedling age/seed rate, method of sowing, plant protection measures and inappropriate weed

control measures without considering critical stage),

T_2: Recommended practices(90 kg N and 40 kg P_2O_5 and 40 kg K_2O/ha in rice, 120 kg N, 60 kg P_2O_5 and 30 kg K_2O in wheat and other practices as in farmers' practice)

T_3: Full recommended package of practices (100% NPK, transplanting/seeding at proper stage with proper method and spacing, irrigation at proper stage, herbicidal weed control & proper plant protection measures).

T_4: **T_3** + 10 t FYM/h

The experiments were conducted on 36 farmers' fields during four years of study.

For overall comparison, the grain yields of rice and wheat were converted into rice-grain equivalent on price basis (Tomer and Tiwari, 1990). Productivity (kg/ha/day) was obtained by dividing total production in terms of rice + wheat in a sequence by 365, while profitability (Rs/ha/day) was obtained by dividing net monetary return in a particular treatment by 365. Economics of the treatments was computed based upon prevalent prices. Area Equivalent Ratio (AER), Relative Profit, Additional Profit and Profit Equivalent Ratio (PER) were determined as given by Rana *et al.,* 2010:

AER = Cost of cultivation of conventional cropping sequence/cost of cultivation of alternative cropping sequence

Relative Profit (Rs/ha) = AER x net returns (Rs/ha)

Additional Profit (Rs/ha) = Relative profit of alternative cropping sequence – net returns of conventional cropping sequence

PER = Relative profit (Rs/ha)/ net returns of conventional cropping sequence

The statistical analysis of the data was performed in randomized block design considering locations as replication.

RESULTS AND DISCUSSION

Crop yields: The application of recommended fertilizer nutrients to the farmer's practice resulted in significantly higher grain and straw yields of rice and wheat over farmer's practice alone during all the years of investigation (Table1). Single intervention of applying recommended fertilizer nutrients in the existing farmer's practice increased the grain yield of rice and wheat by about 18.1 and 21.9%, respectively. Such a response to recommended application of nutrients clearly depicts that in states like Himachal Pradesh, productivity of these crops can be substantially boosted by applying balanced nutrient doses. Yields further increased by adopting full package of practices in all the years. Based on the overall mean, the magnitude of increase in rice and wheat grain yields owing to the application of recommended package of practices over full NPK was 8.1%, and 10.2%, respectively. Balanced application of nutrients and improved cultivation practices have been reported to be essential for sustained productivity (Prasad et al. 2002, Rinwa *et al.*, 2003 & Sharma *et al.*, 2011). However, application of FYM along with the recommended cultivation practices resulted in higher yield of grain and straw of both rice and wheat in all the years. The essentiality of organics in combination with inorganic in obtaining sustained higher yield and soil quality improvement has been amply demonstrated (Singh *et al*., 2011).

Rice grain equivalent yield: Owing to increased rice and wheat yields, the system productivity as expressed in terms of rice equivalent yield was significantly higher under recommended application of fertilizer nutrients over the farmer's practice alone (Table 1). Rice grain equivalent yield further increased with the adoption of full package. On an average, the recommended package of practices without FYM increased rice grain equivalent yield by 30.4% over the farmer's practice and 12.2% over recommended application of nutrients only. Full package of practices inclusive of FYM increased rice equivalent yield by 12.2% over its application without FYM. The increase in rice grain equivalent yield over farmers' practice was 46.3% (equivalent to 47% in terms of total rice + wheat yield i.e. 994 kg/ha of rice grain and 1223 kg/ha wheat grain). These results are clearly depicting that if resources are not limiting, yield of rice-wheat cropping system can be immediately increased by about 1.5 times.

Productivity and profitability: Owing to better utilization of resources and higher yield, recommended package of practices with FYM resulted in greater productivity (19.0 kg/ha/day) and profitability (Rs 192.1/ha/day) (Table 2). Thus, there was sufficient per day availability of food and cash for the better livelihood of the marginal and small farmers who would follow the recommended package of practices with FYM. The productivity and profitability under the recommended package of practices with FYM was 6.1 kg & Rs 63.9, 3.5 kg & Rs 31.0 and 2.1 kg & Rs 12.8/day/ha, higher over farmers practice, recommended nutrients and recommended package, respectively.

Economic viability: The higher yields following the application of recommended fertilizers to the farmer's practice and full recommended package of practices increased gross and net returns. On an average, the recommended technology package resulted in 40% higher net returns over farmer's practice and 11.3% higher net returns over recommended application of nutrients. Net returns were further increased by about 7.1% by the inclusion of FYM at 10 t/ha along with the recommended package of practices.

As indicated by AER (0.73-0.92), a farmer cultivating 'rice - wheat' in one ha with his own cultivation methods worth Rs 29782, when switches to alternative 'recommended package with FYM ', 'recommended package without FYM ' and 'recommended nutrient application 'can cultivate 72.5, 88.1 and 92.3% of farm, respectively with the same amount (Table 2). Consequently relative profit from these alternative practices is also reduced by 27.5, 11.9 and 7.7%, respectively of that obtained from one ha. However, additional profit was still higher by Rs 4094 and Rs 10889 and

Table 1. Effect of different agronomic practices on crop yields and economics under rice-wheat cropping sequence

Practice	Yield (kg/ha)				Rice equivalent	Gross Return (Rs/ha)	Net Return (Rs/ha)
	Rice		Wheat				
	Grain	Straw	Grain	Straw			
Farming Situation I (Una, Hamirpur & Kangra) (2007-08) Average of 8 locations							
T1	2338	3248	2453	3128	3972	71492	44860
T2	2838	3855	2970	3756	4818	86507	57407
T3	3019	4191	3269	4162	5198	93616	62960
T4	3298	4464	3649	4584	5730	102968	65812
CD (P=0.05)	120	239	236	353	230	4292	4292
Farming Situation I (Una, Hamirpur & Kangra) (2008-09) Average of 8 locations							
T1	2319	3213	2277	3131	3837	69415	42783
T2	2774	3849	2938	3734	4732	85160	56060
T3	3088	4233	3282	4295	5276	95152	64496
T4	3532	4778	3744	4905	6029	108632	71476
CD (P=0.05)	302	451	278	464	469	8657	8657
FarmingSituation II, Kangra (2009-10) Average of 8 locations							
T1	2384	3452	2411	3002	3723	81207	48275
T2	2767	3998	2927	3545	4393	95705	60305
T3	3071	4282	3228	4033	4864	106082	69126
T4	3421	4728	3579	4543	5410	118100	73144
CD (P=0.05)	216	314	179	261	270	5513	5513
FarmingSituation II, Kangra (2010-11) Average of 12 locations							
T1	2234	3411	2430	3340	3449	84120	51188
T2	2572	3648	2833	3871	3988	96848	61398
T3	2660	3787	3079	4177	4200	102201	65245
T4	3000	4334	3489	4551	4744	115032	70076
CD (P=0.05)	93	166	129	231	102	2476	2476
Overall (average of 36 locations)							
T1	2319	3331	2393	3150	3745	76559	46777
T2	2738	3838	2917	3727	4483	91055	58793
T3	2960	4123	3215	4167	4885	99263	65457
T4	3313	4576	3615	4646	5478	111183	70127
CD (P=0.05)	183	293	206	327	268	5235	5235

Recommended fertilizer dose: N, P_2O_5 & K_2O (kg/ha) Rice: 90, 40 & 40; Wheat 120, 60 & 30

Table 2. Productivity, profitability, AER and PER under different treatments

Treatment	Productivity (kg/ha/day)*	Profitability (Rs/ha/day)$	Cultivation cost (Rs/ha)	AER	Relative profit (Rs/ha)	Additional profit (Rs/ha)	PER
T1	12.9	128.2	29782	-	-	-	-
T2	15.5	161.1	32263	0.923	54272	7496	1.16
T3	16.9	179.3	33806	0.881	57665	10889	0.98
T4	19.0	192.1	41056	0.725	50870	4094	0.78
CD (P=0.05)	1.1	14.3	-	-	-	-	-

* Based on rice grain equivalent yield; $ Based on net return, AER, area equivalent ratio; PER, profit equivalent ratio

Rs7496/ha/annum, respectively under 'recommended package with FYM ', 'recommended package without FYM and 'recommended nutrient application'. Cultivation of 'rice - wheat' using 'recommended package with FYM (T4)', 'recommended package without FYM ' and 'recommended nutrient application 'gave 0.78, 0.98 and 1.16 times,

respectively higher profit than its cultivation in the entire area. Thus by switching to cultivation using these alternatives, a farmer with resources just sufficient for cultivation with his own methods can spare rest of his land resource for some other economic activity.

The findings of the present investigation conclusively infer that farmers should go for recommended package of practices in rice-wheat cropping system without any compromise. Resource poor and marginal farmers, who can not afford to apply the full package, should at least apply the recommended dose of nutrients to sustain yields and higher returns. Where FYM is available it would be worthwhile to apply it at 10 t/ha along with the recommended package of practices.

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Growth, Yield Attributes and Yield of Rice (*Oryza sativa* L.) as Affected by Age of Seedling and Time of Nitrogen Application under Temperate Conditions

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Abstract: In order to study the effect of seedling age and time of nitrogen application on growth, yield attributes and yield of rice (*Oryza sativa* L.), a field experiment was carried out at Research Farm of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar. The experiment was laid out in randomized completely block design with three replications. Treatments included 3 levels of seedling age (25, 35 and 45 days old seedling) and 6 levels of time of nitrogen application (Control, Recommended practice, 1/4 basal and ¾ in 3 equal splits at 14 days interval, ¼ basal and ¾ in 2 equal splits at 14 days interval, ½ basal and ½ in 2 equal splits at 14 days interval, ½ basal and remaining at LCC <4 @20 kg ha^{-1} per application). Yield of rice increased significantly by transplanting 35-days old seedling with concomitant improvement in yield attributes viz., panicles m^{-2}, panicle weight, spikelets $panicle^{-1}$, grains $panicle^{-1}$ and growth characters like plant height, tillers m^{-2} and leaf area index. Seedling age didn't make a significant difference on panicle length and 1000-grain weight. Application of nitrogen as ½ basal and remaining at LCC <4 @20 kg ha^{-1} per application resulted in improvement in yield along with growth and yield attributing characters. Highest benefit: cost ratio of 2.19 was also recorded when 35-days old seedlings were fertilized with ½ N as basal and remaining at LCC <4 @20 kg ha^{-1} per application. It is concluded that the yield of rice can be improved by transplanting 35-days old seedling under late transplanted conditions and by following LCC guided nitrogen management.

***Key Words*:** Nitrogen, Oryza sativa, Seedling age, Yield and yield attributes

Achieving a sustainable increase in rice production can provide global food security and contribute to poverty alleviation. To cope with the rising population, rice production needs to be increased following vertical, instead of horizontal expansion. Increase in productivity can be achieved by proper use of different factors of production. Age of seedling is an important factor as it has a tremendous influence on the tiller production, grain formation and other yield contributing characteristics. Transplanting healthy seedlings of optimum age at right time, results in higher productivity.

Constraints like late onset of monsoon, scarcity of agricultural labor, non-availability of inputs and financial credit in time, lead to transplanting of aged seedlings. When the seedlings are allowed to stay for a longer period of time in the nursery, the primary tiller buds on the lower nodes of the main culm develop in the nursery itself and later on degenerate after transplanting. Thus only a few tillers are produced during vegetative period leading to poor yield (Mobasser *et al*., 2007). The tillers that emerge late grow at a slower rate and die due to insufficient supply of assimilates and nutrients (Quyen *et al*., 2004), thus affecting yield.

A holistic and intensive analysis of world rice improvement efforts reveals that the grain yield improvement of rice was principally achieved by nitrogen fertilization. Nitrogen is required in adequate quantities at early and mid tillering stage to maximize panicle number and during reproductive stage to produce optimum spikelets per panicle and to increase the percentage filled spikelets (Murty *et al*., 1992). Improving the synchrony between crop nitrogen demand and nitrogen supply from soil and/or the applied nitrogen is the most promising strategy to increase nitrogen use efficiency (Singh *et al*., 2010). As nitrogen fertilization is a major agronomic practice affecting the yield and quality of rice crop, the synergistic influence of time of nitrogen application on the characteristics of younger/older seedling and yield after transplanting needs to be considered. Keeping these facts in view a research programme was undertaken to find the optimum age of seedling under late transplanting conditions and to find the proper time of nitrogen application under these conditions.

MATERIAL AND METHODS

The experiment was carried out at Research Farm of Shere-Kashmir University of Agricultural Sciences and Technology of Kashmir, *Kharif* 2011. The site is situated towards the North of Srinagar (34°05` N latitude and 74°89` E longitude, 1587 m above mean sea level) at a distance of 15 km from the center of city. Soil of the experimental field was

low in available nitrogen (253.6 kg ha^{-1}), medium in available phosphorus (14.3 kg ha^{-1}), and medium in available potassium (248 kg ha^{-1}). The experiment was laid out in Randomized Completely Block design with three replications. There were 18 treatment combinations including 3 levels of seedling age; 25 (A_3), 35 (A_2) and 45 (A_1) days old seedling and 6 levels of time of nitrogen application; Control (N_0), Recommended practice (N_1), ¼ basal and ¾ in 3 equal splits at 14 days interval (N_2), ¼ basal and ¾ in 2 equal splits at 14 days interval (N_3), ½ basal and ½ in 2 equal splits at 14 days interval (N_4), ½ basal and remaining at LCC <4 @20 kg ha^{-1} per application (N_5). Plot size was 4m × 3m with row to row and plant to plant spacing of 15 cm. Diammonium phosphate (DAP) and Muriate of Potash (MOP) were applied as basal dose to each plot (except control plots) at the rate of 60 kg P_2O_5 ha^{-1} and 30 Kg K_2O ha^{-1}, respectively before transplanting. Nitrogen was applied @ 120 Kg ha^{-1} as per treatment in the form of Urea. In case of LCC based treatments top dressing of Urea was done only at LCC <4 @ 20 kg ha^{-1} $application^{-1}$. Transplanting of seedlings of all the three ages was done on 21st June. Standard cultural practices were followed until the crop matured. Seven hills (excluding border hills) were randomly selected from each plot for measuring plant height, tiller number and panicle number. Ten hills (excluding border hills) were randomly selected from each plot prior to harvest for measuring other yield components. Yield was determined from net harvest area of 7.4 m^2 after excluding border rows.

RESULTS AND DISCUSSION

Effect of seedling age

Seedling age had a significant effect on growth, yield attributes and yield. Plant height increased consistently upto 60 days after transplanting (DAT) and showed gradual increase thereafter till harvest with respect to all treatments. At all stages of growth plant height of 35 days old seedling was maximum followed by 25 days old seedling and 45 days old seedling (Table 1). Decreased height of 45 days old seedling is attributed to transplanting shock which caused 45 days old seedling to utilize their stored carbohydrates for repairing damaged roots in early growth stages, so their percent increase in plant length was slower than that of the younger ones. Amin and Haque (2009) also reported higher plant height with 35 days old seedling compared to 15, 25, 45 or 65 days old seedling. At 30 DAT and onwards, 25 days old seedling remained at par with 35 days old seedling and produced significantly higher number of tillers compared to 45 days old seedling (Fig. 1). This is in agreement with findings of Bagheri *et al*. (2011). The leaf area index was not significantly affected by age of seedling at 15 and 30 DAT. At 45 DAT and onwards, 25 and 35 days old seedling recorded significantly higher LAI than 45 days old seedling (Fig. 3).

The 35 days old seedling recorded significantly higher number of panicles m^{-2} (380.22), spikelets $panicle^{-1}$(105.83), grains $panicle^{-1}$ (85.16) and higher panicle weight (2.27 g). The 25 days old seedling recorded significantly highest spikelet sterility (32.13 %) (Table 2). The improvement in yield attributes of 35 days old seedling was due to the production of healthy tillers which had undergone normal physiological growth and field duration, resulting in more healthy panicles with more filled spikelets. 25 days old seedlings were subjected to comparatively lower environmental elements in terms of temperature and sunshine hours which hindered them to exploit their potential and their sterility percentage increased. Pattar *et al*. (2001) also observed higher number of filled grains $panicle^{-1}$ in 35 days old seedling compared to 25 days old seedling. Chopra *et al*. (2002) indicated improvement in yield attributes of 35 days old seedling over 45, 55 and 65 days old seedling. Seedling age showed no significant effect on panicle length and 1000 grain weight. The 35 days old seedling gave significantly more grain yield (74.19 q ha^{-1}) and biological yield than 25 days old seedling and 45 days old seedling (Table 2). The better yield attributing characters recorded in 35 days old seedling contributed to the higher grain yield. Similar findings are in conformity with Amin and Haque (2009) and Faghani *et al*. (2011).

Effect of time of nitrogen application

Among nitrogen application treatments, N_5 (½ basal, remaining at LCC <4 @ 20 kg ha^{-1} $application^{-1}$) resulted in better growth, yield attributes and yield. At 15 DAT the time of nitrogen application could not make any significant difference in plant height. At 30 and 45 DAT all the nitrogen treatments though at par resulted in significantly superior plant height than N_0 (control). At 60 DAT and onwards, N_5 (½ basal, remaining at LCC <4 @ 20 kg ha^{-1} $application^{-1}$) remained at par with N_1 (recommended practice) and N_2 (¼ basal, ¾ in 3 equal splits at 14 days interval) and was significantly superior to N_3 (¼ basal, ¾ in 2 equal splits at 14 days interval) and N_4 (½ basal, ½ in 2 equal splits at 14 days interval) (Table 1). At 60 days after transplanting (DAT), N_5 recorded the significantly higher number of tillers while it remained at par with N_1 and N_4. Similar trend was followed at 75, 90 DAT and at harvest (Fig. 2). N_5 also recorded significantly higher LAI than other treatments from 60 days after transplanting (DAT) onwards (Fig. 4). Improvement in growth characters resulting from N_5 was due to the fact that LCC guided nitrogen management

Table 1. Plant height (cm) as influenced by age of seedling and time of nitrogen application

Treatment	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	At harvest
Age of seedling							
A_1	25.18	42.38	73.21	105.97	106.49	106.50	106.62
A_2	27.89	48.18	78.76	111.09	111.67	111.73	111.84
A_3	20.75	44.06	75.28	107.62	108.50	108.72	108.82
CD (0.05)	2.05	4.09	2.78	3.38	3.33	2.93	3.05
Time of nitrogen application							
N_0	22.01	35.34	67.30	98.95	99.14	99.27	99.34
N_1	25.72	44.39	77.32	111.90	112.81	112.98	113.06
N_2	24.30	46.62	76.44	111.97	112.40	112.53	112.59
N_3	24.84	47.22	76.20	107.07	107.63	107.80	107.89
N_4	25.79	49.32	78.81	107.09	107.67	107.94	107.99
N_5	24.98	48.38	78.42	113.67	114.45	114.59	114.66
CD (0.05)	NS	5.79	3.94	4.78	4.71	4.14	4.28

DAT= Days after transplanting.
A_1= 45 Days old seedling, A_2= 35 Days old seedling and A_3= 25 Days old seedling.
N_0= Control, N_1= Recommended practice, N_2= 1/4 basal and ¾ in 3 equal splits at 14 days interval, N_3= ¼ basal and ¾ in 2 equal splits at 14 days interval, N_4= ½ basal and ½ in 2 equal splits at 14 days interval, N_5= ½ basal and remaining at LCC <4 @20 kg ha^{-1} per application.

Table 2. Yield attributes, yield and harvest index of rice as affected by as affected by seedling age and N application timing

Treatment	Panicles m^{-2}	Panicle length(cm)	Panicle weight(g)	Spikelets panicle^{-1}	Grains panicle^{-1}	Spikelet sterility (%)	1000 grain weight (g)	Grain yield	Biological yield	Harvest index (%)
Age of seedling										
A_1	306.83	19.89	1.97	95.55	69.66	26.90(31.15)	25.66	58.20	136.69	42.61
A_2	380.22	20.89	2.27	105.83	85.16	19.56(25.89)	26.04	74.19	161.59	45.91
A_3	343.33	20.29	2.02	102.67	73.50	28.41(32.13)	25.91	64.52	147.45	43.75
CD (0.05)	28.59	NS	0.19	4.80	4.11	2.52 (1.68)	NS	4.96	6.38	2.02
Time of nitrogen application										
N_0	263.55	17.89	1.24	90.55	63.55	28.65(32.31)	24.97	27.77	97.47	29.71
N_1	380.22	21.80	2.42	105.33	81.11	25.23(30.03)	26.11	74.03	163.53	45.27
N_2	346.88	20.44	2.09	106.00	79.22	24.31(29.44)	26.11	71.76	157.96	45.42
N_3	353.47	20.07	2.05	99.22	72.00	26.75(31.01)	26.03	64.01	146.11	43.81
N_4	336.00	20.03	1.90	99.55	74.25	26.12(30.56)	25.82	66.28	148.79	44.54
N_5	399.44	21.90	2.80	106.44	88.55	18.26(25.01)	26.15	86.69	182.59	47.47
CD (0.05)	40.43	1.38	0.27	6.79	5.82	3.56 (2.38)	0.79	7.01	9.02	2.86

Values in brackets were obtained after transformation. See Table 1 for treatment details

provided specific amounts of nitrogen as per crop need throughout the growing season and reduced leaching of nitrate (NO^-_3) in the soil. Sathiya and Ramesh (2009) also reported significantly higher plant height with nitrogen application based on LCC value 4.

N_5 resulted in significantly higher number of panicles (399.44 m^{-2}), grains panicle^{-1}(88.55), spikelets panicle^{-1} (106.44), higher panicle weight (2.80 g), lowest sterility per cent, highest grain yield (86.69 q ha^{-1}) and biological yield (Table 2)**.** This is attributed to the fact that formation of yield components is not only dependent on the absolute amount of nitrogen but also upon the nitrogen supply pattern and uptake process at each growth stage for respective yield components. LCC guided fractional application of nitrogen (synchronizing with the crop demand) was effective in maintaining optimal leaf nitrogen during critical stages of plant growth. This lead to conducive translocation of higher amounts of carbohydrates to sink, which produced superior yield attributes. This is in line with findings of Sathiya and Ramesh (2009). There was an improvement in yield of 45 days old seedling in case of LCC guided nitrogen management which demanded a higher quantity of nitrogen (140 kg ha^{-1}) than recommended dose. Chowdhury *et al*., (2011) also found that grain yield of 60 days old seedling can be improved from 30 to 58 per cent by increasing nitrogen rate from 20 kg ha^{-1} to 40 kg ha^{-1}.

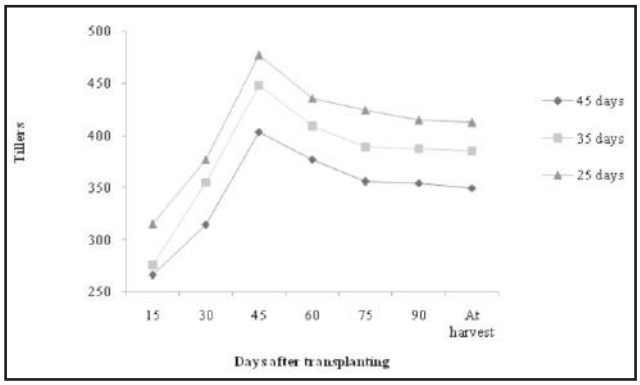

Fig. 1. Effect of age of seedling on number of tillers m^{-2}

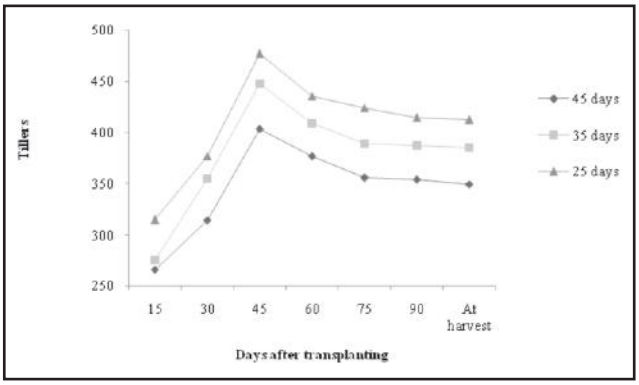

Fig. 2. Effect of time of nitrogen application on number of tillers m^{-2}

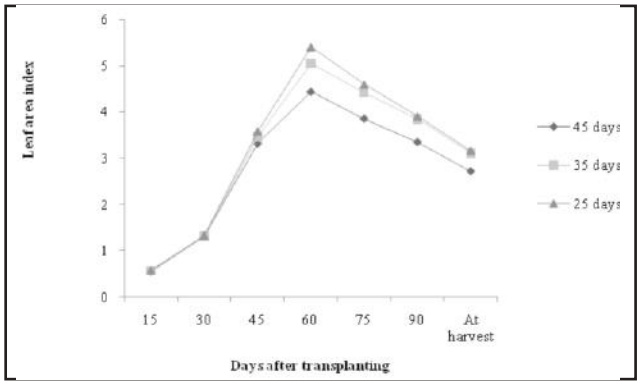

Fig. 3. Effect of age of seedling on leaf area index leaf

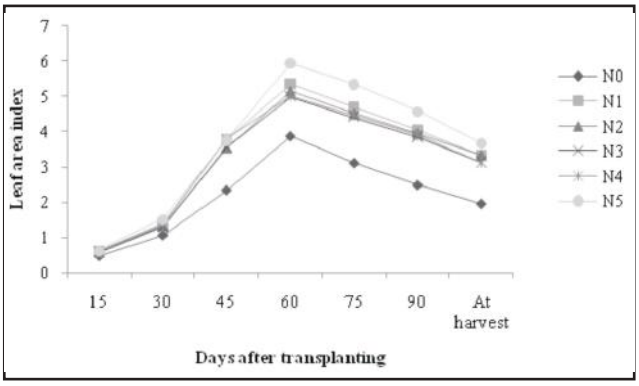

Fig. 4. Effect of time of nitrogen application on area index

Table 3. Relative economics of paddy as influenced by age of seedling and time of nitrogen application

Treatment	Gross returns (Rs. ha^{-1})	Total cost of cultivation (Rs. ha^{-1})	Net profit (Rs. ha^{-1})	B:C ratio
$A_{45}N_0$	41690.0	36559.90	5130.11	0.14
$A_{45}N_1$	95350.0	41249.26	54100.75	1.31
$A_{45}N_2$	82935.0	41374.26	41560.75	1.00
$A_{45}N_3$	78360.0	41249.26	37110.75	0.90
$A_{45}N_4$	81540.0	41249.26	40290.75	0.98
$A_{45}N_5$	109230	41642.64	67587.36	1.62
$A_{35}N_0$	82215.0	36559.90	45655.11	1.25
$A_{35}N_1$	110510	41249.60	69260.74	1.68
$A_{35}N_2$	108280	41374.26	66905.74	1.62
$A_{35}N_3$	105160	41249.26	63910.74	1.55
$A_{35}N_4$	96245.0	41249.26	54995.75	1.33
$A_{35}N_5$	131715	41249.26	90465.74	2.19
$A_{25}N_0$	69330.0	36559.90	32770.11	0.90
$A_{25}N_1$	98250.0	41249.26	57000.74	1.38
$A_{25}N_2$	85995.0	41374.26	44620.74	1.08
$A_{25}N_3$	84390.0	41249.26	43140.74	1.08
$A_{25}N_4$	91375.0	41249.26	50125.74	1.22
$A_{25}N_5$	112770	40875.68	71644.32	1.76

A_{45}= 45 days old seedling, A_{35}= 35 days old seedling and A_{25}= 25 days old seedling

Cost of seed = Rs. 20.50 kg^{-1}
Cost of urea = Rs. 5.86 kg^{-1}
Cost of DAP = Rs. 20.90 kg^{-1}
Cost of MOP = Rs. 5.35 kg^{-1}
Cost of Butachlor = Rs. 26 kg^{-1}
Cost of labour = Rs. 125 $labour^{-1}$
Cost of grain = Rs 12 kg^{-1}
Cost of straw = Rs. 12 $shief^{-1}$

Relative economics

Net profit of Rs. 90,465.74 ha^{-1} and a benefit cost ratio of Rs. 2.19 was obtained when 35 days old seedling were transplanted and fertilized with N_5 (½ basal, remaining at LCC <4 @ 20 kg ha^{-1} $application^{-1}$) (Table 3) and it (B:C ratio) was highest among all treatments. Gupta *et al*. (2011) also achieved a beni-fit cost ratio of 4.42 to 5.58 by applying nitrogen as per LCC reading (<4), compared to benefit cost ratio of 3.73 to 3.81 in simple split application of nitrogen at fixed growth stages.

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Pearlmillet Based Cropping Systems Involving Pulses, Oilseeds and Vegetables for Attaining Sustainability and Economic Viability in Semi-Arid Regions of India

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***Abstract*:** The field experiments were conducted during the year 2010-11 and 2011-12 at Agronomy Research Farm of CCS Haryana Agricultural University, Hisar, India. The experiment was laid out in randomized block design with seven cropping systems replicated four times. The study indicate that cotton-wheat cropping system gave highest wheat equivalent yield of 10598 kg/ha followed by clusterbean-broccoli-onion with 10112 kg/ha. System productivity also followed the same pattern. Employment generation was higher in cropping system involving vegetables with total man days of 298 in a year. Net return of Rs.81554/ha/annum, economic efficiency of Rs.223 /ha/day and water use of 89.7 ha-cm was higher in cotton-wheat cropping system.

Key Words: Wheat equivalent yield, System productivity, Economic efficiency and Nutrient use productivity

Cropping system needs to be inherently flexible to avail advantage of economic opportunities and or adapt to environmental modalities under changing climatic scenario. A dynamic cropping system concept characterized by management approach, whereby crop sequencing decisions are undertaken on an annual basis to improve the adaptability of cropping practices to externalities. A sound cropping system represents a long term strategy of annual crop sequencing that optimizes crop and soil use options to attain production, economic and resource conservation goals considering ecological management principles, however, short term research efforts can help to identify crop sequence synergisms and antagonisms, thereby providing the necessary foundation for developing strategies to sequence crops over a longer period of time.

Pearlmillet-wheat and cotton-wheat are the two most dominating crop sequence of south-west Haryana. Both these cropping systems are fertility exhaustive and needs heavy nutrition. Continuous cropping of these heavy feeders of crop sequences over a long period of time reduces productivity and soil fertility. The inclusion of pulses and oilseeds in the conventional cropping system like pearlmillet-wheat in the south western part of Haryana will suit the need of the farmer for his family liability and will fetch the market of Delhi. Short duration pulses like mungbean, cowpea etc and vegetables like onion will fit into this traditional system and will be monetarily beneficial to the growers. Therefore, the present experiment was carried out to find out suitable alternate cropping system for semi-arid region with higher sustainability productivity and economic viability which include pulses, oilseeds and vegetables.

MATERIAL AND METHODS

The field experiments were conducted during cropping years 2010-11 and 2011-12 at CCS HAU, Hisar under All India Coordinated Research Project on Integrated Farming System. The soil of experimental field was sandy loam in texture and classified typic haplastepts, having organic carbon content 0.36% and available N 154 kg/ha (low), P 12.4 kg/ha (medium) and K 294 kg/ha (high).

Seven cropping systems viz. Pearlmillet-Wheat, Cotton-Wheat, Pearlmillet -Barley-Mungbean, Clusterbean-Broccoli-Onion, Mungbean-Mustard+Kasni, Pearlmillet-Wheat(d)-Cowpea and Pearlmillet+mung bean-Wheat+mustard were evaluated using randomized block design with four replications. For comparison purpose between different crop sequences, the yields of all the crops were converted into wheat equivalent yield on price basis. Production effiency was calculated by dividing the mean wheat equivalent yield by 365 days and the mean data of two years was analyzed for computing other indices (Katyal *et al.* 1999). Prevailing minimum support price/university rates for 2010-11 and 2011-12 were used for computing economic returns. The economic efficiency of cropping systems was calculated by dividing net returns/ha in a sequence by 365 days. Nutrient use productivity was calculated by dividing the wheat equivalent yield of system with the total quantity of fertilizers applied to different crops in a system. Water use (ha-cm) was computed on the basis of total water applied to the crops.

The individual plot size was 10m x 8.1m with 1m margins on both sides of plot to curtail effects of runoff. Pearlmillet, cluster bean, mung bean, wheat, barley, mustard, wheat (tall) and cowpea were sown by drill. Cotton was sown by dibbling while broccoli and onion were transplanted. Recommended rates of nutrients were applied to all the crops. Nitrogen was applied in two splits i.e. half at sowing/planting and the remaining half as top dressing as per recommendations in the base as well as inter crops. The full dose of phosphorus was applied as compound fertilizer in seed row and covered with soil at the sowing time. Urea and DAP were used as source of nitrogen and phosphorus. Potassium was applied in onion only through murate of potash (MOP). Various agronomic practices/manipulations were done as per recommendations of respective crops in the command areas.

RESULTS AND DISCUSSION

Yield of component crops

Rainy Season

Pearlmillet is an important rainy season crop of semi-arid region. Yield of pearlmillet varied between 2704 kg/ha to 2826 kg/ha and from 3016 kg/ha to 3244 kg/ha during 2010-11 and 2011-12, respectively. The highest yield of pearlmillet was 2826 and 3244 kg/ha in pearlmillet-barley-mungbean cropping system and pearlmillet-wheat (*desi*) – cowpea during 1st and 2nd year of experimentation, respectively. The yield of pearlmillet was 1782 kg/ha and 2667 kg/ha when mungbean was taken as intercrop during both the years with additional yield of 168 and 206 kg/ha, in 2010-11 and 2011-12, respectively (Table 2).

The higher pearlmillet yield in pearlmillet-barley-mung bean and pearlmillet-wheat (*desi)*-cowpea might be

Table 1. Details of agronomic practices carried out in different cropping systems during the crop growth period

Crop	Variety	N+P+K(kg/ha)	Sowing time	No. of irrigations applied	Harvesting time
			Kharif		
Pearlmillet	HHB-197	125+62.5	Last week June	2	Last week Sept.
Cotton	H-1226	88+30	2nd week May	5	Last week Oct.
Clusterbean	HG-365	20+40	Last week June	1	2nd week Oct.
Mungbean	Satya	20+40	Last week June	1	2nd week Oct.
			Rabi		
Wheat	WH-502	150+60	Last week Oct.	5	1st week April
Barley	BG-75	60+30	Last week Oct.	4	3rd week March
Broccoli	Palam Smaridhi	100+50	Last week Nov.	3	Last week Jan.
Mustard	RH-30	80+30	Last week Oct.	2	3rd week March
Wheat (tall)	C-306	60+30	Last week Oct.	2	Last week March
			Summer		
Mungbean	Satya	20+40	2nd week April	2	2nd week July
Onion	Hisar-2	125+50+25	1st eek Feb.	5	2nd week May
Cowpea	Pusa Komal	25+62.5	2nd week April	3	2nd week July

Table 2. Yield, system productivity and production efficiency under different cropping systems

Cropping System	Yield (kg/ha)									Production efficiency (kg/ha/day)
	2010-11			2011-12			System productivity			
	Rainy	Winter	Summer	Rainy	Winter	Summer	2010-11	2011-12	WEY Mean	
Pearlmillet-Wheat	2704	5464	-	3016	5634	-	7498	7982	7740	21.20
Cotton-Wheat	2184	5342	-	2582	5561	-	10009	11187	10598	29.04
Pearlmillet -Barley-Mungbean	2826	3476	396	3163	3218	378	5604	5896	5750	15.75
Clusterbean-Broccoli Onion	- 1018	942*	21300	1076	1790	12308	10582	9643	10112	27.70
Mungbean-Mustard+Kasni	866	1768+207	-	988	2376+149	-	7172	8048	7610	20.85
Pearlmillet-Wheat(d) Cowpea	- 2796	2814	864	3244	2944	923	6080	6871	6475	17.74
Pearlmillet +mung bean-Wheat-mustard	1782+168	4836+114	-	2667+206	4964+146	-	7599	7689	7644	20.94

due to mung bean and cowpea crop in summer which fixes N and succeeding pearlmillet crop gets benefit in terms of higher production. Seed cotton yield of 2184 and 2582 kg/ha was recorded in cotton-wheat cropping system during 2010-11 and 2011-12, respectively. The yield of clusterbean and mung bean in clusterbean-brocolli-onion and mungbean-mustard+kasni was 1018 and 1076 kg/ha and 866 and 988 kg/ha, during 2010-11 and 2011-12, respectively. Kumar *et.al.* (2014) has also reported higher yield of seed cotton in cotton-wheat and pearlmillet in pearlmillet – wheat cropping system.

Winter season

Wheat being the important crop of winter season is grown after pearlmillet and cotton in semi-arid region. The yield of wheat in pearlmillet-wheat and cotton-wheat cropping system was recorded 5964and 5634 kg/ha and 5342 and 5561 kg/ha during 2010-11 and 2011-12, respectively. The yield of wheat (Table 2) was higher in pearlmillet-wheat cropping system as to cotton-wheat and this may be due to the reason that pearlmillet crop is less nutrient exhaustive than cotton crop. The wheat yield in wheat + mustard cropping system was recorded 4836 and 4964 kg/ha with additional yield of 114 and 146 kg/ha from mustard during 2010-11 and 2011-12, respectively. Barley and mustard crops yielded 3476 and 3218 kg/ha and 1768 and 2376 kg/ha in pearlmillet-barley-mustard and mung bean-mustard + kasni cropping system during 2010-11 and 2011-12, respectively. Additional yield of 207 and 149kg/ha from kasni was also recorded in mung bean-mustard + *kasni* during 2010-11 and 2011-12, respectively. Broccoli did not bear flowers during 2010-11 and only green fodder yield of 942 kg/ha was recorded, whereas, during 2011-12, broccoli yield of 1790 kg/ha was recorded.

Summer season

During summer season mung bean, onion and cowpea were grown. The yield of mung bean in pearlmillet-barley-mung bean was recorded 396 and 378 kg/ha and cowpea in pearlmillet-wheat (*desi*)-cowpea recorded 864 and 923 kg/ha and onion yielded 21300 and 12308 kg/ha in clusterbean-broccoli-onion cropping system during 2010-11 and 2011-12, respectively (Table 2). Similar results have been reported by Yadav *et al.* (2010).

System productivity

The mean system productivity of 10598 kg/ha (Table 2) was recorded in cotton-wheat cropping system followed by clusterbean-broccoli –onion cropping system with mean system productivity of 10112 kg/ha. The mean system productivity of mungbean-mustard+ kasni, pearlmillet-wheat (*desi*)-cowpea and pearlmillet+mungbean-wheat + mustard was 7610, 6475and 7644 kg/ha, respectively. The results shows that cotton-wheat cropping system is the best established cropping system of this region however, clusterbean-brocolli-onion cropping system closely follows it (Table 2). Pearlmillet-wheat system productivity was 25.71 per cent higher than pearlmillet-barley-mung bean cropping system where as it was 1.68 per cent higher than pearlmillet-wheat (desi)-cowpea cropping system. System productivity of cotton-wheat was 26.97 per cent higher than pearlmillet-wheat cropping system. Walia *et al.* (2011) and Kumar *et al*. (2014) related the equivalent yield of cropping systems with yield potential and economic value of the produce and reported similar results.

Production efficiency

Production efficiency of 15.75 to 29.04 kg/ha/day was recorded in different cropping systems based on system productivity (Table 2). The highest production efficiency of 29.04 kg/ha/day was recorded in cotton- wheat cropping system which shows the importance of this cropping system for this region. This is closely followed by clusterbean-broccoli-onion cropping system with production efficiency of 27.70 kg/ha/day. Production efficiency of cotton-wheat cropping system was 27 and 28.2 per cent higher over pearlmillet-wheat and mung bean-mustard+kasni cropping sytem, respectively. Walia *et al.* (2011) corroborate the above findings.

Employment generation

In general regardless of the crops in a sequence intensive cropping system with three crops in a year generated higher employment (mandays). The highest employment opportunity of 298 man days was generated in clusterbean-broccoli-onion involving 91, 115 and 92 man days during rainy, winter and summer season, respectively. Cotton-wheat generated 226 man days employment during the year. Cotton generated 134 man days due to longer growing period while wheat generated 92 man days employment. Yadav *et al.,* 2010 justified that employment generation was associated with duration of crop and vegetables involved in the system.

Monetary advantage

The net return were higher in cotton-wheat cropping system with Rs. 81554/ha/annum (Table 4) supporting market value of cotton crop which proved to be the most remunerative cropping system followed by pearlmillet-wheat with a net return of Rs. 71128/ha/annum. The lowest net returns of Rs.41450 /ha/annum was recorded in pearlmillet-barley-mungbean cropping system. The pearlmillet-barley-mungbean, mungbean-mustard+kasni and pearlmillet-wheat (*desi*)-cowpea recorded net profitability of Rs. 41450, Rs. 58935 and Rs. 50517/ha, respectively.The economic efficiency (Table 4) of the cropping systems varied between

Table 3. Employment (mandays) and nutrient use productivity (kg grain/kg nutrient applied) in different cropping systems (mean of two years)

Cropping systems	Employment (mandays)				Nutrient use productivity
	Rainy	Winter	Summer	Total	
Pearlmillet-Wheat	87	92	-	179	19.47
Cotton-Wheat	134	92	-	226	32.31
Pearlmillet -Barley-Mungbean	87	71	35	193	17.03
Clusterbean-Broccoli-Onion	91	115	92	298	24.66
Mungbean-Mustard+Kasni	64	73	-	137	44.76
Pearlmillet-Wheat(d)-Cowpea	87	70	42	199	17.74
Pearlmillet +mung bean+Wheat+mustard	88	93	-	181	19.23

Table 4. Economics (Rs./ha), economic efficiency (Rs./ha/day) and water use (ha-cm) in different cropping systems (mean of two years)

Cropping systems	Net return	B.C. ratio	Economic efficiency	Water use			
				Kharif	*Rabi*	Summer	Total
Pearlmillet-Wheat	71128	2.65	195	30.1	42.0	-	70
Cotton-Wheat	81554	2.22	223	47.7	42.0	-	89.7
Pearlmillet -Barley-Mungbean	41450	1.88	114	30.1	30.5	20	80.6
Clusterbean-Broccoli-Onion	66622	2.22	183	31.0	23.8	35.8	86.3
Mungbean-Mustard+Kasni	58935	2.56	161	26.7	33.9	-	60.6
Pearlmillet-Wheat(d)-Cowpea	50517	2.07	138	30.1	28.6	19.2	77.9
Pearlmillet +mung bean+Wheat+mustard	63109	2.49	173	30.1	42.0	-	72.1

Rs. 114/ha/day to Rs. 223/ha/day being highest in cotton-wheat and lowest in pearlmillet-barley-mungbean. The Second highest economic efficiency (Rs. 195/ha/day) was recorded in pearlmillet-wheat followed by clusterbean-broccoli-onion (183). Highest B:C ratio was however recorded in pearlmillet-wheat (2.65) followed by mungbean-mustard+kasni (2.56). Gangwar *et.al.* (2004) reported similar type of monetory advantage by inclusion of pulses and oilseeds in different cereal based cropping systems.

Nutrient use productivity and water use

The nutrient use productivity (Table 4) of cropping systems varied between 17.03 kg grain/kg nutrient applied to 44.76 kg grain/kg nutrient applied. The mungbean-mustard+kasni showed highest nutrient use productivity of 44.76 followed by cotton-wheat with 32.37 kg grain/kg nutrient applied. This may be due to higher yield potential and price of these crops. The nutrient use productivity of pearlmillet-wheat, pearlmillet-barley-mungbean, clusterbean-broccoli-onion, pearlmillet-wheat (*desi*) – cowpea and pearlmillet + mungbean – wheat + mustard + was 19.47, 17.03, 24.66, 17.74 and 19.23 kg grain/kg nutrient applied, respectively. Walia *et al.* (2011) and Narkhede *et al.* (2011) also reported the similar type of results in different cropping systems. Maximum water use was recorded in cotton-wheat (89.7 ha-cm) followed by clusterbean-broccoli-onion (86.3 ha-cm). Lowest water use was recorded in mungbean-mustard+kasni being short duration crops.

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Evaluation of Organic Farming Package for Rice-Groundnut Crop Sequence

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***Abstract*:** The experiments were taken during the year 2003-04 to 2011-12 to compare the organic farming package for productivity and profitability of *kharif* rice - summer groundnut crop sequence. The soil of the experimental site was clayey with organic carbon (0.59 %), bulk density (1.45 g/cc), available nitrogen (225 kg/ha), phosphorus (43kg/ha) and potassium (318 kg/ha). There was reduction during initial years in paddy equivalent yield under the treatments, which received organic source of nutrient management over chemical fertilizer as well as integrated management (T_7 and T_1). But in pooled, the treatment (T_2) in which, each different organic sources equivalent to 1/3 of recommended N from FYM, vermicompost and castor cake recorded significantly higher paddy equivalent yield (14652 kg/ha), which was at par with 50% recommended NPK from inorganic fertilizer + 50% N from FYM along with micronutrients as per soil test (14355 kg/ha). Significantly highest net return was recorded under 50% recommended NPK from inorganic fertilizer + 50% N from FYM along with micronutrients as per soil test (96950 /ha) followed by each different organic sources equivalent to 1/3 of recommended N from FYM, vermicompost and castor cake (82701 /ha). Even after considering 25 % higher premium price of organic product during initial year 2003-04, crop sequence which received 100 % organic sources of manure (T_2) was not profitable over T_7, but at the end of ninth year, the treatment T_2 become profitable.

***Key Words*:** Net return, Organic farming, Paddy equivalent yield, Productivity, Profitability

In order to achieve higher targets of food production to meet the ever-increasing population demands, soils have been over-exploited through the use of selected and highly pure fertilizers, use of poor irrigation quality without proper drainage. This has resulted in reduced productivity year after year. The intensive use of highly pure fertilizers without organic manures led to nutrient deficiencies reduced microbial activities and reduction in soil humus or organic matter. In the long run, soil is degraded with pollution of underground water with nitrates and formation of nitrosamines (carcinogenic substances). The percentage share of organic land to the total agricultural land in India was 0.3% in 2006. Currently, India ranks 33rd in total land under organic cultivation and 88th position for agricultural land under organic crops to total farming area. Gujarat ranks 12th place among the different states of India with respect to area under organic farming (Mahapatra *et al.,* 2009).

Sustainable crop production can be achieved through the adoption of organic farming that enhances the soil biological productivity. Further integrated nutrient management system implying organic manures and bio-fertilizers with the minimum input of chemical fertilizers can help in improving the biological productivity of the soil for sustainable production. Organic farming helps in protecting the long term fertility of soils by maintaining organic matter levels, encouraging soil biological activity and careful mechanical intervention. Keeping in view, the need to find out the sustainable organic farming package over inorganic nutrient management in rice- summer groundnut crop sequence, present experiment was undertaken.

MATERIAL AND METHODS

The experiments were taken during the year 2003-04 to 2011-12 at Farming System Research Farm, Navsari Agriculture University, Navsari (Gujarat) to compare the organic farming package for productivity and profitability of *kharif* rice - summer groundnut crop sequence. Climate is characterized by fairly hot summer, moderately cold winter, humid and warm monsoon with heavy rain. Average rainfall during the experimental years recorded about 1600 mm in 62 rainy days with highest evaporation rate of 7.2 (mm/day) in the month of May. Minimum bright sunshine hours observed during month of July (1.2 BSSH), while clear atmosphere with maximum bright sunshine hours in the month of April (11.0 BSSH). The soil of the experimental site was clayey with organic carbon (0.59 %), bulk density (1.45 g/cc), available nitrogen (225 kg/ha), phosphorus (43kg/ha) and potash (318 kg/ha). The experiment comprised of eight treatments along with one dummy treatment in non replicated trial with plot size of 365.04 m^2. The treatments details was, T_1: 50%

recommended NPK+ 50% N from FYM + inorganic sources of micronutrients as per soil test, T_2 : Different organic sources each equivalent to 1/3 of recommended N (FYM + vermicompost + castor cake), T_3 : T_2 + Intercropping or trap crop (location specific in each season), T_4 : T_2 + Agronomic practices for weed and pest control (No chemical pesticides and herbicides), T_5 : 50% N from FYM + Bio fertilizer for N (*Azatobactor/Rhizobium*)+ Rock phosphate to substitute P requirement of crop + Phosphate solubilizing bacterial culture (PSB-16), T_6 : T_2 + Bio fertilizer containing N (*Azotobactor*) and P carriers (PSB-16), T_7 : 100% NPK+ Secondary and micro-nutrients based on soil test, T_8 : Dummy plot (T_2). Organic source *viz.*, FYM, vermicompost, castor cake and rock phosphate were analyzed for their NPK composition and applied at the time of sowing according the treatments. In T_2, applied quantity of phosphorus and potash was not considered due to sufficient availability of native P and K in soil, while applied potash in T_5. The seeds were treated as per treatment with *Rhizobium, Azotobacter* and PSB culture and were dried under shade before sowing for 2 hrs. The rice and groundnut crops were fertilized with 100+30+00 NPK kg/ha and 25+50+00 NPK kg/ha, respectively. Grain and straw yields of paddy and pod & haulm yields of summer groundnut were recorded at the time of harvest of each crop. Equivalent yield of paddy was calculated on the basis of farm gate prices for each crop. No plant protection measures were taken during the crop season for the both crops. Soil analysis was carried out by collecting soil samples from 0 - 15 cm depth at 10 different spots ascertained in a random manner. The samples were drawn before the application of fertilizers to the experimental field during the each year. The experiment was non replicated, so for the statistical analysis, year is taken as replication and for that initial five years mean data taken as first replication and remaining individual year was 2nd, 3rd, 4th and 5th replication, respectively. The treatment T_8 was taken as dummy treatment, so it was not considered in statistical analysis.

RESULTS AND DISCUSSION

Productivity: Results revealed that reduction in rice yield was observed in treatments receiving organic sources (T_2, T_3, T_4, T_5 and T_6) as compared to chemical (T_7) and integrated nutrient management (T_1) during initial years (mean of 2003-04 to 2007-08, Table 1). The reduction in yield due organic nutrient management ranges from 18.2 % (T_4) to 9.7 % (T_6) over 100 % chemical sources of nutrients used (T_7). While in the year 2011-12, it was increased up to 17.5 % in T_6 over T_7. From the pooled data, it revealed that significantly higher *kharif* rice grain yield was recorded under treatment T_7 (3801 kg ha^{-1}), which was statistically at par with treatments T_6, T_2 and T_3.

The groundnut pod yield was reduced under the treatments which received organic sources of fertilizers during initial years (Mean of 2003-04 to 2007-08). In the year 2008-09, the highest groundnut yield was recorded under the treatment T_1, while it was highest under T_2 during 2009-10 and 2010-11. During 2011-12, it was highest under T_4 (1997 kg ha^{-1}). In pooled results, the significantly higher groundnut yield was recorded under Treatment T_2 (1928 kg ha^{-1}), which was statistically at par with T_1 (1835 kg ha^{-1}). The significantly lowest groundnut yield was recorded under T_5. The percent increase in groundnut yield to the tune of 21.79 %, 10.23 %, 8.46 %, 7.39 % under T_2, T_3, T_6 and T_4, respectively over T_7.

There was reduction in paddy equivalent yield under the treatments which received organic source of nutrient management over chemical fertilizer as well as integrated management (T_7 and T_1) during initial years (Table- 3). During 2011-12, T_4 (12860 kg ha^{-1}), recorded highest paddy equivalent yield followed by T_2 (12694 kg ha^{-1}). The per cent increase in paddy equivalent yield to the tune of 14.6 %, 13.1 % and 10.7 % under T_4, T_2 and T_6, respectively over T_7. The lowest paddy equivalent yield was recorded under treatment T_5. In pooled results, the treatment T_2 recorded significantly higher paddy equivalent yield, which was statistically at par with T_1. The percent increase in PEY to the tune of 13.2 %, 5.2 %, 4.4 % and 0.7 % under treatment T_2, T_6, T_3 and T_4 over chemical treatment (T_7). The significantly lowest paddy equivalent yield was observed under T_5 (11781 kg ha^{-1}). The lower paddy equivalent yield during most of all the years of experimentation because this treatment received 50 % N from FYM + Bio fertilizer for N (*Azatobactor/Rhizobium*) + Rock phosphate to substitute P requirement of crop+ Phosphate solubilizing bacterial culture (PSB-16). This indicated that biofertilizer is not able to fix the atmospheric nitrogen for the crop.

On the basis of pooled data from 2003-04 to 2011-12, treatment T_6: (T_2 + Bio fertilizer containing N (*Azotobactor*) and P carriers (PSB-16) recorded higher paddy equivalent yield as compared to T_3, T_4 and T_5 and 15.6 %, 14.6 % and 10.6 % higher paddy equivalent yield over T_5 (11781 kg ha^{-1}), respectively.The increases under T_2 in paddy equivalent yield might be due to synergistic effect of optimum rate of integrated sources of nitrogen fertilizers, which enhanced the photosynthetic activity and accumulation of carbohydrates, which in turn was translocated in large amount to the seeds resulting in higher grain yield. This results are confirmed by those reported by Prasad *et. al*.

Table 1. Effect of organic farming treatments on rice grain yield (kg/ha)

Treatment	2003-04 to 2007-08 (Mean)	2008-09	2009-10	2010-11	2011-12	Pooled
T_1	4373	4798	4199	3585	2472	3885
T_2	3781	4548	3546	4501	2218	3719
T_3	3914	4364	3482	3874	2170	3561
T_4	3550	4413	3508	3360	2051	3376
T_5	3708	3733	3044	3649	2000	3227
T_6	3922	4649	3706	3745	2649	3734
T_7	4344	4591	4134	3681	2254	3801
					C.D. (p=0.05)	340
					CV (%)	7.21

Table 2. Effect of organic farming treatments on groundnut yield (kg/ha)

Treatment	2003-04 to 07-08 (Mean)	2008-09	2009-10	2010-11	2011-12	Pooled
T_1	1962	1929	1929	1700	1653	1835
T_2	1917	1852	2052	1900	1921	1928
T_3	1741	1817	1817	1653	1698	1745
T_4	1529	1748	1748	1479	1997	1700
T_5	1604	1505	1505	1463	1366	1489
T_6	1451	1871	1871	1651	1743	1717
T_7	1462	1620	1620	1600	1614	1583
					C.D. (p=0.05)	158
					CV (%)	7.07

Table 3. Effect of organic farming treatments on rice equivalent yield (kg/ha) in rice- groundnut sequence from 2003-04 to 2011-12

Treatment	2003-04 to 07-08 (Mean)	2008-09	2009-10	2010-11	2011-12	Pooled
T_1	15135	16135	15374	13449	11683	14355
T_2	14219	15465	15274	15609	12694	14652
T_3	13516	15012	13914	13514	11579	13507
T_4	12014	14668	13564	12066	12860	13034
T_5	12570	12633	11792	12209	9700	11781
T_6	12128	15660	14512	13369	12423	13618
T_7	12601	14205	13691	12989	11219	12941
					C.D. (P=0.05)	960
					CV (%)	5.48

(2002) and Lavanya and Manapathy(2009).

Profitability: Highest net return was recorded under the treatment T_1 during mean of 2003-04 to 07-08, 2008-09 and 2009-10. In 2011-12, it was highest under treatment T_4 (Rs.67903/ha). In pooled result, significantly highest net return was recorded under T_1 (Rs 88458 /ha) followed by T_2 (Rs 87418 /ha) and T_6 (Rs 76047 /ha). The lowest net profit was recorded under the treatment T_5 (Rs.66824 /ha). The decrease in net profit under T_7 (chemical fertilizer) might be due to the higher paddy equivalent yield of the treatment T_1 and T_2 as compared to T_7 during the pooled result, which resulted into higher gross and net profit (Table 4).

Considering premium price of product

During all the years, even after considering 25 % higher premium price of organic product of treatment T_2 growing, rice crop was not profitable as compared to chemical treatment T_7, while in case of groundnut it was profitable throughout the experimentation period (Table 5). In case of crop sequence study, during initial year 2003-04, crop sequence T_2, which received 100 % organic sources of manure (Rs.102025/ha) even after considering 25 % higher premium price of organic product was not profitable over T_7 (Rs. 112357/ha), but at the end of ninth year, the treatment T_2 (Rs.87418 /ha) become profitable even without considering 25 % higher prices over T_7(Rs.66824 /ha). The percent increase in net profit under T_2 to the tune of 30.8 per cent over T_7.

From the result, it can be concluded that at the end of ninth year of experimentation, the organic farming package i.e. each sources equivalent to 1/3 of recommended

Table 4. Effect of organic farming treatments on net return (/ha) in rice -groundnut sequence from 2003-04 to 2011-12

Treatment	2003 -04 to 07 - 08 (Mean)	2008 -09	2009 - 10	2010 -11	2011 - 12	Pooled
T_1	96950	107839	99552	78589	59360	88458
T_2	82701	96270	94186	97840	66093	87418
T_3	74496	90785	78828	74480	53406	74399
T_4	58694	87594	75566	59255	67903	69802
T_5	75423	76107	66944	71484	44163	66824
T_6	59816	98277	85781	73327	63033	76047
T_7	82426	99891	94292	86642	67376	86125
					C.D. (P=0.05)	10454
					CV (%)	10.25

Table 5. Net return of organic treatments by considering 25 % higher premium price

Treatments		Net return (ha)					
		Rice		Groundnut		Sequence	
		(25% higher price for T_2, T_5 and T_6)	(Without 25% higher price for T_2, T_5 and T_6)	(25% higher price for T_2, T_5 and T_6)	(Without 25% higher price for T_2, T_5 and T_6)	(25% higher price for T_2, T_5 and T_6)	(Without 25% higher price for T_2, T_5 and T_6)
		2003 -04	Pooled	2003 -04	Pooled	2003 - 04	Pooled
T_1	50 % NPK+ 50 % N from FYM	38202	22957	63822	55363	102025	88458
T_2	1/3 + 1/3+1/3 (FYM + VC+ CC)	29169	18256	79871	59197	109040	87418
T_5	50 FYM + Bio F. + RP	52753	17975	66150	43919	110903	74399
T_6	T_2 + Azo. + PSB	48968	20425	40619	50204	89587	69802
T_7	100 % NPK	52528	21339	44456	46327	112357	66824

N (FYM + vermicompost + castor cake) recorded significantly higher productivity over all rest of organic farming package followed by integration of 50% recommended NPK from inorganic and 50% N from FYM along with micronutrients as per soil test. In case of profitability of crop sequence, 50% recommended NPK inorganic fertilizer and 50% N from FYM along with micronutrients as per soil test recorded highest profitability followed by the application of each sources equivalent to 1/3 of recommended N (FYM + vermicompost + castor cake). By considering 25 % higher premium prices of organic product, organic farming package become profitable over inorganic fertilizer.

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Changes in Soil Microflora with Herbicides Application in Autumn Sugarcane Based Intercropping Systems

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Abstract: Soil health and microbial diversity have become vital issues for the sustainable agriculture and safe environment. The effect of herbicide application in intercropping systems on major soil microbial population was studied at PAU, Ludhiana, at two different sites during 2010-11 and 2011-12, respectively. The experiment consisted of 3 cropping systems {sole sugarcane, sugarcane + gobhi sarson (1:1) and sugarcane + raya (1:2)}in the main plots and six weed control treatments {pendimethalin 0.56 kg & 0.75 kg ha^{-1} pre emergence, alachlor 1.25 kg & 1.88 kg ha^{-1} pre emergence, hand weeding and weedy check} in sub plots replicated thrice in a split plot design. The autumn sugarcane intercropped with gobhi sarson and raya had differential effect on population of different soil microbes during four weeks of study. After 30 days, at site II, bacterial population declined from 48.9 x 10^6 cfu g^{-1} in sole sugarcane to 40.5 x 10^6 cfu g^{-1} in sugarcane and raya intercropping, while actinomycetes increased (30.3 x 10^4 to 35.0 x 10^4 cfu g^{-1}) with intercropping of *Brassica* crops. The count of fungal colonies did not vary much with intercropping at site I. Pre emergence application of pendimethalin and alachlor at varying doses was not showing any detrimental effect to soil microbes (bacteria, actinomycetes and fungi). However, a temporary reduction in number of bacteria was observed immediately after herbicide application and later it was recovered within four weeks.

***Key Words*:** Alachlor, Intercropping, Pendimethalin, Soil microbes

Intercropping in autumn sugarcane is quite common and an economical approach for higher unit productivity from same piece of land. Pulses, oilseeds and vegetables can be successfully grown during *rabi* season as intercrops in the space between sugarcane rows without having any adverse effect on the main crop (Singh and Vashisht, 2004). Intercropping of gobhi sarson (*Brassica napus*) and raya (*Brassica juncea*) in autumn sugarcane has been found to be one of the viable option to augment the production and income (Singh *et al.* 2007). In agricultural systems, weeds often pose a major threat to crop yields and in intercropping systems and manual weed control is not always feasible. Hence, it necessitates the use of herbicides for timely weed control. Pendimethalin (*N*-(1-ethylpropyl)-2,6-dinitro-3,4-xylidine) and alachlor (2-chloro-2',6'-diethyl-N-(methoxymethyl)- acetanilide) are the selective herbicides used in *Brassica* crops intercropped with sugarcane for effective weed control and increased the intercrop yields (Chauhan *et al.* 2005 and *Shimi et al. 2007*). However, little is known about the effect of these herbicides and intercropping on soil microbial population in autumn sugarcane. Some of the studies show that the microbial diversity of soils is affected by crop management practices and the count and composition of bacterial and fungal communities in soil can be interacted either directly by changing host plant physiology or indirectly by changing the patterns of root exudation. Intercropping usually benefits from increased microbial number, and hence improved soil enzyme activity (Chai *et al.* 2005). The addition of herbicides can cause qualitative and quantitative alterations in the soil microbial communities (Saeki and Toyota, 2004) that may affect the functional stability of the soil microflora and hence the soil health (Girvan *et al*. 2004). Some of the earlier workers reported that the application of herbicides at normal field do not cause any change in total number of soil microorganisms whereas other workers reported that the herbicides may be stimulatory or inhibitory to specific groups of microbes (Oyeleke *et al.* 2011). The present study is an attempt in this direction to investigate how agronomic practices of herbicides application in autumn sugarcane intercropped with gobhi sarson and raya would affect soil microbial population.

MATERIAL AND METHODS

The study was carried out during 2010-11 and 2011-12 in experimental fields of Department of Agronomy, at Punjab Agricultural University, Ludhiana, Punjab. The experiments were laid out in split plot designs with cropping systems in main plots and weed control treatments in sub plots replicated thrice. The cropping systems were sole sugarcane, sugarcane + gobhi sarson (1:1) and sugarcane + raya (1:2). The weed control treatments were pendimethalin

0.56 kg & 0.75 kg ha^{-1} pre emergence, alachlor 1.25 kg & 1.88 kg ha^{-1} pre emergence, hand weeding and weedy check. In both years, trials were conducted on separate experimental fields with different cropping history. On the first experimental site, lemon grass and aloe vera were cultivated for three years while on the second experimental site medicinal crops were grown under the poplar plantations from last five years. Hence, both the sites were varied in their soil physico-chemcial properties reported in Table 1.

Table 1. Soil characteristics of experimental fields (0-30 cm)

Characteristics	Site I 2010-11	Site II 2011-12
Sand (%)	78.3	80.0
Silt (%)	11.0	12.9
Clay (%)	10.7	7.1
pH	7.5	8.3
EC (ds m^{-1})	0.24	0.44
Organic carbon (%)	0.38	0.41
N(mg/kg)	108.3	122.1
P (mg/kg)	8.30	8.79
K (mg/kg)	66.9	95.1

The Sugarcane 'CoJ 85' crop was sown at 90 cm row spacing on 15 September 2010 and 2011 respectively, and one row of gobhi sarson 'GSL-2' and two rows of raya 'RLC-1' were accommodated in between the sugarcane rows. The herbicides were applied using flat fan nozzle by making solution in 750 L of water ha^{-1} on day following sowing of intercrops. The composite soil samples were taken at 0, 15 and 30 days after herbicides spray (DAS) from 0-15 cm soil depth and mixed so as to have a representative sample of the treatment and analysed for the effect on soil microbial populations. On the zero day, the herbicides were applied in the early morning and soil samples were collected in evening approximately 8 hours after spray. The viable microbial counts were analyzed by using serial dilution and pour plating technique. Soil extract agar was used for count of total bacterial population. The population of actinomycetes was estimated on dextrose nitrate agar. The fungal population was cultured on Rose Bengal Agar (Martin 1950). The representative soil samples packed in sterilized polybags were opened under aseptic conditions and a part was drawn for serial dilution. Pre-sterilized standard glass petri-dishes were used for plating of diluted soil samples in triplicate and were incubated at 30+10 ^{0}C in an inverted position for 5-7 days till the countable colonies of each type developed. The respective colonies were counted by visual observations of their characteristics and growth pattern like fungi show mycelia cottony growth on the agar surface with or without variously coloured spores; actinomycetes form white, dull white or grey coloured colonies of comparatively small size and with powdry appearance and bacteria form slimy wet or partially wet, minute pinhead to large spreading colonies on the agar surface.

The microbial counts were expressed as colony forming units per gram (cfu g^{-1}) for which the colonies were counted. Mean of the three replicates was taken and divided by weight of the sample to calculate the count per gram soil on dry weight basis. The data so obtained were multiplied by their respective dilution factors (10^6, 10^4 and 10^3 for bacteria, actinomycetes & fungi, respectively) to express the final count.

All data were subjected to ANOVA using statistical analysis software version 9.3 (SAS 9.3) to test for treatment effects and possible interactions. Normality, homogeneity of variance and interactions of treatments were tested. Where the ANOVA indicated that treatment effects were significant, means were separated at $P \leq 0.05$ with Tukey's tests. Means with same letter were non-significant at 5 per cent level of significance.

RESULTS AND DISCUSSION

The population of bacteria did not vary amongst cropping systems at same day of spray and 15 DAS at both the sites (Table 2 & 3). After 30 DAS, significantly lower bacterial count was observed in the rhizosphere of raya than gobhi sarson and sole sugarcane only at site II. Bacterial population declined from 48.9 x 10^6 cfu g^{-1} in sole sugarcane to 40.5 x 10^6 cfu g^{-1} in sugarcane intercropped with raya. Since plant species differ in their biochemical composition, changes in plant diversity alter the quantity and quality of rhizodeposits and exudates, thereby control the composition and functioning of soil microbial communities (Nilsson *et al.* 2008). The population of actinomycetes did not differ significantly amongst the cropping systems on the same day of spray than sole sugarcane at both the sites. Contrary to bacteria, the actinomycetes count increased with intercropping of *Brassica* crops at 15 and 30 DAS. The differential chemical reaction in the rhizopshere under different crops might be responsible for differences in microbial population under the intercropping systems. Plants can modify their rhizosphere through nutrient, moisture and O_2 uptake from the rhizosphere as a result modify the microbial community (El-Shatnawi and Makhadmeh, 2001). Fungal count did not vary under sole cropping and intercropping of sugarcane during the study period of four weeks at both the sites except at site II where fungal population was significantly lower in sole sugarcane after four weeks.

Bacterial population declined significantly with

Table 2. Soil microbial population (cfu g^{-1}) as influenced by cropping systems and weed control treatments at Site 1

Treatments	Bacteria ($x10^6$)			Actinomycetes ($x10^4$)			Fungi ($x10^3$)		
	Days after spray								
	0	15	30	0	15	30	0	15	30
Cropping systems									
Sugarcane sole	32.2 a	41.5 a	48.6 a	36.0 a	38.6 b	32.7 b	26.3 a	28.8 a	33.1 a
Sugarcane + gobhi sarson	32.4 a	41.0 a	50.0 a	38.0 a	42.0 a	31.9 b	29.5 a	29.3 a	33.2 a
Sugarcane + raya	31.4 a	40.5 a	51.1 a	37.3 a	40.1 a	35.0 a	29.7 a	33.5 a	32.8 a
SEm	1.13	0.88	1.51	0.56	1.21	1.12	1.34	1.81	0.15
F(p)	0.56	0.43	0.06	0.32	0.02	0.015	0.21	0.06	0.93
Weed control treatments									
Pendimethalin 0.56 kg ha^{-1}	29.7 b	40.6 a	46.6 a	39.5 a	41.5 a	32.0 a	25.6ab	27.8 a	30.8 a
Pendimethalin 0.75 kg ha^{-1}	30.3 b	41.8 a	49.5 a	39.5 a	39.7 a	33.3 a	24.6 b	32.1 a	34.1 a
Alachlor 1.25 kg ha^{-1}	30.0 b	41.8 a	49.1 a	36.1 a	39.8 a	31.6 a	27.8ab	28.5 a	32.3 a
Alachlor 1.88 kg ha^{-1}	29.6 b	41.0 a	49.3 a	38.6 a	35.8 a	32.8 a	26.3ab	32.8 a	34.0 a
Hand weeding	36.8 a	40.6 a	53.1 a	34.1 a	44.0 a	34.6 a	32.5ab	31.3 a	32.6 a
Weedy check	35.6 a	40.1 a	52.0 a	38.5 a	41.0 a	34.8 a	34.1 a	30.6 a	34.5 a
SEm	0.86	1.62	2.02	0.43	1.90	0.93	2.75	1.41	0.99
F(p)	0.021	0.25	0.42	0.67	0.21	0.14	0.02	0.44	0.32
Interaction F(p)	0.43	0.94	0.60	0.98	0.19	0.07	0.95	0.44	0.27

F(p) values of 0.05 or lesser means significant effect
Treatment means superscripted by different alphabets are statistically different

Table 3. Soil microbial population (cfu g^{-1}) as influenced by cropping systems and weed control treatments at Site II

Treatments	Bacteria ($x10^6$)			Actinomycetes ($x10^4$)			Fungi ($x10^3$)		
	Days after spray								
	0	15	30	0	15	30	0	15	30
Cropping systems									
Sugarcane sole	29.5 a	39.5 a	48.9 a	25.8 a	29.2 b	30.3 b	23.8 a	22.0 a	24.4 c
Sugarcane + gobhi sarson	29.7 a	39.9 a	44.9 ab	26.3 a	30.0 b	31.1 b	24.0 a	22.9 a	26.0 b
Sugarcane + raya	30.0 a	44.5 a	40.5 b	29.8 a	33.5 a	35.0 a	24.3 a	24.3 a	26.9 a
SEm	0.17	1.94	2.94	1.54	1.62	1.79	0.17	0.82	0.89
F(p)	0.91	0.13	0.002	0.07	0.05	0.02	0.90	0.06	0.19
Weed control treatments									
Pendimethalin 0.56 kg ha^{-1}	28.5 b	40.3 a	46.5 a	24.5 a	30.0 a	31.7 a	24.0 a	22.1 a	24.1 a
Pendimethalin 0.75 kg ha^{-1}	28.1 b	40.3 a	45.1 a	27.2 a	31.3 a	32.3 a	22.3 a	22.8 a	26.1 a
Alachlor 1.25 kg ha^{-1}	28.3 b	39.3 a	46.6 a	28.3 a	31.3 a	30.0 a	23.6 a	22.6 a	27.0 a
Alachlor 1.88 kg ha^{-1}	27.0 b	44.5 a	46.5 a	27.8 a	29.2 a	31.7 a	23.8 a	23.5 a	27.3 a
Hand weeding	32.3 a	41.8 a	44.3 a	28.2 a	32.5 a	32.8 a	24.8 a	23.5 a	25.5 a
Weedy check	34.5 a	41.6 a	39.6 a	27.5 a	31.0 a	34.7 a	25.8 a	23.8 a	24.5 a
SEm	2.06	1.27	1.89	0.99	0.67	0.97	0.83	0.44	0.84
F(p)	0.003	0.32	0.15	0.66	0.81	0.64	0.39	0.79	0.47
Interaction	0.46	0.30	0.63	0.98	0.93	0.55	0.72	0.22	0.39

F(p) values of 0.05 or lesser means significant effect
Treatment means superscripted by different alphabets are statistically different

application of pendimethalin and alachlor at their respective doses on the same day of spray at both the sites than unsprayed plots. Higher bacterial populations observed in the unsprayed treatments might be due to the fact that healthy and conducive environment was present in soil for the survival and growth of micro organisms which change unfavorably in the herbicide treated plots. Sarkar *et al.* (2005) reported that pre emergence application of pendimethalin (0.75 kg and 1.0 kg ha^{-1}) reduced the total soil bacterial population after one week in mustard crop. Ismail and Shamsuddin (2005) observed that alachlor caused a reduction in bacterial and fungal counts at 7 and 14 days after its application but had no further effects. However, on the contrary, actinomycetes and fungal count did not differ significantly with herbicide application at 0, 15 and 30 DAS at site I and II. Actinomycetes has been reported to be relatively resistant to herbicides and get affected at high concentration only (Sondhia 2008).

There has been a general rise in microbial count treated with herbicides reaching maximum around four weeks (Table 2 & 3) indicating that the microbial population started building up as the herbicides got degraded to undo the inhibition of microbial growth. The degradation products might serve to improve the soil health. This finding agrees with the study of Kunc *et al.* (1985) who worked on mineralization and changes in the count of bacterial decomposers and observed a rise in microbial count in treated soils. The soil microflora is able to temporarily mineralize and use the degradation products of herbicides as carbon source for the growth of microbes (Ramesh 2003). In addition to this, intercropping in sugarcane with *Brassica* crops also witnessed differential effect on population of bacteria, actinomycetes and fungi. But overall intercropping favoured the buildup of soil microbes as compared with sole cropping.

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Induced Mutagenesis in Bread Wheat (*Triticum aestivum* L. CVS. PBW-373 and Raj-3765) through Temperature and Hydroxyl Amine

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***Abstract*:** The present investigation was undertaken to induce genetic variability through the use of temperature (physical) and Hydroxyl amine (chemical) mutagenic treatments on two popular bread wheat varieties, PBW-373 and Raj-3765. The data on seed quality parameters, like mean germination percentage, shoot length, root length and seedling vigour index, were recorded in M_1 generation. In field, the observations were recorded on characteristics like Days to ear head emergence, Days to blooming, Days to maturity, Plant height (cm) at maturity, Number of effective tillers per plant, Spike length (cm), Number of grains per spike, Number of spikelets per spike, 100 grain weight (g) and Grain yield per plant (g). Analysis of variance (Split plot design) and parameters of statistical and genetic variability (micro mutations) were estimated in the field related traits. Mutagenic treatments were found to increase the phenotypic and genotypic coefficient of variation as well as heritability and genetic advance. Macro mutations of economic and academic interest were also recovered. In general, 50 ^{0}C temperature treatment was observed as best, to improve the seed quality parameters, to create the genetic variability and for the enhancement of grain yield and yield related traits.

Key Words: Genetic variability, Hydroxyl amine, Mutation, Temperature, Wheat

Genetic improvement of crop plants is the key to increase in food productivity. The conventional breeding method have been found useful only combining the characters already existing in the population but no new character can be produced in the variety by these methods. Mutation breeding is relatively cheap and quicker method for improvement, and can be used for the creation of new variation in crop plants. It has long been known that induced mutation could be useful for the solution of specific problem where conventional methods were insufficient, particularly in transferring genes for lodging resistance, disease resistance and changing the grains color. Mutation breeding have been used, in incorporating one or two desirable attributes in otherwise well adapted variety, in upgrading the protein quality, in producing hereditary changes that allow another breeding technique to be applied, in enhancing the genetic variation for quantitative characters, and for the creation of macro, micro and systematic mutations (Ahloowalia *et al.,* 2004).

Mutation breeding in wheat has significantly contributed towards the increase in global food production as wheat being one of the most important food crops of the world. Hundreds of useful mutants have been induced for various plant characters in wheat through treatment with physical and chemical mutagens. Superior mutant types having better agronomic values in terms of yield and yield components has obtained via mutation breeding in wheat (Sakin *et al*., 2005).

The present investigation was undertaken to induce genetic variability through the use of temperature (physical) and hydroxyl amine (chemical) mutagenic treatments on two popular bread wheat varieties, PBW-373 and Raj-3765. Some seed quality parameters and various field related traits were evaluated in mutagenised populations of M_1 generation. Moreover, micro and macro mutations of economic and academic interest were also screened and recovered in the same generation.

MATERIAL AND METHODS

The present study was conducted in Rabi season of 2010-2011 at Agriculture Research Farm of R.B.S. College, Bichpuri, Agra **(**latitude 27.2º North, longitude 77.9º East and altitude 163 meters above mean sea level). The seeds of two popular wheat varieties PBW-373 and Raj-3765 were used in present investigation. Separate lots of 500 dry seeds of both the varieties were subjected to temperature treatments of 50 ºC ± 1ºC, 15 ºC ± 1 ºC and 50 ºC ± 1 ºC plus 15 ºC ± 1 ºC, each for 15 minutes. For chemical mutagenic treatments, 1500 seeds of both the varieties were presoaked in distilled water for 6 hours. The three sets, each of 500 presoaked seeds were soaked for 2 hours in 0.3%, 0.4% and 0.5% hydroxyl amine separately, for both the varieties (Table 1).

Fifty seeds from each of the treatments, including control were sown in petridishes half filled with water and lined with blotting paper. Each treatment of 50 seeds was replicated 3 times and the petridishes were kept in Environmental Growth Chamber at a temperature of 25 ± 1ºC and the relative humidity of 85 ± 5 percent. In field, the seed of both the varieties were sown in split plot design considering

varieties as main treatments and temperature and chemical mutagenic treatments including control as sub treatments. The 7 sub treatments were randomized in the main treatments, which were replicated three times. Each replication comprised of 5 rows, each of 4 meters in length, for each of the sub treatments in a main treatment. The spacing was maintained as 25 x 10 cm and all the necessary field operations were performed, as and when required.

In laboratory, the observations like germination percentage, root length, shoot length and seedling vigor index were recorded. The germinated seeds in petridishes were counted in each treatment and replication on fourth day of sowing, and were recorded as percentage. The root length was measured from the point of emergence up to the tip of longest root, in 10 randomly selected plants of each petridish. The seedling height (shoot length) was measured from the point of emergence to its tip, in the same 10 randomly selected plants. Both root length and shoot length were recorded on the 8^{th} day of germination. Seedling vigour index was calculated according to the formula given by Baki and Anderson (1973) [Seedling vigour Index (SVI) = (Root length + Shoot length) x Germination percentage].

In field, the observations were recorded on characters like Days to ear head emergence, Days to blooming, Days to maturity, Plant height (cm) at maturity, Number of effective tillers per plant, Spike length (cm), Number of grains per spike, Number of spikelets per spike, 100 grain weight (g) and grain yield per plant (g). Means of the respective observations were estimated in various treatments of M_1 generation. Analysis of variance (Split plot design) and parameters of statistical and genetic variability (micro mutations) were also worked out. Some macro mutations of economic and academic interest were also screened.

Table 1. Details of treatments subjected to wheat varieties PBW-373 and Raj-3765

S.N.	Main Treatment
1.	Control (Dry)
2.	50 ºC temp. treatment for 15 minutes
3.	15 ºC temp. treatment for 15 minutes
4.	50 ºC hot and15 ºC cold treatment each for 15 minutes
5.	0.3% Hydroxyl amine for two hours
6.	0.4% Hydroxyl amine for two hours
7.	0.5% Hydroxyl amine for two hours

RESULTS AND DISCUSSION

The data on parameters, like mean germination percentage, shoot length, root length and seedling vigour index, were recorded in M_1 generation (Table 2). It was observed that both the physical and chemical mutagenic treatments had enhanced germination percentage over control in both the varieties. In variety PBW-373, the germination was observed to be 100 % at 50 ºC and 15 ºC, as compared to 93% in control. At 50 ºC plus 15 ºC combined treatment, the germination was found to be 98%. The hydroxyl amine treatments also enhanced the germination percentage. In variety Raj-3765, the separate treatments of 50 ºC and 15 ºC gave 99% and 97% germination respectively, while the 50 ºC plus 15 ºC combined temperature treatment exhibited 95% germination. The hydroxyl amine treatments also recorded more or less similar results. In general, the sole temperature treatments were observed to enhance germination percentage more than the hydroxyl amine in both the varieties. Both the physical and chemical mutagens has enhanced shoot length over control in both the varieties. In variety PBW-373, 16.34 cm was the highest shoot length obtained at 50 ºC, followed by 16.22 cm at 15 ºC, 15.56 cm at 50 ºC plus 15 ºC combined treatment and 15.43 cm in 0.4% hydroxyl amine treatment, whereas the shoot length of 13.76 cm was observed at control. In variety Raj-3765, the highest shoot length of 15.98 cm was estimated at 50 ºC followed by 15.05 cm at 0.3% hydroxyl amine treatment, as compared to 13.87 cm in control. It was observed that both the physical and chemical mutagenic treatments has enhanced root length in both the varieties. In variety PBW-373, the highest root length was observed to be 20.89 cm at 50 ºC, followed by 20.87 cm at 15 ºC, 20.17 cm at 50 ºC plus 15 ºC combined treatments and 20.05 cm at 0.4% hydroxyl amine treatment. In case of control, the shoot length was observed to be 17.57. In variety Raj-3765, the highest shoot length of 20.66 cm was observed at 50 ºC, followed by 19.87 cm at 0.3% hydroxyl amine treatment and 19.56 cm at 15 ºC. In control, the shoot length was observed to be 13.87 cm. Both the physical and chemical mutagens were found to increase seedling vigour index in both the varieties. In variety PBW-373, the highest seedling vigour index of 3723.00 was observed at 50 ºC, followed by 3700.00 at 15 ºC, 3501.54 at 50 ºC plus 15 ºC combined treatment and 3094.15 at 0.3% hydroxyl amine. However, seedling vigour index of 2913.69 was observed in control. In variety Raj-3765, the estimates were 3627.36 at 50 ºC, 3387.24 at 0.3% hydroxyl amine, 3338.74 at 15 ºC and 3162.24 at 0.4% hydroxyl amine, as compared to 2986.38 in control. It is quite clear from the results obtained that 50 ºC temperature is the best treatment to get highest enhancement in the above seed quality parameters in both the varieties and 0.4% hydroxyl amine has appeared to be the best of all doses of the chemical mutagens. The more reduction in estimates of these parameters in higher doses than those in lower doses of mutagenic treatments is in conformity with the findings of Kumar (1978).

In order to study field related traits, the character means for each of the treatments were expressed as percentage over control (Table 3). In general, the reduction in days to ear head emergence was observed due to physical (temperature) and chemical (hydroxyl amine) treatments in both the varieties. As compared to 77.39 (100%) days in control, the minimum of 63.64 (82.83%) days to ear head emergence was observed at 50 ºC temperature in variety PBW- 373. Among the mutagenic treatments, maximum of

73.34 (94.76%) days to ear head emergence were recorded at combined temperature treatment. In variety Raj-3765, as compared to 79.07 (100%) days in control, the lowest of 65.96 (83.42%) days were recorded at 50 ºC, whereas the maximum record of 75.05 (94.92%) days was observed at 50 ºC plus 15 ºC combined treatment. The temperature treatments has hastened ear head emergence more than the hydroxyl amine treatments in PBW-373. In Raj-3765, except for 50ºC, the effect of other temperatures and hydroxyl amine treatments were similar and they induced earlier ear head emergence as compared to control. All the treatments enhanced earlier blooming in comparison to control. As

Table 2. Estimates of the seed quality parameters in M_1 generation

Treatment	Germination %	Mean shoot length (cm)	Mean root length (cm)	Seedling vigour index
PBW -373				
T_1 = Control	93	13.76	17.57	2913.69
T_2 = (50 ºC)	100	16.34	20.89	3723.00
T_3 = (15 ºC)	100	16.22	20.78	3700.00
T_4 = (50 ºC + 15 ºC)	98	15.56	20.17	3501.54
T_5 = 0.3% Hydroxyl amine	95	14.12	18.45	3094.15
T_6 = 0.4% Hydroxyl amine	98	15.43	20.05	3477.04
T_7 = 0.5% Hydroxyl amine	96	14.35	19.23	3223 .68
Raj- 3765				
T_8 = Control	94	13.87	17.90	2986.38
T_9 = (50 ºC)	99	15.98	20.66	3627.36
T_{10} = (15 ºC)	97	14.86	19.56	3338.74
T_{11} = (50 ºC + 15 ºC)	95	14.04	18.25	3067.55
T_{12} = 0.3% Hydroxyl amine	97	15.05	19.87	3387.24
T_{13} = 0.4% Hydroxyl amin e	96	14.27	18.67	3162.24
T_{14} = 0.5% Hydroxyl amine	96	14.66	19.43	3272.64

Table 3. Estimates of means expressed as percentage over control for various characters under study in M_1 generation

Treatment	Days to ear head Emergence	Days to blooming	Days to maturity	Plant Height (cm)	No. of Tillers/ Plant	Spike length (cm)	No. of Grains/ spike	No. of Spikelets/ Spike	100 Seed Weight (g)	Grain yield/ Plant
Variety PBW -373										
T_1 = control	77.39 (100)	92.80 (100)	133.66 (100)	103.90 (100)	12.54 (100)	10.77 (100)	48.17 (100)	12.73 (100)	3.40 (100)	32.27 (100)
T_2 = (50 ºC)	63.64 (82.83)	81.12 (87.41)	115.00 (86.03)	79.67 (76.67)	18.27 (145.69)	14.90 (138.34)	81.57 (169.33)	21.89 (171.95)	5.49 (161.47)	51.66 (160.08)
T_3 = (15 ºC)	65.51 (84.64)	82.96 (89.39)	117.66 (88.02)	82.55 (79.45)	18.23 (145.37)	14.76 (137.04)	81.52 (169.23)	20.34 (159.78)	4.81 (141.47)	50.19 (155.53)
T_4 =(50 ºC +15 ºC)	66.66 (86.13)	83.37 (89.83)	122.00 (91.27)	86.13 (82.89)	17.97 (143.29)	13.47 (125.06)	72.69 (150.90)	17.49 (137.39)	4.6 (135.29)	49.16 (152.33)
T_5 = 0.3% Hydroxyl amine	73.34 (94.76)	90.12 (97.11)	130.66 (97.75)	96.57 (92.94)	13.26 (105.73)	11.42 (106.03)	53.55 (111.16)	15.00 (117.83)	4.24 (124.70)	34.35 (106.44)
T_6 = 0.4% Hydroxyl amine	67.28 (86.93)	84.01 (90.52)	123.33 (92.27)	91.84 (88.39)	17.08 (136.20)	13.06 (121.26)	67.73 (140.60)	16.59 (130.32)	4.57 (134.41)	47.05 (145.80)
T_7 = 0.5% Hydroxyl amine	71.51 (92.40)	88.69 (95.57)	127.33 (95.26)	89.98 (86.60)	15.76 (125.67)	11.70 (108.63)	54.92 (104.01)	14.98 (117.67)	4.49 (132.05)	37.30 (115.58)
Variety Raj -3765										
T_8 = Control	79.07 (100)	96.27 (100)	133.33 (100)	108.50 (100)	10.26 (100)	10.71 (100)	46.66 (100)	13.76 (100)	3.15 (100)	31.62 (100)
T_9 = (50 ° C)	65.96 (83.42)	83.05 (86.27)	119.00 (89.25)	85.54 (78.84)	18.11 (176.51)	14.54 (135.76)	78.69 (168.65)	18.57 (134.96)	4.78 (151.75)	49.98 (158.06)
T_{10} = (15 ° C)	69.07 (87.35)	86.50 (89.85)	125.66 (94.25)	88.23 (81.32)	16.41 (159.94)	12.60 (117.65)	61.10 (130.95)	15.43 (112.14)	4.53 (143.81)	42.20 (133.46)
T_{11} = (50 ° C +15 ° C)	75.05 (94.92)	92.20 (95.77)	133.33 (100)	99.38 (91.60)	12.68 (123.59)	11.40 (106.44)	49.85 (106.84)	14.42 (104.80)	4.2 (133.33)	45.10 (142.63)
T_{12} = 0.3% Hydroxyl amine	68.86 (87.09)	86.28 (89.62)	124.33 (93.25)	87.86 (80.98)	16.85 (164.23)	12.82 (119.70)	62.97 (134.95)	16.13 (117.22)	4.57 (145.08)	43.70 (138.20)
T_{13} = 0.4% Hydroxyl amine	72.39 (91.55)	89.60 (93.07)	128.33 (96.25)	92.67 (85.41)	14.71 (143.37)	11.25 (105.04)	54.03 (115.80)	14.07 (102.25)	4.32 (137.14)	36.60 (115.75)
T_{14} = 0.5% Hydroxyl amine	70.45 (89.10)	87.50 (90.89)	126.33 (94.75)	89.53 (85.52)	16.12 (157.11)	12.42 (115.96)	57.33 (122.87)	15.25 (110.83)	4.52 (143.59)	39.14 (123.78)

against the maximum of 92.80 (100%) in control, the minimum of 81.12 (87.41%) days to blooming were recorded at 50 ºC in variety PBW-373. In variety Raj-3765, as against the maximum of 96.27 (100%) days in control, the minimum of 83.05 (86.27%) days to blooming were recorded in the temperature treatment of 50 ºC. Except for the combined temperature treatment in variety Raj-3765, the temperature has been observed to induce earlier blooming as compared to hydroxyl amine treatments. The maximum of 133.66 (100%) and 133.33 (100%) days to maturity were recorded in control for varieties PBW-373 and Raj-3765, respectively. The variety PBW-373 recorded minimum of 115.00 (86.03%) days to maturity at temperature treatment of 50 ºC. Both the physical (temperature) and chemical mutagenic treatments had more or less similar impact on the reduction of days to maturity. The maximum plant height of 103.90 cm (100%) and 108.50 cm (100%) were recorded in control for varieties PBW-373 and Raj-3765, respectively. The minimum plant height of 99.67 cm (76.67%) and 85.54 cm (78.84%) were observed at temperature treatment of 50 ºC in varieties PBW-373 and Raj-3765, respectively. The temperature treatments decreased plant height more than the hydroxyl amine treatments in variety PBW-373; however, in variety Raj-3765, the effect of temperature and hydroxyl amine treatments were more or less similar. The maximum mean number of tillers per plant *i.e.,* 18.27 (145.69%) were recorded at temperature treatment of 50 ºC in variety PBW-373. The variety Raj-3765 recorded maximum tiller number of 18.11 (176.91%) at 15 ºC. All the treatments increased number of tillers per plant in both the varieties. In variety Raj-3765, the increase in number of tillers per plant due to various treatments was higher than that in PBW-373. The maximum mean spike length of 14.90 cm (138.34%) and 14.54 cm (135.76%) were recorded at temperature treatment of 50 ºC in varieties PBW-373 and Raj-3765, respectively. The control in varieties PBW-373 and Raj-3765 recorded the minimum spike length of 10.77 cm (100%) and 10.77 cm (100%) respectively. The temperature treatments were observed to be more effective than hydroxyl amine treatments in increasing spike length in both the varieties. The maximum mean number of grains per spike *i.e.,* 81.57 (169.33%) and 78.69 (168.65%) were recorded at 50 ºC in varieties PBW-373 and Raj-3765, respectively. Both the varieties recorded minimum number of grains per spike at control. Temperature treatments were observed to be more effective in increasing number of grains per spike in variety PBW-373. The maximum number of spikelets per spike *i.e.,* 21.89 (171.95%) and 18.57 (134.96%) were recorded at 50 ºC, by varieties PBW-373 and Raj-3765, respectively. The minimum number of spikelets per spike of 12.73 (100%) and 13.76 (100%) were observed at control in these varieties, respectively. The temperature treatments were more effective in variety PBW-373 for increasing the number of spikelets per spike, whereas in variety Raj-3765, the temperature and hydroxyl amine treatments have more or

Table 4. Analysis of variance (Split plot design) for various characters under study

Source of variance	d.f.	Days to ear head Emergence	Days to Blooming	Days to maturity	Plant Height (cm)	No. of Tillers/ Plant	Spike length (cm)	No. of Grains/ spike	No. of Spikeles / Spike	100 Seed Weight (g)	Grain yield/ Plant
Due to Replication	2	73.07	78.71	0.50	8.45	0.13	0.294	13.81	1.55	0.040	0.30
Due to Main treatment	1	51.50**	71.89**	91.52**	95.19**	13.63*	4.03*	525.26**	27.73*	0.506	39.77*
Due to Error(a)	2	8.64	13.46	5.88	12.32	5.38	1.49	29.18	10.35	0.480	12.00
Due to Sub Tr.	6	103.69**	87.86**	161.20**	338.18**	27.88**	9.84**	678.26**	30.19**	1.89*	245.74**
Due To Int. (V x C)	6	26.02*	26.40*	53.41**	68.98*	11.50*	3.03*	220.33**	8.69	0.16	64.22*
Due to Error(b)	24	6.68	7.55	14.60	23.71	3.46	0.948	74.61	3.37	0.10	18.30

* and ** = Significant at 5% and 1% levels, respectively

less similar effects. The maximum mean 100 seed weight of 5.49 g (161.47%) was recorded by variety PBW-373 at temperature treatment of 50 ºC, whereas the variety Raj-3765 recorded maximum mean 100 seed weight of 4.78 g (151.75%) at the same temperature treatment. In general, the temperature treatments increased 100 seed weight more as compared to hydroxyl amine treatments. The maximum mean grain yield per plant of 51.66 g (160.08%) and 49.98 g (158.06%) were recorded at 50 ºC treatment in varieties PBW-373 and Raj-3765, respectively. In variety Raj-3765, the minimum mean grain yield per plant of 31.62 g (100%) was recorded at control. Temperature treatments were observed to increase the grain yield per plant more as compared to hydroxyl amine treatments.

The analysis of variance (split plot design) for characters are presented in Table 4. The perusal of which depicts that the main treatments differed significantly for the characters, days to ear head emergence, days to blooming, days to maturity, plant height and number of grains per spike. However, the sub treatments showed significant differences among themselves for all the characters except 100 seed weight. Estimates of the parameters of variability (micro mutations) like mean, range, coefficient of variance (CV), environment variance ($ó^2e$), genotypic variance ($ó^2g$), phenotypic variance ($ó^2p$), genotypic coefficient variance (GCV), phenotypic coefficient of variance (PCV) and heritability in broad sense ($h^2_{(b)}$) and genetic advance (GA) for the characters studied on the plot wise data are presented in Table 5. It is quite obvious that mutagenic treatments increased phenotypic and genotypic coefficient of variation as well as heritability and genetic advance. This suggests that the further improvement of wheat varieties is possible through induced mutation.

Macro mutations of economic and academic interest were also recovered in M_1 generation. The bold shiny seeded mutant was recovered at the temperature treatment of 50 ^{0}C in variety PBW-373. Moreover, high grain yielding mutants were observed at 50 ^{0}C temperature and 0.3% hydroxyl amine, in variety PBW-373, whereas similar mutants were observed at 0.4% hydroxyl amine in variety Raj-3765. However, the further testing of these mutants is required in future generations.

Thus on the basis of present investigation, it may be concluded that 50 ^{0}C temperatures is the best treatment, to improve the seed quality parameters, to create the genetic variability and for the enhancement of grain yield and yield related traits.

Similar studies were also conducted by various workers. Singh and Balyan (2009) through mutagenesis with gamma rays in bread wheat, reported significantly higher mean values for number of tillers per plant, number of spikelets per spike and harvest index compared to the control. They studied M_1 to M_3 progeny lines of wheat and isolated a number of semi-dwarf mutant lines with many improved traits. Early maturing plants were observed in M_1 populations of wheat by some researchers (Irfaq and

Table 5. Estimates for the parameters of statistical and genetic variability (micro mutation) for various characters under study in M_1 generation (based on main treatment)

Treatment parameter	Days to ear head Emergence	Days to Blooming	Days to maturity	Plant Height (cm)	Number of Tillers/ Plant	Spike length (cm)	Number of Grains/ spike	Number of Spikelets/ Spike	100 Seed Weight (g)	Grain yield/ Plant
Range	69-71	86-88	124-127	90.09 -93.10	15-16	12.25 -12.87	58-65	15-17	1.29 -4.51	41.19 -43.14
Mean	70.44	87.46	125.71	91.60	15.59	12.56	62.20	16.19	4.40	42.17
C.V.	1.28	1.29	0.59	1.18	4.59	3.00	2.68	6.13	4.85	2.53
$ó^2e$	2.88	4.48	1.96	4.10	1.79	0.49	9.72	3.45	0.16	4.00
$ó^2g$	14.28	19.47	28.54	27.62	2.74	0.84	165.36	5.79	0.008	9.25
$ó^2p$	17.16	23.96	30.50	31.73	4.54	1.34	175.08	9.24	0.168	13.25
GCV	45.03	47.18	4.25	54.91	41.99	25.94	163.04	59.82	4.42	46.85
PCV	49.36	52.34	4.39	58.85	53.98	32.72	167.77	75.56	19.55	56.06
$h^2_{(b)}$	0.83	0.81	0.93	0.87	0.60	0.62	0.94	0.62	0.051	0.69
G.A.	7.10	8.19	10.64	10.10	2.65	1.50	25.74	3.92	0.043	5.23

Nawab, 2003; Khan *et al*., 2003; Qasim and Ahmad, 2004; Singh and Balyan, 2009); whereas, different flowering time mutants of wheat have been reported by Díaz *et al*. (2012). Mutagenic improvement in various agronomic traits of wheat was observed by Jamil and Khan (2002). However, Irfaq and Nawab (2001) reported the decrease in grain yield of wheat due to induced mutations. Similarly, decrease in germination (%) and survival rate (%) of plants was observed due to mutagenesis in wheat by Albokari (2014).

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Genetic Divergence Analysis in Germplasm of Indian Mustard [*Brassica Juncea* (L.) Czern & Coss.]

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***Abstract*:** A study was conducted to assess genetic diversity of 200 germplasm of Indian mustard with respect to fifteen characters. The D^2 analysis indicated that number of secondary branches per plant, number of primary branches per plant, siliqua angle, 1000 seed weight and speed of germination contributed more than 70% of the total divergence. Out of 10 clusters, cluster I was the largest comprising 28 germplasm lines, followed by cluster II and III consisting of 26 germplasm lines, cluster IV, V, VI, VII, VIII, IX and X contained 22, 21, 21, 21, 15, 11 and 9 germplasm lines, respectively. No correspondence was observed between the geographical and the genetic diversity, but distribution of genotypes were random and independent. Cluster VII have highest mean values for seedling vigour (1005.43) and seed yield per plant (33.502). The magnitude of inter-cluster distance was greater than intra-cluster distances, suggesting presence of diversity among the clusters. The maximum inter-cluster distance was observed cluster VI and VIII (6.542) and the cluster VIII exhibited minimum intra cluster distance (5.419).

Key Words: *Brassica juncea,* Cluster analysis, D^2 analysis, Genetic divergence

Indian mustard [*B. juncea (*L.) Czern & Coss.], is one of the most important oilseed crops of the country and it accounts considerably large acerage among the *Brassica* group of oil seed crops. India stands first both in acerage and production of rapeseed and mustard in Asia. The crops are cultivated on an area of 6.51 million ha with a production of 7.67 million tones, with an average yield of 1179 kg/ha (Anonymous, 2011). Assemblage and assessment of divergence is essential to distinguishing genotypic responses as groups in framing a successful breeding programme. Estimation of degree of divergence between biological population and computation of relevant contribution of different components to the total divergence plays a vital role in planning breeding programme to develop superior cultivars or hybrids. Inclusion of more diverse parents (within a limit) in hybridization is supposed to increase the chance of obtaining maximum heterosis and give a broad spectrum of variability in segregating generations. With this aim, an attempt was made in the present study to analysis genetic diversity among 200 germplasm of Indian mustard.

MATERIAL AND METHODS

This study was carried out at the research area of the Oilseeds Section, Department of Genetics & Plant Breeding, CCS HAU, Hisar (29°10N lat., 75°46E long., 215 m alt.) during 2010-11. Two hundred diverse germplasm of Indian mustard was planted in randomized block design with two replications having plot size of 2m x 3m. The experiment received all recommended agronomic and cultural treatments throughout the season.

The data was recorded on fifteen characters, form five competitive plants excluding border plants in each germplasm lines, which were randomly selected from each replication (Table 1). Oil content was estimated by Sokshlet method (AOAC, 1995). Germination percentage, speed of germination and **seedling vigour** were determined by the following way

Germination percentage: 50 seed per replicates for each treatment were placed on sufficiently moistened filter paper in germination plate (top of paper) at the temperature 25±1°C with 92 to 95 percent RH in the seed germination. The first count of germination was recorded on 4^{th} day and final count was recorded on 7^{th} day. Only the normal seedling considered for percent germination according to the rules of the International Seed Testing Association (ISTA, 1999). Number of normal seedling obtained was expressed as percent germination.

Germination percentage (G %) = n / N × 100,

Where, n is the number of germinated seed at the seventh day; N is the number of total seeds.

Speed of germination: The number of seedling emerged were counted on each day up to seedling establishment (21^{th} day) and the speed of emergence was calculated as described by Maguire (1962).

$$\text{Speed of emergence} = \frac{\text{No. of seedling emerged}}{\text{First day of count}} + \ldots + \frac{\text{No. of seedling emerged}}{\text{Day of last count (21th day)}}$$

Seedling vigour: From the observation recorded for

standard germination and seedling length, seedling vigour was calculated according to methods suggested by Anderson and Baki (1973).

Vigour Index = Germination (%) x Seedling length

Mahalanobis (1936) D^2 - statistic analysis was used for assessing genetic divergence among the test entries. The clustering of D^2 values was formed by using Tocher's method as described by Rao (1952) while the intra and inter cluster distance was calculated using formula given by Singh and Choudhary (1985).

RESULTS AND DISCUSSION

The analysis of variance and dispersion were highly significant among the different genotypes for all the fifteen traits under study, which revealed the presence of considerable variability among the genotypes. Similar findings were observed by Singh *et al. (*2010). All 200 genotypes were grouped into10 clusters, using the Tocher's method, in such a way that the genotypes within the cluster had smaller D^2 values among themselves than those belonging to different clusters (Table 1). Out of 10 clusters, cluster I was the largest comprising 28 germplasm lines, followed by cluster II and III consisting of 26 germplasm lines, cluster IV, V, VI, VII, VIII, IX and X contained 22, 21, 21, 21, 15, 11 and 9 germplasm lines, respectively, however these were solitary in regard to multivariate composition. The clustering pattern indicated that there was lot of diversity among the germplasm lines and there was no relationship between the genetic and geographical diversity of the germplasm lines, but the distribution of the germplasm lines was random and independent. This could be due to genetic drift, selection pressure and environment which create morphological diversity rather than actual genetic distances. The composition of different clusters varied, containing 9 to 28 germplasm lines in most of the clusters involving strains from different areas and sources. Similarly, the strains developed at one station germplasm lines collected from the same region were also grouped in different clusters which suggested that there might have been introgression of genes among the germplasm lines of various origins and operation of similar forces of selection.

The cluster means for the 15 characters studied in 200 germplasm of Indian mustard revealed considerable differences among all the clusters (Table 2). Cluster IX possessed high mean values for plant height (2.327) and oil content (40.177); Cluster X for number of primary branches per plant (6.159) and siliqua angle (27.716); cluster III for primary branch angle (37.314), main shoot length (93.494) and siliqua length (4.689); Cluster IV for sliquae on main shoot (62.548) and 1000 seed weight (5.994); cluster VII for

Table 1. Clustering pattern of 200 germplasm lines of *Indian* mustard

Cluster	No. of germplasm lines	Germplasm lines
I	28	RC-1446,RC-1004,RC-1027,RC-1030,RC-1064,RC-1381,RC-1260,RC-1427-23,RC-1427-24,RC-1065,RC-1067,RC-1301,RC-1427-25,RC-1295,RC-1631,RC-1286,RC-1445,RC-1426,RC-1628,RC-1068,RC-1096,RC-1036,RC-1579,RC-1091,RC-1071,RC-1079,RC-1560,RC-1000
II	26	RC-1447,RC-1305,RC-1332,RC-1427-20,RC-1031,RC-1217,RC-1359,RC-1350,RC1341,RC1344,RC1372,RC1427-21,RC-1465,RC-1334,RC-1427-18,RC-1566,RC-1427-15,RC-1427-14,RC-1427-29,RC-1427-26,RC-1427-11,RC-1427-12,RC-1427-13,RC-1427-19,RC-1001, RC-1427-27
III	26	RC-1086,RC-1099,RC-1088,RC-1209,RC-1362,RC-1122,RC-1317,RC-1118,RC -1177,RC-1112,RC -1145,RC-1339,RC-1123,RC-1171,RC-1205,RC-1330,RC-1556,RC-1165,RC-1113,RC-1115,RC-1254,RC-1133,RC-1258,RC-1216,RC-1140
IV	22	RC-1515,RC-1047,RC-1153,RC-1090,RC-1155,RC-1045,RC-1006,RC-1017,RC-1486,RC-1507,RC-1019,RC-1021,RC-1052,RC-1056,RC-1249,RC-1058,RC-1059,RC-1149,RC-1141,RC-1142,RC-1143,RC-1002
V	21	RC-1029,RC-1201,RC-1093,RC-1203,RC-1324,RC-1340,RC-1347,RC-1427-17,RC-1062,RC-1051,RC-1156,RC-1177,RC -1554,RC-1620,RC-1627,RC-1630,RC-1621,RC-1624,RC-1633,RC-1135,RC-1136,RC-1011
VI	21	RC-1022,RC-1152,RC-1221,RC-1354,RC-1263,RC-1264,RC-1218,RC-1267,RC-1269,RC-1576,RC-1043,RC-1082,RC-1106,RC-1103,RC-1108,RC-1087,RC-1060,RC-1116,RC-1223,RC-1185,RC-1352
VII	21	RC-1008,RC-1010,RC-1454,RC-1538,RC-1202,RC-1429,RC-1057,RC-1130,RC-1329,RC-1342,RC-1170,RC-1313,RC-1288,RC-1626,RC-1167,RC-1072,RC-1456,RC-1460,RC-1463,RC-1200,RC-1353
VIII	15	RC-1193,RC-1159,RC-1173,RC-1550,RC-1634,RC-1555,RC-1558,RC-1559,RC-1574,RC-1618,RC-1580,RC-1575,RC-1175,RC-1190,RC-1157
IX	11	RC-1085,RC-1307,RC-1277,RC-1033,RC-1453,RC-1148,RC-1126,RC-1186,RC-1548,RC-1161,RC-1160
X	9	RC-1578,RC-1009,RC-1037,RC-1549,RC-1070,RC-1035,RC-1038,RC-1053,RC-1007

Table 2. Cluster mean values for seed yield and its component characters in Indian mustard

Cluster	Plant height (cm)	No. of 1^0 branches/ plant	Primary branch angle	No. of 2^0 branches/ plant	Main shoot length (cm)	Siliquae on main shoot	No. of seeds/ siliqua	Siliqua angle	Siliqua length (cm)	1000 seed weight (g)	Oil content (%)	Germination (%)	Speed of germination	Seedling vigour	Seed yield/ plant (g)
I	2.004	4.885	32.820	12.280*	85.585	55.347	13.822**	22.275	4.071	5.346	37.664*	88.107*	8.404	928.275	26.615*
II	2.055	5.176	32.822	12.531	86.687	51.291*	11.316*	21.696*	4.402	5.033	38.104	88.827	8.777	908.083	28.429
III	2.091	5.486	37.314**	13.389	93.494**	61.178	13.358	22.779	4.689**	5.953	38.911	91.167	11.117	996.395	28.083
IV	2.157	5.180	32.567	13.816	85.236	62.548**	13.173	25.328	4.358	5.994**	39.618	88.068	8.295*	877.679	33.189
V	2.281	5.033	34.574	12.764	79.861	52.306	13.341	23.840	4.126	5.643	38.905	91.571	11.467**	904.040*	27.972
VI	2.088	5.560	31.088	28.760*	91.707	54.833	13.628	23.343	4.604	4.632*	38.120	89.133	8.800	924.010	30.197
VII	2.191	5.288	31.008	13.862	83.624	55.582	12.854	25.550	4.171	4.997	37.833	92.167	11.321	1005.43**	33.502**
VIII	1.940*	4.698*	29.589*	13.364	84.400	54.014	13.306	23.286	4.561	4.940	39.886	92.190**	11.393	930.855	28.569
IX	2.327**	5.294	30.859	13.414	77.898	58.870	13.289	26.506	4.112	5.407	40.177**	90.115	9.773	959.790	27.547
X	2.266	6.159**	32.435	15.055	77.527*	52.434	13.040	27.716**	4.015*	4.819	38.177	87.500	8.486	915.354	32.969

* - Lowest value, ** - Highest value

seedling vigour (1005.43) and seed yield per plant (33.502); cluster VIII for germination percent (92.190) and speed of germination (11.393); however cluster VI for number of secondary branches per plant (28.760); cluster I for number of seeds per siliqua (13.822). This indicated that the parents selected for hybridization on the basis of these characters are represented to be genetically diverse. The above results were supported by Goswami and Behl (2006); Kumar *et al.* (2007) and Yu-cheng *et al.* (2007).

The intra-cluster distances were relatively smaller than inter-cluster distances indicating homogenous nature of the groups and presence of narrow genetic variation within a cluster (Table 3). The intra-cluster D^2 values varied from 4.163 to 5.419 within cluster and 4.843 to 6.542 between clusters. This indicated that cluster were homogenous within themselves and heterogeneous between themselves. The cluster VIII exhibited maximum intra cluster distance (5.419) which indicate that genotypes in this cluster were more diverse than the other cluster. Maximum inter cluster distance was observed between cluster VI and VIII (6.542) followed by cluster IX and X (6.447); cluster VIII and IX (6.420); cluster VIII and X (6.408); cluster V and IX (6.394); cluster VII and VIII (6.376); cluster III and VIII (6.359); cluster II and VIII (6.222) and cluster V and VIII (6.171) indicating wider genetic diversity between the genotypes in these clusters. Large inter cluster distance signifies that genotypes grouped in cluster are different from the genotype of other cluster for one or more characters, which made them so divergent from other. Selection of diverse parent having most of the desirable characters from such clusters in breeding programs is likely to produce more transgressive segregants and hetrotic F_1's when crossed. The minimum inter cluster distance was observed between cluster III and VI (4.843) revealing that genotypes belonging to these clusters were relatively closer. The observed distance showed that genetic diversity among and within clusters and clustering was useful to identify the diverse genotypes. Hence, the parents for hybridization should be selected from these clusters in order to get desired results for the development of useful progenies.

The contribution of characters towards the total genetic divergence is important in deciding the characters for selection. The characters like number of secondary branches per plant (29.301), speed of germination (8.161), number of primary branch per plant (7.200), siliqua angle (6.394), 1000 seed weight (6.602), primary branch angle (6.133) and seed yield per plant (6.102) contributed more than 70 % of the total divergence in the germplasm lines examined (Table 4). Parallel to present result, maximum contribution towards the divergence for number of secondary branches per plant was

Table 3. Average both intra-cluster distances (diagonal) and inter-cluster distances among 200 germplasm lines of *Indian mustard*

Clusters	I	II	III	IV	V	VI	VII	VIII	IX	X
I	4.375	5.065	5.287	5.126	5.224	5.288	5.664	6.060	5.778	5.546
II		4.789	5.662	5.510	5.399	5.509	5.772	6.222	5.903	5.828
III			4.242	5.070	5.207	4.843	5.115	6.359	5.369	5.634
IV				4.544	5.631	5.471	5.863	6.200	5.650	5.640
V					4.163	5.048	5.148	6.171	6.394	5.474
VI						4.425	5.192	6.542	5.832	5.417
VII							4.818	6.376	5.920	5.553
VIII								5.419	6.420	6.408
IX									5.169	6.447
X										4.567

Table 4. Contribution of different characters towards genetic divergence in *Brassica juncea*

Characters	Percentage contribution
Plant height (cm)	4.637
No. of primary branches/plant	7.200
Primary branch angle	6.133
No. of secondary branches/plant	29.301
Main shoot length (cm)	4.858
No. of siliquae on main shoot	5.173
No. of seeds/siliqua	4.908
Siliqua angle	6.394
Siliqua length (cm)	4.028
1000 seed weight (g)	6.602
Oil content (%)	1.659
Germination (%)	1.336
Speed of germination	8.161
Seedling vigour	3.508
Seed yield/plant (g)	6.102

previously reported by Doddabhimappa et al. (2010). The characters having high contribution towards the total genetic divergence may be used in selecting genetically diverse parents.

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Influence of Bio-fertilizers in Conjunction with Organic and Inorganic Fertilizer on Soil Properties and Productivity of Turmeric *Curcuma longa* L.

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***Abstract*:** A field investigation was carried out to determine the effects of organic manure (FYM), inorganic nitrogen and bio-fertilizer consortium (*Azotobacter*, PSB and PGPR) on different soil properties and the yield, quality of turmeric during 2012-13 at Punjab Agricultural University, Ludhiana. The treatments were comprised of 75, 100 (25 t ha^{-1} FYM ~ 125 kg N ha^{-1}) and 125 per cent of recommended N through organic or inorganic source of nitrogen alone and in combination with bio-fertilizers and control. The application of organic manure (FYM) showed beneficial effect on the yield of turmeric. The maximum yield of 204.4 q/ha was obtained with 125 per cent of recommended N applied through organic manure, which was at par with the 100 per cent of recommended N applied through organic manure with or without biofertilizers. The maximum curcumin yield of 111.6 kg ha^{-1} was obtained with the application of 125 per cent recommended N organic + biofertilizer which were at par with 100 per cent recommended N organic + bio-fertilizer. The application of organic manure significantly improved the available nitrogen and potassium content of soil. The application of bio-fertilizers considerably increased the soil microbial count when applied in combination with organic manure.

***Key Words*:** Biofertilizers, FYM, Inorganic nitrogen, Quality, Turmeric, Yield

Turmeric is a long duration crop, takes long time to sprout and has slow initial growth. There are various factors responsible for increasing the productivity of turmeric, but the use of optimum dose of nitrogen has vital importance (Borah and Langthasa, 1994). Being a nutrient exhaustive crop, turmeric requires heavy input of fertilizers in order to meet its nutritional requirement to obtain optimum yield. The indiscriminate and imbalanced use of fertilizers, for higher yield resulted in many problems like deterioration of soil health, contamination of underground water and increases the cost of production (Bhati *et al.,* 2011). However, the efficiency of the applied fertilizer depends upon the several factors. Nitrogenous fertilizers suffer more than 50 per cent losses due to denitrification and, leaching etc (Pandey and Kumar, 1988). Similarly, the phosphorus fertilizer becomes unavailable to the plants due to the fixation with the soil colloids. The microbial count of the soil is also depleted by the excessive chemical fertilizers. Therefore, it becomes inevitable, to use a strategy involving bio-fertilizers in combination with the organic manures and inorganic fertilizers which facilitate sustainable farming by judicious use of chemical fertilizer. Moreover, the soil health and soil microbial count could be maintained with the application of bio-fertilizers like *Azotobacter*, PSB and PGPR.

MATERIAL AND METHODS

The experiment to study the effect of FYM and inorganic nitrogen in combination with bio-fertilizers on turmeric was conducted during 2012-13 at Punjab Agricultural University, Ludhiana. It was laid out in randomised complete block design with 13 treatments and 4 replications. The detail of the treatments are; T_1 - 75 % of recommended N organic, T_2 - 100 % of recommended N organic (25 t ha^{-1} FYM equivalent to 125 kg N ha^{-1}), T_3 - 125 % recommended N organic, T_4 - 75 % recommended N organic + biofertilizers, T_5 - 100 % recommended N organic + biofertilizers, T_6 - 125 % recommended N organic + biofertilizers, T_7 - 75 % recommended N inorganic, T_8 - 100 % recommended N inorganic, T_9 - 125 % recommended N inorganic, T_{10} - 75 % recommended N inorganic + biofertilizers, T_{11} - 100 % percent recommended N inorganic + bio-fertilizers, T_{12} - 125 % recommended N inorganic + bio-fertilizers and T_{13} - Control. A uniform basal dose of 25 kg ha^{-1} each of phosphorus and potassium was applied before planting. Farmyard manure (as a source of organic N) was applied as per the treatments and thoroughly mixed with the soil before planting of crop. Urea as a source of inorganic nitrogen was applied in four equal splits i.e. at sowing, 75, 100 and 125 days after planting (DAP) as per treatments. The biofertilizer consortium comprising *Azotobacter,* phosphate solubilizing bacteria (PSB) and plant growth promoting rhizobacteria (PGPR) inoculums of 10 kg ha^{-1} was applied according to the plot size. The biofertilizer consortium were

mixed with the soil and applied in the crop rows at the time of planting.

The soil of the experimental field was categorized as loamy-sand. It was low in organic carbon (0.21%) and available nitrogen (182.4 kg ha^{-1}), but the available phosphorus (12.9 kg ha^{-1}) and potassium (194.6 kg ha^{-1}) status were medium. The soil pH (7.9) and electrical conductivity (0.20 dSm^{-1}) values were within the normal range. The planting was done during first week of May at a spacing of 30 cm x 20 cm spacing using 20 q ha^{-1} of seed. Mulching was done by applying 6.25 t ha^{-1} of paddy straw immediately after planting the crop. The harvesting of the turmeric was done manually in second fortnight of January. The rhizome yield and nutrient content in both rhizome and plant of turmeric was recorded at harvesting of crop. The quality parameters like curcumin and oil content were recorded from the processed turmeric (after drying and processing of the fresh rhizome). The soil parameters pH, EC, organic carbon, available nitrogen, phosphorus and potassium were recorded before planting and after the harvesting of the crop. The microbial count (cfu/g of soil) was recorded before sowing, 90, 180 DAP and after harvesting the crop.

RESULTS AND DISCUSSION

Yield

The yield was significantly higher under the treatments having organic manure as compared to inorganic nitrogen and control. The maximum fresh (204.4 q ha^{-1}) and processed rhizome yield (31.2 q ha^{-1}) was obtained with the 125 per cent of recommended organic manure along with bio-fertilizers (T_6) which was statistically at par with that of 100 per cent of recommended organic manure with (T_5) or without bio-fertilizers (T_2). The fresh and processed rhizome yield of turmeric increased significantly by the each increase in the level of organic manure. However, the differences among the treatment having inorganic nitrogen were non-significant, when applied alone (T_7, T_8, T_9) and in combination with the bio-fertilizers (T_{10}, T_{11}, T_{12}). The application of bio-fertilizers improved the processed yield of turmeric when compared with their respective control having no biofertilizers, though the differences were non-significant. The data also showed that the fresh and processed rhizome yield was statistically at par with the different levels of inorganic nitrogen with or without biofertilizers. It has also been observed that the magnitude of increase in the fresh rhizome yield with bio-fertilizers was more with the organic manures as compared to the inorganic fertilizers. This showed that the response of bio-fertilizers was improved under organic manures. Gill *et al*. (1999) observed that increase in the level of FYM significantly increased the fresh rhizome yield of turmeric.

Quality

The curcumin content and oil content of the turmeric did not influence significantly by the source of nitrogen applied i.e. organic or inorganic. The bio-fertilizers also showed non-significant increase in the curcumin content and oil content of turmeric over their respective treatments without biofertilizers. Kandiannan and Chandaragir (2006) and Gill *et al.* (2001) also observed that different nitrogen levels had non-significant affect on the curcumin content of turmeric. The application of nitrogen through inorganic source failed to improve the curcumin yield of turmeric significantly. The bio-fertilizers increase the curcumin yield

Table 1. Effect of different treatments on yield and quality of turmeric

Treatment	Fresh yield (q ha^{-1})	Processed yield (q ha^{-1})	Oil % (v/w)	Curcumin (%)	Curcumin yield (kg ha^{-1})
T_1	177.5	23.7	4.9	3.1	74.4
T_2	191.2	28.3	4.8	3.1	89.9
T_3	202.4	30.9	5.0	3.5	108.5
T_4	181.7	24.7	4.5	3.0	75.0
T_5	193.7	29.4	4.8	3.4	95.2
T_6	204.4	31.2	5.1	3.6	111.6
T_7	121.5	17.4	4.6	3.0	51.0
T_8	124.0	18.6	4.6	2.8	53.2
T_9	124.3	18.7	4.5	3.1	58.9
T_{10}	122.9	17.9	4.7	3.4	61.2
T_{11}	124.9	18.6	4.8	2.8	53.2
T_{12}	125.4	19.4	4.6	3.0	57.0
T_{13}	113.3	14.3	4.8	3.1	43.4
CD (p=0.05)	14.7	3.4	NS	NS	19.5

Table 2. Effect of different treatments on the N, P and K content (%) in leaf and rhizome of turmeric

Treatment	Leaves			Rhizomes		
	N	P	K	N	P	K
T_1	1.27	0.17	1.58	1.89	0.26	2.45
T_2	1.28	0.19	1.61	1.91	0.28	2.47
T_3	1.31	0.20	1.64	1.95	0.31	2.56
T_4	1.29	0.21	1.61	1.93	0.28	2.50
T_5	1.27	0.19	1.63	1.95	0.30	2.48
T_6	1.32	0.21	1.64	1.96	0.31	2.62
T_7	1.27	0.16	1.56	1.89	0.26	2.44
T_8	1.26	0.17	1.60	1.91	0.28	2.39
T_9	1.28	0.18	1.58	1.93	0.28	2.48
T_{10}	1.29	0.17	1.58	1.89	0.31	2.41
T_{11}	1.28	0.19	1.60	1.95	0.26	2.45
T_{12}	1.26	0.19	1.61	1.93	0.26	2.46
T_{13}	1.26	0.16	1.56	1.86	0.23	2.21
CD (p =0.05)	NS	NS	NS	NS	NS	NS

Table 3. Effect of different treatments on the soil properties of the experimental field

Treatment	pH	EC (dSm^{-1})	OC (%)	Available N ($kg\ ha^{-1}$)	Available P ($kg\ ha^{-1}$)	Available K ($kg\ ha^{-1}$)
T_1	7.87	0.21	0.22	194.4	13.2	200.6
T_2	7.68	0.20	0.22	197.5	13.0	201.6
T_3	7.65	0.19	0.23	200.7	14.2	203.5
T_4	7.77	0.20	0.22	198.8	13.5	201.1
T_5	7.79	0.21	0.23	200.7	14.8	202.7
T_6	7.57	0.19	0.24	206.9	14.7	204.9
T_7	7.74	0.20	0.21	184.4	13.3	194.9
T_8	7.83	0.20	0.21	186.5	13.2	197.1
T_9	7.75	0.21	0.22	188.7	12.7	197.9
T_{10}	7.72	0.20	0.21	184.9	12.8	195.4
T_{11}	7.89	0.20	0.21	187.0	12.9	198.4
T_{12}	7.68	0.21	0.22	189.0	12.9	199.2
T_{13}	7.71	0.21	0.20	169.4	12.1	182.4
CD (p = 0.05)	NS	NS	NS	7.5	NS	2.8
Initial	7.9	0.20	0.21	182.4	12.8	194.6

considerably, but the differences were non-significant as compared to the treatments, where bio-fertilizers were not applied.

N, P, K content in rhizome and leaves

The N, P and K content in leaves and rhizome analysed after the harvesting revealed that the N, P and K in the leaves and rhizome was not affected by the different source of nitrogen. Similar results were obtained with the application of biofertilizers. This indicates that contents of nutrients as N, P and K were not varied significantly with source of nitrogen applied. Gill *et al.* (2004) also reported non-significant effect of organic manure (FYM) on N, P, K content of rhizomes.

Fertility status of the soil

Soil properties like pH, electrical conductivity (EC) and organic carbon (OC) did not vary significantly by the source of nitrogen. The organic carbon status of the soil improved slightly with 100 and 125 per cent of recommended FYM. The application of FYM significantly improved the available N, P and K status of the soil as compared to the inorganic nitrogen. The application of inorganic nitrogen increased the available nitrogen with the increase in level of nitrogen, although the increase was non-significant. Same trend was observed in the case of potassium. However, the

Table 4. Effect of different treatments on *Azotobacter*, PAB and PGPR count (cfu/g) in the rhizosphere of turmeric

Treatment	90 DAP	180 DAP	Harvesting	90 DAP	180 DAP	Harvesting	90 DAP	180 DAP	Harvesting
	Azotobacter (x 10^5)			PSB (x 10^4)			PGPR (x 10^4)		
T_1	2.8	3.1	3.7	0.29	0.56	0.61	1.4	1.8	2.0
T_2	3.0	3.5	3.9	0.31	0.60	0.68	1.5	2.1	2.3
T_3	3.2	3.6	4.2	0.35	0.62	0.72	1.7	2.3	2.4
T_4	3.1	3.4	4.0	0.31	0.59	0.67	1.6	2.1	2.3
T_5	3.3	3.8	4.1	0.38	0.65	0.71	1.9	2.6	2.8
T_6	3.5	4.1	4.7	0.43	0.69	0.76	2.1	2.9	3.1
T_7	2.4	2.7	2.9	0.23	0.41	0.47	1.0	1.4	1.6
T_8	2.5	2.6	2.8	0.24	0.43	0.48	1.1	1.4	1.8
T_9	2.5	2.7	3.0	0.24	0.44	0.50	1.1	1.5	1.8
T_{10}	2.5	2.8	3.1	0.26	0.42	0.49	1.2	1.6	1.7
T_{11}	2.6	2.8	3.2	0.28	0.45	0.50	1.3	1.7	1.9
T_{12}	2.7	2.9	3.3	0.28	0.46	0.50	1.2	1.7	1.9
T_{13}	2.4	2.6	2.9	0.23	0.39	0.46	1.0	1.4	1.6
Initial		2.3 x 10^5			0.20 x 10^4			2.0 x 10^4	

available soil phosphorous remained unaffected by the different source of nitrogen. The availability of soil P was more in the case of FYM, but the differences were non-significant.

Microbial population (Azotobacter, PSB, PGPR)

Micro-organisms are important for decomposition of organic residues and transformation of different nutrients to available forms in soil, therefore, micro-organisms ultimately affect crop production. The data showed that the bacterial count increased with the advancement of the crop growth, this may be due to the decomposition of the mulch applied to the crop field. However, the increase was more under the organic manure than inorganic fertilizers. The each increase in level of FYM tended to increase the microbial count of the soil but the increase in the level of nitrogen did not influence the microbial count. The application of bio-fertilizers increased the microbial count in respect to their respective control. But this increase was more under the FYM. Gosal *et al.* (2012) also observed that application of bio-fertilizers increased the microbial count of the soil than their respective control. The trend of increase in the microbial count with FYM was same for all the bacteria i.e. *Azotobacter*, PSB and PGPR. This proved that efficiency of the bio-fertilizers were more under the organic management. Mohapatra and Das (2009) also reported that the activity of microbes was improved by the use of organic manure.

The organic manure has beneficial effects on the yield of turmeric, availability of the nutrients and the microbial activity in the soil as compared to inorganic fertilizers. The bio-fertilizers also improved the yield potential of the turmeric.

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Potential of *Rhiobium* Species to Enhance Growth and Symbiosis in Berseem (*Trifolium alexandrinum L.*)

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Abstract: Twenty four isolates were obtained from root nodules of berseem plants and were evaluated for IAA producing ability and other plant growth promoting traits such as Phosphate solubilization, siderophore, ammonia and HCN production. Maximum IAA production was reported in isolate B-2 (50.8±0.90 µg/ml). Isolate B-33 produced maximum catechol type siderophore (102 µg/ml) and isolate B-2 produced maximum hydroxamate type siderophore (57 µg/ml). Among all the isolates, three isolates (B-2, BK and B-33) were selected and used as inoculants in pot and field study. Maximum germination was observed in BK treatment in pot as well as field conditions. The rhizobial isolate BK showed positive effect in inoculation, which resulted in a significant increase in number and dry weight of nodules over B-33 and un-inoculated control. Maximum mean chlorophyll content was also observed in BK (2.85 mg/g fresh weight of leaves) as compared to control (2.45 mg/g fresh weight of leaves). The same trend was evident with yield attributing traits, leghaemoglobin content and N–content of leaves. Thus BK and B-33 inoculation significantly enhanced all symbiotic and growth parameters.

Key Words: Berseem, Growth and yield, Nodulation, *Rhizobium* inoculation

Among fodders berseem (*Trifolium alexandrinum L.*) is the most widely grown multi-cut legume crop grown during rabi. It is highly nutritious fodder which contains 15.8-26.7 % Crude protein, 1.4-3.0 % ether extract, 14.9-28.3% crude fiber and 1.4 - 2.58 % calcium. Berseem is either grown solely or mixed with other fodder crops like barley, oats or *Brassica*. Its symbiotic activity in increasing soil nitrogen contents has given berseem an importance in crop rotation (Ahmad *et al.,* 2009). Berseem clover is capable of producing moderate to high quantities of herbage across a range of environments. It performs best in areas with reliable late spring rainfall, where acidity levels are low.

Berseem has the quality to provide habitat to soil-borne bacteria (*Rhizobium*) in their root system. The correct strain of *Rhizobium* ensures maximum fixation of atmospheric nitrogen through symbiosis. Increase in yield can be obtained through inoculation with *Rhizobium* even in the fields where berseem is grown previously, to obtain residual effect for subsequent crop with varying performance from strain to strain (Ahmad *et al.,* 2009). Therefore inoculation with efficient strains of *Rhizobium* possessing effective plant growth promoting(PGP) traits would be required for increasing nodulation and their functioning for enhancing N-fixation and improving plant growth and productivity (Gray and Smith 2005). Thus the present study was undertaken firstly to isolate and screen free living rhizobia from root nodules of berseem and to evaluate their performance in terms of nodulation, growth and yield of berseem under greenhouse and field conditions.

MATERIAL AND METHODS

Collection of samples and isolation of rhizobia: A total of 20 samples of root nodules from berseem were collected randomly from different locations of Punjab and used for isolating rhizobia on CRYEMA medium. *Rhizobium leguminosarum* bv *trifolii* strains B-33 and B-1-95 were obtained from department of Microbiology, PAU, Ludhiana. All the isolates were further tested for growth and characterized based on morpho-physiological and biochemical traits.

Evaluation of PGP traits: Rhizobial isolates were tested for their potential for IAA production, P-solubilization ability Siderophore production by the method of Kaur and Khanna (2014) and Cyanide production was detected according to the method described by Bakker and Schippers (1987).

Pot Experiment: Soil from field was taken and sterilized by autoclaving at 121°C for 1 hr for 3 consecutive days. Experiments were performed with four treatments in triplicates using *Rhizobium* isolates BK, B-2, B-33 and un-inoculated control with berseem variety BL-42.

Field experiment: Field experiment was conducted using three berseem varieties BL-1, BL-10, BL-42. Four treatments comprising un-inoculated control, *Rhizobium* isolates (BK and B-2) along with B-33 were selected. Treatments were laid down in randomized blocks and seeds were treated before sowing as per recommended package of practices. Sampling for number of nodules, nodule dry weight, percent germination, shoot and root length and biomass for all treatments was done at 30 DAS, 45 DAS and 90 DAS. Five

plants were randomly uprooted from each experimental plot by digging 15cm around the plant, washed with clean water to remove attached soil from roots and nodules. The nodules were counted and oven dried at 60°C for 48 hours and weighed. The roots and shoots of plants were also separated, oven dried at 60°C till constant weight. Leghaemoglobin and chlorophyll content was also determined. For statistical analysis software CPCS1 was used.

RESULTS AND DISCUSSION

Isolation and identification of rhizobial isolates: All 24 rhizobial isolates selected and purified on CRYEMA media were maintained on YEMA slants at 4°C. All isolates were tested morphologically and biochemically (Table 1) and identified as *Rhizobium* spp.

Table 1. Biochemical Characterization of *Rhizobium* Isolates

Biochemical test	*Rhizobium* spp.
Gram reaction	-
Oxidase	+
Starch hydrolysis	+
Citrate utilization	+
Methy red (MR)	-
Voges Proskauer (VP)	-
3-Ketolactose production	-

Evaluation of PGP traits:

IAA production*:* All the 24 rhizobial isolates were assessed for their natural ability to produce IAA which ranged from 42.3 to 50.8 µg/ml in presence of L-tryptophan after 5days of incubation. Highest IAA production was shown by isolate B2 followed by B-33 (Table 2). Alikhani and Yakhchali (2009) also reported 74% of the rhizobial strains are capable of producing IAA.

Phosphate solubilzation: Phosphate solubilization ranged from 13.8 to 32.2 mg/100 ml after 5 days of incubation.

Production of HCN, NH_3 and Nitrate reduction: Out of 24 rhizobial isolates, only one isolate was found to produce HCN. Six isolates (25%) were able to produce ammonia. Fifteen (62.5%) isolates led to nitrate reduction (Table 2).

Siderophore Production: Siderophore production was found to start after 24 h of incubation, reaching a maximum after 72 h, when organism has entered into stationary phase. Diameter of halo zone varied from 0.8-2.5 cm on CAS agar plates, maximum being produced by isolate B-2-S (2.5 cm) followed by B-33 (2.0). All the 15 isolates producing orange halo on CAS plates were found to produce catechol and hydroxamate type siderophore. Isolate B-33 produced maximum catechol type siderophore (102 µg/ml) and maximum hydroxamate type siderophore was produced by isolate B-2 which was 57 µg/ml followed by B-2-S (53 µg/ml) and B-33 (52 µg/ml) (Table 2).

Out of 24 rhizobial isolates, 3 isolates (B-2, B-33 and BK) were selected on the basis of PGP traits (Table 2) and used as inoculants in pot and field study.

Effect of inoculation of rhizobia on symbiotic parameters under pot conditions: Results of germination revealed that inoculation with rhizobial isolates significantly affected the germination of seeds over control. Isolate BK showed highest percent germination (85%) followed by B-33 (80%) and B-2 (75%) over control (70%) (Table 3). Similar findings have been reported by Abbasi *et al.* (2008). Their studies also revealed increase in yield or germination due to *Rhizobium* inoculation.

Seed inoculation with rhizobial strains increased nodule number. The maximum nodule number was observed in case of BK (7NN/plant at 30 DAS, 12 NN/plant at 45 DAS and 15 NN/plant at 60 DAS) as compared to control. Larger response to inoculation and higher number of nodules per plant in comparison with uninoculated crop were also reported by Abbasi *et al.* (2008). Similar result was found in case of dry weight of nodules where isolate BK showed maximum weight (16.4 mg $plant^{-1}$ at 30 DAS, 21.9 mg $plant^{-1}$ at 45 DAS and 23.3 mg $plant^{-1}$ at 60 DAS) in comparison to control.

Positive effect on inoculation was observed on plant biomass. Significant increase in dry weight of shoot was observed in B-2 (0.86 g $plant^{-1}$ at 30 DAS, 1.96 g $plant^{-1}$ at 45 DAS and 2.08 g $plant^{-1}$ at 60 DAS) followed by BK (0.96 g $plant^{-1}$ at 30 DAS, 1.72 g $plant^{-1}$ at 45 DAS and 2.04 g $plant^{-1}$ at 60 DAS). Maximum dry weight of root was recorded in BK (0.09 g $plant^{-1}$ at 30 DAS, 0.12 g $plant^{-1}$ at 45 DAS and 0.20 g $plant^{-1}$ at 60 DAS) as compared to control (0.06 g $plant^{-1}$ at 30 DAS, 0.08 g $plant^{-1}$ at 45 DAS and 0.12 g $plant^{-1}$ at 60 DAS) (Table 3). It is reported that enhancement in root dry weight with rhizobial inoculation may be ascribed to ability of *Rhizobium* to conserve carbohydrates. Increase in dry weight of root was also observed in *Rhizobium* inoculated legumes in chickpea (Elkoca *et al.,* 2008).

Similar trends were observed in case of shoot and root lengths where isolate BK gained maximum shoot length i.e. 6.1 cm $plant^{-1}$ at 30 DAS, 16.3 cm $plant^{-1}$ at 45 DAS and 25.9 cm $plant^{-1}$ at 60 DAS and in root length maximum enhancement was recorded as 4.8 cm $plant^{-1}$ at 30 DAS, 8.3 cm $plant^{-1}$ at 45 DAS and 11.1 cm $plant^{-1}$ at 60 DAS. Once again in confirmation, maximum N content was also observed in BK treatment (23.87 %) followed by B-2 (21.13%) as compared to control (20.81%) (Table 4). Similarly isolate BK showed maximum chlorophyll content in leaves (2.48 mg/g) and leghaemoglobin content of nodules

Table 2. Evaluation of PGP traits of selected rhizobial isolates

Rhizobial isolates	IAA production (µg/ml)	Phosphate solubilization (mg/100 ml)	HCN production	NH_3 production	Nitrate reduction	Siderophore production (dia. in cm)	Hydroxamate type Siderophore production (µg/ml) *	Catechol type Siderophore production (µg/ml) *
B-2	50.8±0.90	13.85±0.30	-	+	-	1.2	57±0.15	28±0.3
B-33	48.6±0.25	32.29±0.36	-	+	+	2.0	52±0.1	102±0.07
BK	42.3±0.25	18.4±0.20	+	-	+	1.5	48±0.1	33±0.30

Table 3. Effect of rhizobial isolates on symbiotic parameters in berseem under pot conditions

Treatment	Germination (%)	No.of nodules / Plant		Dry weight of nodules (mg plant $^{-1}$)		Dry weight of shoot (g plant $^{-1}$)		Dry weight of root (mg plant $^{-1}$)		Stem length (cm plant $^{-1}$)		Root length (cm plant $^{-1}$)	
		Number of DAS											
		45	60	45	60	45	60	45	60	45	60	45	60
Control	70.33	8	11	16.3	18.3	1.02	1.87	0.08	0.12	12.2	19.3	5.8	9.0
B-2	75.0	10	13	17.3	18.4	1.96	2.08	0.09	0.11	15.4	24.1	6.4	8.1
B-33	80.0	12	15	21.9	23.3	1.72	2.04	0.12	0.20	16.3	25.9	8.3	11.3
BK	85.0	11	14	18.2	19.6	1.38	1.95	0.11	0.13	13.6	20.8	8.8	11.1
p=0.05	3.16	NS	NS	0.5	0.9	0.88	NS	NS	NS	0.6	0.5	0.5	1.4

Table 4. Effect of isolates on N-content, Chlorophyll and leghaemoglobin content in berseem under pot conditions

Treatment	Nitrogen (%) content		Total chlorophyll content (mg/g fresh weight of leaves)		Leghaemoglobin content (mg/g fresh weight of nodules)
	45 DAS	60 DAS	45 DAS	60 DAS	45 DAS
Control	18.61	20.81	2.59	2.24	2.59
B-2	20.12	21.13	2.62	2.42	2.62
BK	19.31	23.87	2.90	2.48	2.90
B-33	19.0	20.58	2.87	2.42	2.87
p=0.05	NS	2.5	NS	NS	NS

(2.90 mg/g).

Effect of inoculation of rhizobia on symbiotic parameters under field conditions

Germination: The percent germination was non-significant in BL-42 variety but significant more in BL-1 variety of berseem. Maximum germination was observed in BK treatment (80% in BL-1 variety, 80% in BL-10 and 85% in BL-42) and B-33 treatment (85% in BL-1 variety, 80% in BL-10 variety and 80% in BL-42 variety). The results are in accordance with the findings of Abbasi *et al. (2008)* who reported increase in yield due to *Rhizobium* inoculation.

Nodulation: There was a significant difference in different varities at 60 DAS. Once again isolate BK showed highest mean number of nodules (11 NN/plant at 30 DAS, 16.33 NN/plant at 45 DAS and 18.33 NN/plant at 60 DAS) (Table 5). Significantly higher nodule dry weight was recorded with BK (11.10 to 25.40 mg/plant) followed by B-33 (10.5 to 20.0 mg/plant) as compared to control. Tilak *et al.* (2006) reported nodules occupied by the introduced efficient rhizobial strain results in positive effect on symbiosis and legume yield.

Plant growth: The data showed significant increase in dry weight of shoot as compared to control. Maximum dry weight of shoot was recorded in BK (0.96 g/plant in BL-1 variety, 0.80 g/plant in BL-10 variety and 0.83 g/plant in BL-42 variety) at 45 DAS. At 60 DAS, BK showed increase in dry weight of shoot (2.04 g/plant in BL-1 variety, 2.71 g/plant in BL-10 variety and 2.32 g/plant in BL-42 variety). There was a further increase in dry weight of shoot at 90 DAS. At this stage again the maximum production was recorded by BK (2.19 g/plant in BL-1 variety, 3.14 g/plant in BL-10 variety and 3.86 g/plant in BL-42 variety). Higher shoot dry weight in plants inoculated with rhizobial species may be ascribed to more N supply to crop through N fixation by bacteria.

Similarly in root dry weight, maximum weight was observed by BK treatment (0.80 g/plant in BL-1 variety, 0.60 g/plant in BL-10 variety and 0.70 g/plant in BL-42 variety) at 45 DAS. After that there was decrease in dry weight of root at 90 DAS.

The mean of stem length at 45 DAS was observed maximum in isolate BK (6.36 cm/plant). At 60 DAS the highest mean of stem length was also produced by isolate BK (16.83 cm/plant) followed by B-2 and even at 90 DAS, BK showed the maximum mean followed by B-2 (Table 6). The interaction between the treatments and varieties were significant at 45 DAS but showed non-significant difference at 60 and 90 DAS.

The root length showed a significant difference in root length in different treatments and varieties. The plants of

Table 5. Effect of rhizobial isolates on symbiotic parameters in berseem under field conditions

Treatments	Number of nodules (NN/plant) (60 DAS)				Dry weight of nodules (mg plant^{-1}) (60 DAS)				Dry weight of shoot (g plant^{-1}) (90 DAS)				Dry weight of root (g plant^{-1}) (90 DAS)			
	BL-1	BL-10	BL-42	Mean	BL-1	BL-10	BL -42	Mean	BL-1	BL-10	BL-42	Mean	BL-1	BL-10	BL-42	Mean
Control	13.0	17.0	10.0	13.33	17.20	18.30	17.60	17.70	1.98	2.07	2.06	2.03	0.18	0.19	0.17	0.18
B-2	16.0	18.0	13.0	15.66	19.60	21.20	18.80	19.86	2.11	2.83	2.79	2.57	0.16	0.18	0.14	0.16
BK	19.0	19.0	17.0	18.33	25.30	25.40	24.20	24.96	2.19	3.14	3.86	3.06	0.21	0.30	0.29	0.26
B-33	20.0	19.0	16.0	18.55	19.40	15.43	20.0	18.27	2.03	3.56	3.11	2.90	0.19	0.26	0.18	0.21
Mean	17.0	18.42	14.0		20.37	20.08	20.15		2.07	2.90	2.95		0.18	0.23	0.19	
p=0.05	Variety (V) = 0.49 Treatment (T) = 1.03 V x T = 1.78				Variety (V) = NS Treatment (T) = 3.35 V x T = NS				Variety (V) = 0.30 Treatment (T) = 0.26 V x T = 0.45				Variety (V) = 0.12 Treatment (T) = 0.18 V x T = 0.31			

BL-10 variety were found to have significantly more height than BL-1 and BL-42 variety at 45, 60 and 90 DAS. At 45 DAS, BK treatment attained maximum height (3.90 cm plant^{-1} in BL-10, 3.50 cm plant^{-1} in BL-42 and 2.60 cm plant^{-1} in BL-1). Even at 60 and 90 DAS, the mean of BK treatment was found to have maximum height i.e. 6.40 cm plant^{-1} and 9.43cm plant^{-1} respectively (Table 7).

Nitrogen content

Significant effect of inoculation was observed on nitrogen content in shoot (Table 8). Maximum N content was observed in BK (27.32%) and B-33 (27.32%) followed by B-2 (25.37%) as compared to control. Many researchers carried out experiments on *Rhizobium* inoculation with and without fertilizers on legume crops and found increased nitrogen contents of seed, number of nodules, yield and yield components (Nadeem *et al.,* 2004). Higher values of plant NP content with *Rhizobium* species might be attributed to better root system and more prolific root growth owing to presence of growth hormone in the rhizosphere (Qureshi *et al.,* 2013).

Leghaemoglobin and chlorophyll content: All the treatments significantly enhanced leghaemoglobin content of nodules over control, maximum being recorded with isolate BK (2.85 mg/g in BL-1, 2.66 mg/g in BL-10 and 3.02 mg/g in BL-42 mg/g fresh weight of nodule) (Table 8). In confirmation with our study, Deka and Azad (2006) have also reported that the leghaemoglobin has a positive correlation with N_2 fixation and nitrogenase activity in nodules using *Brady rhizobium* as biofertilizer.

Maximum mean chlorophyll content was observed in BK (2.88 mg/g fresh weight of leaves) followed by B-33 (2.82 mg/g fresh weight of leaves). Zhou *et al.* (2006) reported positive effects on plant photosynthesis and increase in chlorophyll content after rhizobia inoculation in soyabean. This improvement in chlorophyll content may be due to increased nitrogen uptake by larger root surface areas associated with additional root hairs and lateral root development and/or BNF, either directly by the inoculants strains or indirectly by stimulating BNF activity of the associated rhizosphere community.

Hence, it was concluded that BK and B-33 emerged as effective strains for plant growth promotion and can be used to enhance symbiotic efficiency in berseem. So, these can be used as bioenhancers and biofertilizers.

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Table 6. Stem length (cm plant^{-1}) under field conditions

Treatments	45 DAS				60 DAS				90 DAS			
	BL-1	BL-10	BL-42	Mean	BL-1	BL-10	BL-42	Mean	BL-1	BL-10	BL-42	Mean
Control	5.60	7.80	4.90	6.10	13.70	14.20	13.20	13.70	22.70	25.10	24.70	24.16
B-2	6.50	6.20	5.50	6.06	15.30	15.10	14.06	14.82	24.10	26.10	24.40	24.86
BK	6.80	5.60	6.70	6.36	16.50	17.30	16.70	16.83	26.20	28.90	27.90	27.66
B-33	5.70	4.40	5.60	5.23	13.90	15.06	14.90	14.62	23.40	24.60	23.30	23.76
Mean	6.15	6.0	5.67		14.85	15.41	14.71		24.10	26.17	25.07	
p=0.05	Variety (V) = NS Treatment (T) = 0.63 V x T = 0.08				Variety (V) = 0.27 Treatment (T) = 0.54 V x T = NS				Variety (V) = 1.00 Treatment (T) = 0.64 V x T = NS			

Table 7. Root length (cm plant^{-1}) under field condition

Varieties /	45 DAS				60 DAS				90 DAS			
Treatments	BL-1	BL-10	BL-42	Mean	BL-1	BL-10	BL-42	Mean	BL-1	BL-10	BL-42	Mean
Control	1.80	3.60	2.10	2.50	4.30	6.20	5.30	5.26	6.50	7.90	7.60	7.33
B-2	1.90	3.50	3.40	2.93	5.40	6.30	5.20	5.63	7.10	8.70	6.50	7.43
BK	2.60	3.90	3.50	3.33	6.50	7.10	6.40	6.66	8.30	10.20	9.80	9.43
B-33	2.30	3.70	2.30	2.76	6.30	6.8	6.10	6.40	6.90	8.90	8.70	8.16
Mean	2.15	3.67	2.82		5.62	6.60	5.75		7.19	8.92	8.15	
p=0.05	Variety (V) = 0.86 Treatment (T) = 0.12 V x T = 0.21				Variety (V) = 0.37 Treatment (T) = 0.20 V x T = 0.34				Variety (V) = 0.13 Treatment (T) = 0.47 V x T = 0.82			

Table 8. Nitrogen, Chlorophyll and Leghaemoglobin content of leaves under field condition

Varieties /Treatments	Nitrogen (%) content (90 DAS)				Chlorophyll content (45 DAS)				Leghaemoglobin content (45 DAS)			
	BL-1	BL-10	BL-42	Mean	BL-1	BL-10	BL-42	Mean	BL-1	BL-10	BL-42	Mean
Control	25.21	20.56	26.06	23.94	2.43	2.51	2.41	2.45	2.30	2.41	2.10	2.27
B-2	28.76	21.66	25.71	25.37	2.70	2.62	2.81	2.71	2.29	2.40	2.18	2.29
BK	30.75	24.12	27.11	27.32	2.82	2.93	2.89	2.88	2.85	2.66	3.02	2.84
B-33	26.98	23.28	31.72	27.32	2.71	2.87	2.88	2.82	2.61	2.89	2.73	2.74
Mean	27.92	22.40	27.65		2.66	2.73	2.74		2.51	2.59	2.50	
p=0.05	Variety (V) = 1.01 Treatment (T) = 0.75 V x T = 1.31				Variety (V) = 0.40 Treatment (T) = 0.14 V x T = NS				Variety (V) = NS Treatment (T) = 0.39 V x T = 0.21			

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Effect of Cowpea *Bradyrhizobium* (RA-5) on Growth Parameters of Pigeonpea Plant under Various Salt Concentrations at Different Time Intervals

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***Abstract*:** The pot experiment was conducted to evaluate the effect of cowpea *Bradyrhizobium* (RA-5) on plant growth parameters in pigeonpea plant under various salt concentrations at 10, 20 and 30 days after sowing (DAS). All the growth parameters studied were found to decrease progressively with the increasing salinity levels. Best growth of the plants was observed in treatment containing RA-5 with no salt. Very Poor growth was observed in treatments applied with saline solutions containing 200 mM and 300 mM salt concentrations. The similar trend was observed at 10, 20 and 30 days after sowing.

Key Words: Cowpea *Bradyrhizobium*, Growth parameter, NaCl, Pigeonpea, Time interval

Pigeonpea finds an important place in the farming systems adopted by small and marginal farmers in a large number of developing countries as it restores soil fertility from the leaf fall and through nitrogen fixation (Mapfumes *et al*., 1998). Pigeonpea may derive upto 90% of its nitrogen from nitrogen fixation (La Favre and Focht, 1983), however in intercropping systems, it may derive as much as 96% of its nitrogen from nitrogen fixation (Kumar Rao *et al*., 1986). The fixed nitrogen (Ammonia) is later incorporated into amino acids and finally into protein. In addition, pigeonpea requires low input and minimal maintenance for its cultivation.

Salinity is considered as one of the most important abiotic stresses limiting crop production in pigeonpea in salt affected areas. Soil salinity adversely affects plant growth and development. The detrimental effects of salt are generally observed at the whole plant level. Therefore, in order to improve plant growth under salinity stress conditions and for sustainable crop production, it is necessary to improve salt tolerance in pigeonpea cultivars. Thus, rigorous plant breeding efforts are needed to develop or transfer salt tolerance traits in this crop. Inoculating crop seeds and seedlings with root nodule forming bacteria is an alternative option to reduce salt stress effects in various crops like pigeonpea (Tank and Saraf, 2010). Therefore, keeping in view the mitigation of salinity stress with the help of nodule forming bacteria, the present study was conducted to evaluate the effect of Cowpea *Bradyrhizobium* (RA-5) on plant growth parameters of pigeonpea under various salt concentrations at different time intervals.

MATERIAL AND METHODS

The present study was conducted during 2012-14 in controlled conditions at the microbial genetics laboratory of the Department of Genetics and Plant Breeding, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (India). Seed of Pigeonpea cv. Bahar, obtained from the same department was used as experimental material for the study. The bacterial strain cowpea *Bradyrhizobium (*RA-5*)* used for inoculation was obtained from the Microbial Genetics Laboratory of the department.

Bold and healthy seeds were surface sterilized with 0.2 % (w/v) mercuric chloride for 2 minutes, rinsed in sterilized water and germinated in autoclaved petriplates paved with blotting paper at the bottom. The petriplates were then kept in incubator at 28^{0}C and timely supplemented with deionised water for proper germination. Germinated seeds, after 3-5 days of sowing were transferred to plastic pots filled with air dried and sterilized sand. The pots were arranged in a complete randomized design with three replications for seven treatments (six inoculated treatments and one control). All the treatments were inoculated with bacterial strain cowpea *Bradyrhizobium* (RA-5) except for control plants. The pots were kept in an ambient air conditioned chamber under artificial light. Except for control, all the treatments were irrigated with separate NaCl solutions of 0mM, 25mM, 50mM, 100mM, 200mM and 300mM concentration along with thortons nutrient solution. 0mM NaCl means that no salt was applied with nutrient solution to the Cowpea *Bradyrhizobium* (RA-5) treated plants. However, control plants were treated with nutrient solution only. Observations on various plant growth parameters were recorded on five randomly selected plants from each replication at 10, 20 and 30 days after sowing. Growth parameters such as plant height, chlorophyll content,

number of nodules per plant, root length per plant, shoot length per plant, number of leaves per plant and fresh weight per plant were recorded. The statistical analysis for CRD was carried out using Microsoft Excel Package.

RESULTS AND DISCUSSION

Significant and positive effect of Cowpea *Bradyrhizobium* (RA-5) was observed on various growth parameters like plant height, chlorophyll content, number of leaves per plant, number of nodules per plant, fresh weight per plant, root length per plant and shoot length of pigeonpea plants. However, application of saline treatment was observed to show reduction in plant growth at 10, 20 and 30 days after sowing (DAS) even in the presence of Cowpea *Bradyrhizobium* (RA-5). Best growth of the plants was observed in treatment containing RA-5 with no salt. Very Poor growth was observed in treatments with 200 mM and 300 mM salt concentrations.

The average plant height of saline treated plants at 20 DAS decreased from 22.00 to 8.00 cm when the concentration of salt solution applied was increased from 0mM to 300mM. However, in control the average plant height was observed to be 16.00 cm. The average chlorophyll content decreased from 14.00 to 5.25 SPAD units under the similar set of conditions, whereas for control the average chlorophyll content was observed to be 13.41 SPAD units at 20 DAS. The average number of nodules per plant of saline treated plants at 20 DAS decreased from 34.67 to 10.67 when the concentration of saline solution applied was changed from 0mM to 300mM. However, the control recorded an average number of nodules per plant of 20.67 at 20 DAS. Similarly, the average number of leaves per plant for saline treated plants decreased from 9.33 to 2.33 at 20 DAS. The control was found to record 7.00 leaves per plant at 20 DAS. The average fresh weight per plant of saline treated plant decreased from 0.72 g to 0.25 g, whereas control recorded an average fresh weight of 0.55 g at 20 DAS. The average root length per plant of saline treated plants decreased from 13.50 cm to 9.00 cm over the similar set of conditions. However, the control plants showed the average root length of 11.83 cm at 20 DAS. The average shoot length per plant also exhibited the similar behaviour and decreased from 21.67 cm to 9.67 cm. The control recorded an average shoot length per plant of 17.00 cm at 20 DAS. Similar trend as recorded on plant growth parameters at 20 DAS was also observed for 10 and 30 DAS (Tables 1, 2 and 3).

The results of present investigation that microbial inoculated plants recorded better growth parameters than non-inoculated ones and increase in salt concentration leads to decrease in plant growth attributes, confirm the findings of

Table 1. Effect of Cowpea *Bradyrhizobium* on different growth parameters of pigeonpea under salt stress conditions at 10 DAS

Treatment	Plant height (cm)	Chlorophyll content	No. of nodules per plant	No. of leaves per plant	Fresh weight (g)	Root length (cm)	Shoot length(cm)
No salt+ No RA5 (control)	14.33	11.00	14.33	3.00	0.41	11.00	13.00
No salt+ RA-5	19.50**	13.00**	19.00**	4.67**	0.55**	12.50**	14.00**
25 mM NACl+RA-5	13.00**	11.33**	14.67**	4.33**	0.44**	11.67**	11.67**
50 mM NaCl+ RA-5	12.67**	9.33**	11.33**	3.33**	0.37**	9.67**	9.67**
100 mM NaCl+ RA-5	12.00**	7.00**	9.00**	2.67**	0.32**	9.17**	9.00**
200 mM NaCl+ RA-5	10.33**	7.33**	3.67**	2.00**	0.24**	8.83**	7.67**
300 mM NaCl+ RA-5	7.00**	4.67**	3.00**	2.33**	0.22**	8.33**	6.00**
SEM ±	0.57	0.57	0.57	0.23	0.02	0.29	0.37
C D (p=0.05)	1.22	1.23	1.23	0.49	0.04	0.63	0.79
C D (p=0.01)	1.70	1.70	1.70	0.68	0.06	0.88	1.09
C V (%)	9.54	13.36	11.34	15.14	11.21	6.14	7.68

** = Significant at 1% level

Table 2. Effect of Cowpea *Bradyrhizobium* on different growth parameters of pigeonpea under salt stress conditions at 20 DAS

Treatments	Plant height (cm)	Chlorophyll content	No. of nodules per plant	No. of leaves per plant	Fresh weight(g)	Root length(cm)	Shoot length(cm)
No salt + No RA-5 (control)	16.00	13.41	20.67	7.00	0.55	11.83	17.00
No salt + RA-5	22.00**	14.00**	34.67**	9.33**	0.72**	13.50**	21.67**
25 mM NACl + RA-5	14.00**	13.00**	30.67**	8.33**	0.62**	12.64**	19.00**
50 mM NaCl + RA-5	15.28**	9.85**	19.00**	5.00**	0.42**	11.08**	15.17**
100 mM NaCl + RA5	13.10**	8.67**	14.67**	3.67**	0.36**	12.50**	14.00**
200 mM NaCl + RA-5	11.00**	6.80**	13.00**	2.33**	0.24**	9.48**	11.67**
300 mM NaCl + RA-5	8.00**	5.25**	10.67**	2.33**	0.25**	9.00**	9.67**
SEM ±	0.44	0.57	1.08	0.52	0.02	0.46	0.37
C D (p=0.05)	0.95	1.23	2.31	1.13	0.04	0.98	0.79
C D (p=0.01)	1.31	1.70	3.21	1.56	0.05	1.36	1.09
	6.59	13.36	11.18	20.50	8.37	8.45	7.68

** = Significant at 1% level

Table 3. Effect of Cowpea *Bradyrhizobium* on different growth parameters of pigeonpea under salt stress conditions at 30

Treatments	Plant height (cm)	Chlorophyll content	No. of nodules per plant	No. of leaves per plant	Fresh weight(g)	Root length(cm)	Shoot length(cm)
No salt + No RA-5 (control)	20.00	15.00	26.52	7.67	0.75	10.67	15.33
No salt + RA-5	25.22**	15.57**	37.11**	9.67**	1.02**	13.83**	22.33**
25 mM NACl + RA-5	18.33**	13.14**	31.60**	8.67**	0.91**	13.25**	21.33**
50 mM NaCl + RA-5	16.33**	10.00**	22.15**	5.00**	0.65**	12.66**	15.00**
100 mM NaCl + RA-5	13.80**	9.04**	19.68**	4.33**	0.53**	12.69**	13.33**
200 mM NaCl + RA-5	13.00**	7.00**	14.66**	3.00**	0.46**	10.14**	9.00**
300 mM NaCl + RA-5	9.93**	5.92**	12.70**	2.67**	0.38**	9.35**	7.33**
SEM ±	0.63	0.52	2.24	0.38	0.03	0.68	1.05
C D (p=0.05)	1.34	1.12	4.80	0.83	0.07	1.46	2.25
C D (p=0.01)	1.86	1.55	6.66	1.15	0.09	2.03	3.12
C V (%)	7.96	10.22	20.65	13.94	9.78	12.27	15.03

** = Significant at 1% level

previous workers (Soussi *et al*., 1999 and Shereen *et al.,* 1998). Koyro (2000) and Jamil *et al.* (2007) reported the significant decline in chlorophyll content with an increase in NaCl concentration. Han and Lee (2005) reported the significant effect of salt stress on various plant growth parameters in lettuce crop. Dhanapackiam and Ilyas (2010) observed that number of nodules per plant in *Sesbania grandiflora* decreased with an increase in salinity levels. Shukla *et al.* (2012) reported that the interaction of PGPR with several crops in saline conditions reduces the extent of poor growth and thus help plants to survive in adverse conditions.

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Growth, Yield and Quality of Chickpea (*Cicer arietinum* L.) as Influenced by Sulphur and Boron Application and *Rhizobium* Inoculation

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***Abstract*:** The experiments were conducted to observe the impct of sulphur, boron with Rhizobium inoculation on chickpea (*Cicerarietinum*L.). The treatments comprised three levels each of sulphur (0,40, 60 kg Sha^{-1}) and boron (0, 1.5, 2.5 kg Bha^{-1}) with and without *Rhizobium*as seed inculcum along with uniform basal application of 20 kg N+ 50 kg P_2O_5+20 kg K_2O ha^{-1}.The crop responded significantly upto 40 kg Sha^{-1} in plant height and upto 60 kg Sha^{-1} in pods $plant^{-1}$, 100-grain weight, grain and straw yield. In case of boron application, branches $plant^{-1}$, grains pod^{-1}, grain yield, stover yield, grain protein and methionine contents showed significant increase with upto 1.5 kg Bha^{-1} while plant height and pods $plant^{-1}$ increased significantly with upto 2.5 kg Bha^{-1}. Seed inoculation with *Rhizobium*registered higher values of plant height, pods $plant^{-1}$, grains pod^{-1}, grain and stover yields and grain protein content over no *Rhizobium*inoculation, where branches $plant^{-1}$, 100-grain weight and methionine content is grain were not influenced by *Rhizobium.*Application of sulphur could not show any significant effect on grain quality. The interaction of SxB indicated that combined use of 60 kg S + 2.5 kg $Bha^{-1}$is optimum to attain higher yield.

Key Words: Boron, Chickpea, Grain quality, G*rowth, Rhizobium*, Sulphurand yield

Chickpea (*Cicerarietinum* **L.**) is the most important pulse crop of India in terms of both area and production. Uttar Pradesh is one of the major chickpea producing states of India. However, productivity of chickpea in the country and state is not satisfactoryinspite of high yielding genotypes for different situations (Pathak *et al.,*2007). The use of high analysis fertilizers has resulted in depletion of secondary and micronutrients in soil.Sulphuris considered as one of the most vital plant nutrients for pulse crops, as it is essential for protein synthesis especially S- containing amino acids like methionine, cysteine and cystine.Boron is one of the most important micronutrient in present agriculture after zinc. It is required for proper development and differentiation of plant tissues. It is found associated with reproductive phase in plants and reduces sterility and any malformation in reproductive organs. Seed inoculation with *Rhizobium*in pulse crop had been proved its utility very well, but its effect on some aspects particularly quality characters and interaction with sulphur and boron fertilization had not been studied intensively (Yadegari*et al.,* 2008; Minaxi*et al.,* 2012). Keeping all above aspects in view, an experiment was conducted to study the effect of sulphur, boron and *Rhizobium*on growth, yield and grain quality of chickpea crop in irrigated condition of central Uttar Pradesh.

MATERIAL AND METHODS

The experimentswere conducted during the winter (*Rabi*) seasons of 2011-12 and 2012-13 at the research farm of Chandra ShekharAzad University of Agriculture and Technology, Kanpur, Uttar Pradesh. The soil was sandy loam, slightly alkaline (pH 7.7) (Jackson, 1973), low in available nitrogen (176 $kgha^{-1}$) (Subbiah and Asija, 1956), available phosphorus (8.70 $kgha^{-1}$)(Olsen *et al.,* 1954), available potassium (158 $kgha^{-1}$) (Jackson, 1973), availablesulphur (6.5 $mgkg^{-1}$) (Jackson, 1973) and available boron (0.43 $mgkg^{-1}$)(Jackson, 1973), respectively. An uniform basal dose of 20 kg N + 50 kg P_2O_5 through Di-ammonium phosphate and 20 kg K_2Oha^{-1} through muriateof potash was applied at the time of sowing during both the years. The treatments comprised of 3 sulphur levels (0,40 and 60 kg ha^{-1}) through elemental sulphur, 3 boron levels (0,1.5 and 2.5 $kgha^{-1}$) through borax and two *Rhizobium*levels (no *Rhizobium*and *Rhizobium*seed inoculation). Seed inoculation with *Rhizobium*culture was done before sowing as per recommended procedure. The experiments were conducted in a factorial randomized block design and were replicated thrice. The seeds of chickpea variety *Radhey* were sown @ 100 kg ha^{-1} behind plough in furrows 40 cm apart in November during both the years. Other than treatments the

crop was raised with recommended package of practices. The crop was harvested in April for both the years. The observations on growth, yield attributes, yield and quality parameters, were recorded. Among quality parameters grain protein content and methionine content in grain were estimated. For protein content, first the nitrogen in grain samples was estimated by Kjeldahl's method and then the protein content was obtained by multiplying the nitrogen content with the factor 6.25 (AOAC, 1970). Methionine content in grain was determined by using colorimetric method (Horn *et al*., 1946). Data were pooled and analysed using the F-test according to Gomez and Gomez (1984). Critical difference (CD) values at p = 0.05 were used to determine the significance of differences between treatment means.

RESULTS AND DISCUSSION

Effect of sulphur:

The application of sulphursignificantly improved the growth, yield attributes and yield of chickpea(Table 1 and 2). However, the number of branches per plant could not be significantly influenced by sulphur application. Increasing levels of sulphur increased number of pods plant^{-1}, 100-seed weight, grain yield and straw yield significantly with upto 60 kg Sha^{-1}. The application of 40 and 60 kg Sha^{-1} increased number of pods plant^{-1} by 5.4 and 15%, 100-seed weight by 2.4 and 4.4% grain yield by 15.9 and 25.2% and stoveryield by 15.2 and 20.2% over no sulphur, respectively. Sulphur levels had a little effect on number of grainspod^{-1} which improved with narrow margins due to sulphur application. These positive effects of increasingsulphur levels on chickpea crop may be ascribed to increased supply of sulphur for crop use and poor status of sulphur in experimental soil (Kumar *et al.,* 2006). It has a favourable effect in chlorophyll synthesis (Kumar *et al.,* 2006)which might have resulted in higher production of photosynthates and their translocation from source of sink. Sulphur also has pivotal role in regulating the metabolic and enzymatic processes including photosynthesis, respiration and legume-*Rhizobium* symbiotic nitrogen fixation (Rao *et al*., 2001). These results confirm the findings of Singh *et al*. (2004). Quality parameters (Table 2) were not significantly influenced by sulphurapplication, however those improved marginally with increasing sulphur levels. Choudhary *et al*.(2013) reported almost similar results in maize.

Effect of boron:

The application of boron also influenced the growth, yield and yield attributes of chickpea. Increasing levels of boron increased plant height and number of branches with upto 2.5 kg Bha^{-1}.The plant height of chickpea was improved by 6.8 and 9.1% and number of branches by 7.1 and 11.1% respectively, with the application of 1.5 and 2.5 kg B ha^{-1} over no B application (Table 1). Number of pods plant^{-1} showed significant increase with boron application upto 2.5 kg Bha^{-1} (Table 1). The margin of increase over no boron was found 2.6% at 1.5 kg B and 5% of at 2.5 kg Bha^{-1}. In case of grain pad^{-1}, both B levels being at par produced significantly more number of grains over no boron. The 100-seed weight was not significantly influenced by boron application. Application of boron increased grain and stoveryield significantly over no boron, however difference between 1.5 and 2.5 kg Bha^{-1} levels was not found significant. The application of 1.5 and

Table 1. Effect of sulphur, boron and Rhizobium application on growth and yield attributes of chickpea

Treatment	Plant height (cm)	Branches plant $^{-1}$	Pods Plant $^{-1}$	Grains pod $^{-1}$	100-grain wt. (g)
Sulphur level (kg ha^{-1})					
0	54.8	5.7	60.8	1.3	12.89
40	55.7	5.8	64.1	1.5	13.20
60	55.6	5.9	69.9	1.5	13.45
CD (p=0.05)	0.76	NS	1.03	0.07	0.22
Boron levels (kg ha^{-1})					
0	52.6	5.5	63.4	1.3	13.09
1.5	56.2	5.8	65.0	1.5	13.19
2.5	57.4	6.1	66.6	1.6	13.29
CD (p=0.05)	0.76	0.27	1.03	0.08	NS
Rhizobium level					
No *Rhizobium*	54.1	5.7	64.1	1.4	13.09
Seed inoculation	56.4	5.9	65.9	1.5	13.16
CD (p=0.05)	0.63	NS	0.84	0.07	NS

Table 2. Effect of sulphur, boron and *Rhizobium* application on yield and quality parameters of chickpea

Treatment	Yield (kg ha^{-1})		Quality parameters	
	Grain	Straw	Grain protein (%)	Methionine
Sulphur level (kg ha^{-1})				
0	1515	1590	19.8	0.949
40	1756	1832	19.9	0.950
60	1898	1911	20.1	0.951
CD (p=0.05)	86	67	NS	NS
Boron levels (kg ha^{-1})				
0	1601	1655	19.9	0.947
1.5	1790	1845	20.0	0.951
2.5	1778	1838	20.1	0.950
CD (p=0.05)	86	68	0.22	0.003
Rhizobium level				
No *Rhizobium*	1603	1650	19.9	0.948
Seed inoculation	1830	1906	20.1	0.951
CD (p=0.05)	71	55	0.18	NS

2.5 kg Bha^{-1} increased grain yield over no boron by 11.8 and 11.1%, and stoveryield by r 11.5 and 11.1%, respectively. The higher yields with boron application might be attributed to improved growth and yield attributes. The significant yield response to boron application may be attributed to the deficiency of available boron in experimental soil (Kumar *et al.*, 2006). Limited yield response only to 1.5 kg Bha^{-1} may be explained that the dose of 1.5 kg Bha^{-1} was sufficient to meet the crop requirement. These results are in accordance to the findings of Sakal*et al*. (1998). Protein and methionine contents in grain also improved with boron application but by the narrow margin over no boron. It might be due to increased uptake of other plant nutrients particularly the nitrogen and potassium with boron application.

Effect of Rhizobium:

Rhizobium seed inoculation increased the plant height significantly over no*Rhizobium*(Table 1). It might be attributed to increased availability of nitrogen for crop use because of better nodulation. Among yield attributes, the podsplant^{-1} and grainspod^{-1} were recorded significantly higher with *Rhizobium*seed inoculation over no inoculation but 100-seed weight remained unaffected (Table 1). *Rhizobium* increased number of pods by 2.8% and grain pod^{-1} by 6.4% over no *Rhizobium*. Grain andstoveryields also increased significantly due to *Rhizobium*inoculation over no *Rhizobium*(Table 2). The percent increase in grain and straw yiel was 14.2 % and 15.5%, respectively.. It might be attributed to improved growth and yield attributes due to *Rhizobium*inoculation. Protein content in grain increased due to *Rhizobium*inoculation but methionine content remained unaffected. It might be associated with more uptake of nitrogen which increased the N-contents in grain. *Rhizobium* inoculation increases the root nodulation and growth thus more atmospheric nitrogen is fixed and simultaneously uptake of other plant nutrients also increased which might have improved the growth, yield attributes and finally the grain and stover yields. These results corroborate to the findings of Verma*et al*.(2013).

***Interaction effect of suplhur and boron*:**

Among different interactions, the SxB interactionswere found significant only on plant height, branches plant^{-1}, pod plant^{-1}, grain and stover yields (Table 3 & 4). The data on plant height revealed that boron application without sulphur increased plant height significantly with upto 2.5 kg Bha^{-1} but with sulphur, increase in plant height beyond 1.5 kg Bha^{-1} was not significant. Similarly, S application increased plant height significantly over no S whereas S with 1.5 kg Bha^{-1} had no significant effect on plant height and with 2.5 kg Bha^{-1}, S caused significant reduction in plant height. It might be due to antagonistic effect between S and B particularly at higher doses of application. In case of branches plant^{-1}, S application at either rate could not increase the number of branches over without S with any level of B application. On the other hand boron @ 2.5 kg ha^{-1} could increase the number of branches significantly only over no B irrespective of S levels. The interaction effect on pods plant^{-1} indicated that effect of higher dose of 2.5 kg Bha^{-1} was significant only with S application. The data on grain and stover yield (Table 4) revealed that higher dose of 2.5 kg Bha^{-1} reduced yield significantly from the yield at 1.5 kg Bha^{-1}, without S application but with S application, 2.5 kg Bha^{-1} yielded numerically higher than 1.5 kg Bha^{-1} application. It might be due to the reason that the application of both S and

Table 3. Interaction effect of sulphur and boron application on growth and yield attributes of chickpea

Sulphur levels (kg ha^{-1})	Boron level (kg ha^{-1})		
	0	1.5	2.5
Plant height (cm)			
0	50.9	55.5	58.0
40	53.4	56.5	57.6
60	54.2	56.4	56.6
CD (p=0.05)		1.33	
Branches plant^{-1}			
0	5.3	5.8	6.0
40	5.6	5.9	6.1
60	5.6	6.0	6.2
CD (p=0.05)		0.46	
Pods plant^{-1}			
0	59.5	61.1	61.9
40	62.7	63.9	65.7
60	67.8	70.0	72.0
S.Ed.		0.89	
CD (p=0.05)		1.78	

Table 4. Interaction effect of sulphur and boron application on grain and stover yield of chickpea

Sulphur levels (kg ha^{-1})	Boron level (kg ha^{-1})		
	0	1.5	2.5
Grain yield (kg ha^{-1})			
0	1422	1655	1468
40	1569	1820	1878
60	1811	1893	1987
CD (p=0.05)		149	
Stover yield (kg ha^{-1})			
0	1493	1737	1541
40	1648	1914	1946
60	1822	1886	2024
CD (p=0.05)		116	

B when applied in combination, they improve the growth and yield of chickpea. Increase in yield attributes and yield of chickpea with combined use of S and B has also been reported by Kumar *et al.* (2006).

This study shows that the application of sulphur and boron along with *Rhizobium* inoculation the plant height, branches plant^{-1} and finally the pod plant^{-1}, which ultimately improved the grain yield of chickpea on sandy loam soils. The quality parameters as well as stover yield was also improved.

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Agro-Biodiversity Conservation for Sustainable Agriculture of Lateritic Region of West Bengal (India)

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Abstract **:** According to an estimate west Bengal possesses vast genetic diversity of rice. In the year 1975, 5,556 rice varieties were recorded in west Bengal. The unfortunate aspect is that out of over five thousand landraces of rice more than 90% of the total number of traditional variety have disappeared from the rice field of Bengal and out of the existing landraces none is being cultivated in organized way. So far, 102 rare and traditional varieties of rice landraces have been documented from the lateritic region of West Bengal and is being tried to be propagated on small farm areas. The work deals with botanical features of these varieties and attempts being taken to conserve them. The outcome of the work will provide scientific, cultural and socioeconomic data, related to the landraces of Lateritic region on the basis of which the local farmers will be encouraged to cultivate these races, so that they are not at loss because of our negligence and the agro-biodiversity of West Bengal can be sustained.

Key Words: Agro-biodiversity, Landraces, Rice, Lateritic Region, Sustainable agriculture

India is a richest reservoir of rice biodiversity. Rice cultivation covers more than 30 percent of total cultivated area of this country and is a staple food grain. Richharia and Govindasamy (1990) stated that this country possesses more than 2 laks rice varieties from the period of Vadic to the present era . Hunter (1876-1881) makes first report on rice variety of the West Bengal Provinces and reported 1,100 landraces present in this provinces. In the year 1970, number of landraces of rice in this state was 5,556 varieties (Guevarra 2000). West Bengal in India is richest reservoir of rice biodiversity, ecotypes of rice; spontaneously evolved types in the state are so diverse and different that scientists at one time coined them as *Oryza sativa* var. *benghalensis* (Chatterjee *et al*., 2008). The unfortunate aspect is that out of over five thousand landraces of rice more than 99% of the total number of traditional variety have disappeared from the rice field of Bengal and out of the existing landraces none is being cultivated in organized way. According to the report of Planning Commission, Govt. Of India (2010) only 400 rice genetic diversity exists in this state. Green revolution has considerably improved production of food grains in our country but high yielding varieties, which are the back bone of green revolution, have indirectly stimulated erosion of landraces and wild varieties of rice. Traditional varieties have evolved in response to changing local selection pressure, still maintaining a high level of genetic variation (Soleri and Cleveland 2007). Landraces offer a valuable gene pool for future breeding program and in present era of overpopulation *Ex-Situ* conservation is the best strategy to conserve these landraces because marginal and poor farmers who are the main keepers of traditional variety of rice are more interested in high production but not in genetic diversity. The main objective of this study was to survey landraces biodiversity of lateritic zones of West Bengal. The outcome of the research work will also provide scientific, cultural and socioeconomic data, related to the collected landraces on the basis of which the local farmers will be encouraged to cultivate these races, so that the agro-biodiversity of West Bengal can be sustained.

MATERIAL AND METHODS

The present investigation was carried out at various districts under the Lateritic Region of West Bengal (Bankura, Purulia and part of the Bardhaman, Birbhum and Paschim Midnapur). Almost all major rice growing portion of this region has been visited during kharif season of 2010 to 2013 and collected more the one hundred landraces of rice from this region. The *In-Situ* cultivation and conservation of this collected landraces of traditional rice from various remote village of the lateritic region was conducted at the village of Ranbahal (22?38´N latitude and 86?36´E-87°47´E longitude with an altitude of 78 meters above sea level) in a smallfarm area. Eighty two (82) landraces of rice cultivars collected from the remote villages of lateritic region of West Bengal, were cultivated and conserved in this study are given in Table1.

The materials were grown using completely randomized block design with three replications. Each variety was transplanted (45 day's old seedling) in a plot of $6m^2$ with a spacing of 25cm. between rows and 20cm. between plants in a row. A random sample of five competitive plants was used for observations on different traits under study. No synthetic nutrients were applied. During the crop period the water depth of the field was 40-50cm. varieties.

RESULTS AND DISCUSSION

Rice diversity of Lateritic region

Traditional rice cultivars are not uniformly cultivated

Table 1. Distribution of landraces of rice in different district of Lateritic region of West Bengal

Region/ District	Name of landraces
Purulia	Kalamkati, Dharansal, Kasiphul, Chandrakanta, Kalobhat, Agniban, Keralasundari, Neta, Kelesh, Asanlaya, Vutmuri, Lakkhansal. Panati, Kataribhog, Langalmura, Bashkamini, Badamsaru
Bankura	Khajurchari, Suakalma, Nagrasal, Kalmkati, Daharlagra, Chandrakanta, Danarguri, Chandrakanti , Kasiphul, Nikunja, Marichsal, Nugen baro, Rupsal, Kalodhopa, Dudherswar, Kaksal, Kalokumro
Paschim Midnapur	Malabati, Patnai-23, Nona Bogra, Chotodidi, Likekak ua, Kheuch, Valki, Kabiraj, Jamai nadu, Jaldhepa, Dudherswar, Bhuri, Dangapatnai, Bachi, Barani.
Bardhaman(part)	Patnai-23, Talmugurdhan, Malsira, Bombaimugi, Radhatilak, Fulpagri, Lal -badshabhog, Badshabhog, Laltipa, Sonagori, Narkeljhopa, Murkimala,.
Birbhum (part)	Sindurmukhi, Kalobyar, Kanakchur, Radhatil ak, Bahurupi, Byamajhupi, Medi, Ragusal, Kartiksal, Bhadoi, Kalojira, Chinakamini, Birahi, Gangajali, Bhurisal, Mukta.

throughout this region. The area under traditional rice varieties is considerable low (Sinha and Mishra 2012, 2012a), (Sinha and Mishra 2013, 2013a, 2013b, 2013c). Some drought tolerant varieties are still grown in various blocks of Purulia and Bankura district. Tradition varieties of this region mainly found in the rainfed none irrigated agricultural field. Maximum numbers of landrace ware found form specific pockets of Purulia and Bankura district. Important agronomic features, potentiality for future crop improvement and use of landraces presently available in lateritic region of West Bengal are given in Table 2.

Rice diversity and sustainable agriculture

High yielding varieties of rice have a great importance to achieve current increasing demand of food. The HYVs which is evolved in focus with low land irrigated agricultural field are failed to perform considerably in this extreme marginal environmental condition of this region. Only some selected traditional varieties have performed good results. In most of

Table 2. Important agronomic features and use of landraces of Lateritic region

Landraces	Special agronomic feature	End Use	Potential for crop improvement
Agniban	Red rice	Daily cooking, making beaten rice	
Asanlaya	Red rice	Daily cooking	Resistant to pest
Bashkamini	Aromatic	Making sweet rice, ritual cuisine	
Badamsaru	Fine rice	Making sweet rice	Non lodging
Bhuri	Bold grain	Daily cooking	Pest resistant
Bachi	Short bold grian	Daily cooking	Pest resistant
Bahurupi	High yielding	Daily cooking	Non lodging
Barani	Brown kernel	Daily cooking	Non lodging, High yield
Bhadoi	Short maturity duration	Daily cooking	Drought resistant
Birahi	Fine grain	Daily cooking	
Bhurisal	Medium slender grain	Daily cooking	Drought resistant
Byamajhupi	Purple leaf sheath	Daily cooking	High yielding
Bombaimugi	Long straw	Daily cooking	Pathogenic resistant
Badshabhog	Aromatic	Making sweet rice, ritual cuisine	
Chandrakanta	Red rice	Daily cooking	Pathogenic resistant
Chandrakanti	Red rice	Daily cooking	Pathogenic resistant
Chotodidi	Bold rice	Daily cooking	Non lodging
Chinakamini	Aromatic	Making sweet rice	
Dharansal	Long bold grain	Daily cooking	Drought resistant
Daharlagra	Short maturity	Daily cooking	Drought resistant
Danarguri	Aromatic	Making sweet rice, ritual cuisine	
Dudherswar	Fine grain	Daily cooking	Pathogenic resistant
Dangapatnai	Slender grain	Daily cooking, making puffed rice	
Fulpagri	Medium slender grain	Daily cooking	
Gangajali	Slender grain, aromatic	Daily cooking, ritual cuisine	Pathogenic resistant
Jaldhepa	Photosensitive	Daily cooking	Non lodging
Jamainadu	Long bold grain	Making moori (rice bubble)	
Kalmkati	Fine grain	Daily cooking	
Kasiphul,	Fine grain	Making moori (rice bubble)	Photosensitive
Kalobhat	Black kernel	Daily cooking	High Fe content
Keralasundari	High yielding	Daily cooking	Non lodging
Kheuch	Presence of long awn	Daily cooking	Drought resistant
Kalokumro	Bold rice	Making cheere (beaten rice)	Drought resistant
Kalodhopa	Bold rice	Daily cooking	Non lodging

Cont...

Kaksal	Long straw	Daily cooking	
Khajurchari	Multiple spikelet's	Making muri (rice bubble) & khoi	
Kelesh	Short maturity	Making muri (rice bubble)	Drought resistant
Kabiraj	Long straw	Daily cooking	
Kataribhog	Aromatic, slender grain	Making sweet rice, ritual cuisine	
Kanakchur	Aromatic, awn	Making sweet rice, ritual cuisine	
Kalobyar	Long straw, black rice	Daily cooking	Lodging resistant
Kartiksal	Long straw	Daily cooking	Pathogenic resistant
Kalojira	Aromatic, black rice	Making sweet rice, ritual cuisine	
Lal-badshabhog	Aromatic, red rice	Making sweet rice, ritual cuisine	
Laltipa	Bold kernel	Daily cooking	Non lodging
Lakkhansal	Early maturity	Daily cooking	
Langalmura	Bold grain	Daily cooking	Drought resistant
Likekakua	Grains with long awn	Daily cooking and making cheere	Drought resistant
Marichsal	Short bold grain	Daily cooking	
Malabati	Bold grain	Daily cooking	Salt& pathogenic resistant
Malsira	Purple colour paddy	Daily cooking	
Murkimala	Photosensitive	Making khoi (puffed rice)	
Mukta	medium land type	Daily cooking	Drought resistant
Medi	Medium land type	Daily cooking	Salt tolerant
Nagrasal	Short bold grain	Daily cooking	Pathogenic resistant
Nikunja	Fine grain	Daily cooking	
Nugen baro	Bold grain	Daily cooking	
Nona Bogra	Long straw	making beaten rice	Non lodging, salt resistant
Neta	Short maturity, awaning	Making beaten rice	Drought resistant
Narkeljhopa	Long straw	Daily cooking	
Panati	Grains with long awn	Daily cooking	Drought resistant
Patnai-23	Long grain	Daily cooking	
Rupsal	Medium maturity	Daily cooking	Pathogenic resistant
Radhatilak	Aromatic	Making sweet rice, ritual cuisine	
Ragusal	Medium maturity	Daily cooking	Pathogenic resistant
Suakalma	Grains with awn	Daily cooking	Pathogenic reistant
Sindurmukhi	Medium slender grain	Daily cooking	Drought resistant
Sonagori	High yield	Daily cooking	
Talmugurdhan	Long straw	Daily cooking	Drought resistant
Valki	Long maturity duration	Daily cooking	
Vutmuri	Short maturity duration	Making moori (rice bubbles)	Drought resistant

the case they have lost their seeds because they have no scientific storage and conservation knowledge, and they well known that seed are remain viable only one year in conventional storage system. Developments of disease resistant varieties are possible only with help of such genes which are available in landraces only. Instead of disease resistant landraces have some other quality also- these are resistant to drought, resistance to osmotic stress, culm elongation, presence of aroma, some landraces are adopted to non-flooded soils some variety can withstand flooding. Variety Bhootmuri, Bombaimugi, Noichi, Kalogorah and Kelas, which are abundant in Latetitic region are drought tolerant and resistant to a wide range of environmental stress. Bhadoi is sown variety and resistant to drought. This variety have very short maturity period and meet the food crisis of the gap period of transplantation and large scale harvesting because most of the landraces have take long time to mature ('Boran' in Bengali). Variety Kelas and Bhootmoori show a high degree of tolerance to osmotic stress.Variety Jabra, Jalkamini and Harma Nona can withstand inundation by stem elongation in response to rice in flood water level. Traditional rice has some aesthetic value also. The main advantage of the traditional rice based agriculture is yield stability. As these varieties are selected by the natural selection overall production of the yield is unaltered in compare to the HYVs which is vastly affected by the slight environmental fluctuation (long drought, late monsoon, early monsoon, heavy rainfall, long time monsoon, pathogenic attack etc). In spite of this traditional rice variety have some medicinal value also. Many landraces of this region have medicinal value. 'Parmaisal' used for child growth, 'Kelas' and 'Bhootmori' variety effective in anaemia, 'Kabirajsal' used for convalescing patients for quick recovery. Landraces varieties have tremendous variation in the shape, colour, weight, and agronomic characters which show vast genetic diversity present in these variety.

It can be concluded that the high yielding varieties will gradually decrease the agro biodiversity of this region as usual to the rest of the part of the State. HYVs give better result in irrigated agricultural field but were not as responsive to the needs of the rainfed agriculture and agriculture in stress. Not only the 'gene mining', to sustain the rainfed agro-ecosystem of the lateritic region of West Bengal, cultivation and conservation of the traditional varieties is the present demand. The proposed research work aims at one of the most serious problems - gradual erosion of rice genetic diversity endemic in West Bengal, strategy to restore it, and sustainable agriculture.

In looking the present scenario we have two options to maintain the agro-biodiversity of this region and sustainable agriculture- 1. Motivate the marginal farmer to cultivate these landraces and aware about their importance

in sustainable agriculture- which is quite impossible and 2. To establish small in-situ landraces growing farm in private-government joint venture basis and maintain the traditional variety of lateritic region of West Bengal.

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Standardization of Tamarind Ready-to-Serve and Syrup

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Abstract**:** An attempt was made to utilize tamarind pulp for the preparation of tamarind RTS and syrup. The chemical compositions and changes in chemical constituents of syrup during storage at ambient temperature have been studied. Results showed that TSS, titratable acidity and sugar content increased, where as ascorbic acid decreased. The result revealed that organoleptically acceptable tamarind RTS could be prepared from tamarind pulp by using a recipe of 15 per cent juice + 15 per cent TSS + 0.3 % acidity + 0.5% salt **+** cardamom (1 capsule) found better quality compared to other recipe with respect to overall acceptability (4.48 out of 5 Scores). The syrup having 40% juice + 70% TSS + 1.5% acidity + 0.5% salt was superior to other recipes. The tamarind syrup retained its characteristic colour, aroma and taste upto 3 months of storage at room temperature.

Key Words: Nutritional quality, Organoleptic evaluation, RTS, Storage,Syrup, Tamarind

Tamarind *(Tamarindus indica* L.) is an arboreal fruit belonging to the family *Fabaceae*. The most outstanding characteristic of tamarind is its most acidic nature with total acidity ranging from 12.2 to 23.8 % as tartaric acid. It is a good source of vitamin B (Siddig *et al*., 2006). Although many medicinal values are claimed for various preparations from the fruit, leaf, flower, bark, etc., of tamarind tree, only the antiscorbutic properties of pulp, laxative action of juice and diuretic properties of leaf sap are well established. (Siddig *et al*., 2006). Looking into the fast increasing area under tamarind cultivation, methods of preservation needs to be developed to regulate the prices of fresh tamarind fruits and to safeguard the interest of tamarind growers during period of glut (Joshi *et al*., 2012). Now a days people are inclined to instant preparations, the convenience in use of tamarind pulp may be enhanced by converting it into paste form. The value added products such as tamarind paste after proper packaging can be transported to the areas where it could be utilized. Tamarind products posses good export potential (Champakam and Peter, 2000). Due to perishable nature of the fruits, they require immediate processing to avoid post harvest losses and changes in colour from brown to black due to phenolics and non-enzymatic browning during storage. Therefore the present investigation was planned and carried out with an aim to develop technology for preparation value added products (RTS and syrup) from tamarind.

MATERIAL AND METHODS

The experiment was carried out at Kittur Rani Channamma College of Horticulture, Arabhavi (Karnataka) during the year 2011-2012. The fully ripe tamarind fruits of cv. DTS-1 were procured from Department of Plantation and Spices Crops, Kittur Rani Channamma College of Horticulture, Arabhavi. The pulp was separated from the shells, seeds were removed manually. The ginger *(Zingiber officinais)* and mango ginger (*Curcuma amada*) were procured from the market. The experiment with seven treatments was conducted using completely randomized block design with three replications

Treatment details :

#Tamarind RTS blended with ginger

T_1- 10 % juice *+ 15% TSS
$TSST_2$- 10 % juice *+ 20% TSS
$TSST_3$- 12 % juice *+ 15% TSS
T_4- 12 % juice *+ 20% TSS
T_5- 15 % juice *+ 15%
T_6- 15 % juice *+ 20%
T_7- 12 % juice **+ 15% TSS
*Tamarind:ginger (9:1)
**Tamarind: Mango ginger (9:1)

Acidity (0.3 %), Cardamom (1 capsule), and Salt (0.5%).

 # Tamarind Syrup blended with ginger

T_1- 40 % juice *+ 60% TSS
T_2- 45 % juice *+ 60% TSS
40% juice *+ 65% TSS
T_4- 45% juice *+ 65% TSS
T_5- 40 % juice *+ 70% TSS
T_6- 45 % juice *+ 70% $TSST_3$-
T_7- 40 % juice **+ 60% TSS
*Tamarind:ginger (9:1)
**Tamarind: Mango ginger (9:1)

#Acidity (1.5%) and salt (0.5%)

Preparation of tamarind RTS: Tamarind juice was mixed with sugar and water as per recepies mentioned in the treatment details. One cardamom capsule per treatment was added to enhance flavor. The beverages were filled in clean, sterile bottles of 200 ml capacity and sealed with caps.

Preparation of tamarind Syrup: For the preparation of tamarind syrup juice was mixed with sugar and water as per recepies mentioned in the treatment details. The beverage was preserved by addition of potassium meta bisulphate @ 0.25 g per litre and salt 0.5 per cent respectively. The beverages were filled in clean, sterile bottles of 200 ml capacity and sealed with caps. Later it was stored at room temperature upto 3 months.

TSS was measured by using digital refractometer (Make Erma); pH meter for pH (Model: Analog, research USA). Titratable acidity was estimated as per the modified procedure of AOAC (Anonymous, 1984). Ascorbic acid content was determined by using 2,6-dichlorophenol indophenol dye titrimetrically as per the modified procedure of AOAC). Sugars were estimated as per the dinitro salicylic acid (DNSA) method (Miller, 1972). The chemical compositions of freshly prepared RTS were analysed. Organoleptic evaluation of freshly prepared tamarind RTS was carried out immediately after preparation (Table 1) by a panel of semi-trained judges consisting of teachers and post-graduate students of College of Horticulture, Arabhavi on a five point Hedonic scale. Organoleptic evaluation of tamarind syrup was done at 30, 60 and 90 days after storage (DAS). Tamarind syrup was diluted with water in the ratio of 1:4 before serving to judges.

RESULTS AND DISCUSSION

Chemical parameters of tamarind RTS blended with ginger

The results indicate that there were significant differences between the treatments with respect to all parameters of tamarind RTS blended with ginger (Table 1). Significantly highest pH was recorded in T_1 consisting of 10 % juice+ 15% TSS (3.86) whereas lowest pH was found in T_6 consisting of 15 % juice + 20% TSS (3.71). Similarly maximum ascorbic acid, reducing sugar, non-reducing sugar and total sugar were found in T_6 (2.22 mg/100g, 4.73 %, 10.73 % and 15.46 % respectively). Similar results have been obtained by (Kotecha and Kadam, 2003) in tamarind RTS.

Organoleptic evaluation of tamarind RTS (Scores out of 5.00):

The significantly higher score for colour, aroma and flavour and taste was observed in T_6 (4.08, 4.08 and 4.36) respectively, whereas least score was recorded in T_1 However with respect to overall acceptability the highest scores were observed in T_5 (4.48) which was on par with T_6, T_4 and T_2 (3.75-4.06).The RTS (T_5) consisting of 15 per cent juice + 15 per cent TSS, scored maximum overall acceptability (Table 1). This might be due to better consistency, acceptable color and sugar acid blend leading to highly acceptable. Similar results have been obtained by (Kotecha and Kadam, 2003) in tamarind RTS.

Changes in chemical composition of tamarind syrup during storage:

The treatment T_6 (71.13 recorded maximum TSS compared to other treatments during storage at 30, 60 and 90 days after storage respectively (Fig 2). This increase might be due to hydrolysis of polysaccharides like starch and pectic substances into simpler substances which contributed to increased TSS content. Similar observations were recorded by Kotecha and Kadam (2003) in tamarind syrup. pH of the prepared products showed an increasing trend during storage (Table 2). The significantly higher pH at 30, 60 and 90 days after storage was in T_1 (2.09, 2.13 and 2.40) which was on par with T_7 and T_2. A corresponding decrease in acidity might be responsible for it. Acidity of the prepared products gradually declined during storage (Fig 3). Among the different treatments maximum acidity was noticed in T_2 (1.46, 1.41 and 1.37%) at 30, 60 and 90 days) which was on par with T_1 after storage respectively, T_4 and T_7 (30 and 60 days) and T_6 (90 days). This decrease in acidity might be due to acid hydrolysis of polysaccharides and non-reducing sugars to their simpler components where the acid is utilized for converting them to hexose sugars or complexes in the presence of metal ions Reduction in acidity during the storage period of the beverages was observed by Lakshmi *et al.* (2005) in flavoured tamarind RTS beverages. The gradual decrease in ascorbic acid was observed in tamarind syrup blended with ginger during storage (Table 2). The significantly highesr ascorbic acid was in T_2 (7.00, 6.84 and 6.82 mg/100 g) which was on par with T_6 and T_3. The gradual decrease of ascorbic acid content may be due to oxidative destruction of as ascorbic acid in the presence of molecular oxygen by ascorbic acid enzymes Since ascorbic acid content of the beverage is directly dependent on blended juice used for its preparation. Comparatively higher ascorbic acid content was observed at the end of storage period in case of samples having higher percentage of juice content in all the beverages. Analogous observations for decline in ascorbic acid content was observed in aonla juice by Gajanana (2002), in rose apple-aonla squash by Basavaraja (2005) and in bael-guava RTS by Nidhi *et al.* (2008).

Increase in sugars was observed in tamarind syrup blended with ginger during storage (Table 3). Significantly higher reducing sugars was recorded in T_6 (13.94 %, 14.14 % and 14.54 %) at 30, 60 and 90 days after storage respectively, which was on par with T_5 (13.74 % at 60 DAS) and T_4, T_5 (13.63 %, 13.80 % at 90 DAS). However, the mean of non- reducing sugars at 30, 60 and 90 days after storage found non-significant. At 30 days after storage significantly highest total sugar was recorded in T_5 (57.74 %). However, the mean total of sugars at 60 and 90 days after storage were non-significant. Total sugar content of tamarind blended ginger syrup increased slightly during storage. It could be attributed to the acid hydrolysis of polysaccharides which resulted in increase in soluble sugars content. Increase in reducing and total sugars and decrease in non-reducing sugars is a general phenomenon as noticed by many workers. Kotecha and Kadam (2003) in tamarind syrup observed an increase in total and reducing sugars and decrease in non-reducing sugars during storage.

Organoleptic evaluation of tamarind syrup (Scores out of 5.00):

Maximum score for colour was observed in T_6 which was on par with T_4, T_5, and T_7. Significantly maximum score for aroma was noticed in T_6 at 30, 60 and 90 days after storage respectively, which was on par with T_2 , T_4, T_5 at 30 days after storage, T_3 , T_4 and T_5 at 60 days after storage and

Table 1. Chemical parameters of tamarind RTS blended with ginger as influenced by treatments

Treatment	pH	Ascorbic acid (mg/100g)	Reducing sugars (%)	Non reducing sugars (%)	Total sugars (%)	Organoleptic evaluation (out of 5.00)			
						Colour	Aroma and flavour	Taste	Overall acceptability
T_1	3.86	2.07	2.86	8.46	11.32	2.36	2.3	2.83	3.46
T_2	3.75	2.08	3.56	8.94	12.50	2.40	3.5	3.16	3.75
T_3	3.78	2.10	4.06	9.62	13.68	3.56	3.5	3.07	3.55
T_4	3.73	2.12	4.62	10.24	14.86	3.78	3.71	3.91	4.05
T_5	3.72	2.15	4.22	10.06	14.28	3.66	3.06	3.03	4.48
T_6	3.71	2.22	4.73	10.73	15.46	4.08	4.08	4.36	4.26
T_7	3.75	2.10	4.01	9.55	13.56	3.00	3.61	3.63	3.35
Mean	3.75	2.12	4.01	9.65	13.67	3.26	3.39	3.42	3.84
CD (p=0,01)	0.03	0.03	1.32	0.77	0.03	0.88	0.77	0.87	0.82

Table 2. Changes in pH and Ascorbic acid (mg/100g) of tamarind syrup blended with ginger during storage

Treatment	pH (days after storage)				Ascorbic acid (days after storage) in mg/100g			
	30	60	90	Mean	30 DAS	60 DAS	90 DAS	Mean
T_1	2.09	2.13	2.40	2.20	6.20	6.04	6.02	6.08
T_2	2.00	2.11	2.38	2.18	7.00	6.84	6.82	6.88
T_3	2.04	2.09	2.36	2.16	6.19	6.03	6.01	6.07
T_4	2.06	2.10	2.37	2.18	6.83	6.73	6.72	6.76
T_5	2.02	2.07	2.34	2.14	6.22	6.07	6.05	6.11
T_6	2.03	2.08	2.35	2.15	6.90	6.83	6.82	6.85
T_7	2.08	2.12	2.39	2.20	6.20	6.04	5.94	6.04
Mean	2.05	2.10	2.37	2.17	6.50	6.37	6.3 6	6.40
CD (p=0.01)	0.01	0.01	0.01		0.50	0.16	0.20	

Table 3. Changes in sugars of tamarind syrup blended with ginger during storage

Treatment	Reducing sugars (%)				Non Reducing sugars (%)				Total sugars (%)			
	30 DAS	60 DAS	90 DAS	Mean	30 DAS	60 DAS	90 DAS	Mean	30 DAS	60 DAS	90 DAS	Mean
T_1	11.98	12.31	12.50	12.26	40.13	40.30	40.61	40.34	52.11	52.61	53.11	52.61
T_2-	12.50	12.83	12.47	12.60	40.88	40.90	41.38	41.05	53.38	53.88	54.38	53.88
T_3	12.95	12.98	13.00	12.97	41.69	42.16	42.64	42.16	54.64	55.14	55.64	55.14
T_4	13.12	13.44	13.63	13.39	42.81	42.99	43.30	43.03	55.93	56.43	56.93	56.43
T_5	13.49	13.74	13.80	13.67	44.25	44.50	45.00	44.58	57.74	58.24	58.80	58.26
T_6	13.94	14.14	14.54	14.20	42.00	42.30	42.40	42.23	55.94	56.44	56.94	56.44
T_7	11.29	11.44	11.57	11.43	42.03	42.38	42.75	42.38	53.32	53.82	54.32	53.82
Mean	12.75	12.98	13.07	12.93	41.97	42.21	42.58	42.25	54.72	55.22	55.73	55.22
CD (p=0.01)	0.22	0.6 2	1.13		NS	NS	NS		2.54	NS	NS	

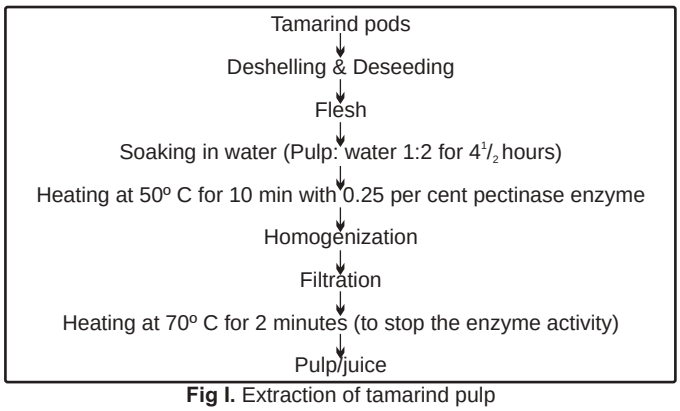

Fig I. Extraction of tamarind pulp

Table 4. Organoleptic scores (out of 5.00) for colour and aroma of tamarind syrup as influenced by treatments

Treatment	Colour (out of 5.00)				Aroma (out of 5.00)			
	30 DAS	60 DAS	90 DAS	Mean	30 DAS	60 DAS	90 DAS	Mean
T_1	3.30	3.20	3.00	3.16	3.00	2.41	2.21	2.54
T_2	3.50	3.40	3.20	3.36	3.51	2.83	2.68	3.00
T_3	3.40	3.30	3.20	3.3	3.16	3.08	2.86	3.03
T_4	3.70	3.60	3.40	3.59	3.78	3.58	3.25	3.53
T_5	3.80	3.70	3.50	3.69	3.68	2.98	2.51	3.05
T_6	3.90	3.80	3.60	3.76	3.83	3.75	3.48	3.68
T_7	3.60	3.50	3.30	3.49	3.26	3.08	2.66	3.00
Mean	3.60	3.53	3.30	3.46	3.46	3.10	2.80	3.11
CD (p=0.01)	0.20	0.18	0.36		0.55	0.88	0.64	

Table 5. Organoleptic scores for taste and overall acceptability of tamarind syrup as influenced by treatments

#Treatment	Taste (out of 5.00)				Overall acceptabilit y (out of 5.00)			
	30 DAS	60 DAS	90 DAS	Mean	30 DAS	60 DAS	90 DAS	Mean
T_1	3.25	3.35	3.46	3.35	3.86	3.83	3.60	3.76
T_2	3.54	3.61	3.75	3.63	3.96	3.53	3.40	3.63
T_3	3.38	3.41	3.55	3.44	4.12	3.9	3.66	3.93
T_4	3.85	3.91	4.05	3.93	3.80	3.73	3.53	3.68
T_5	3.90	4.18	4.48	4.18	4.14	4.00	3.90	4.01
T_6	3.93	4.13	4.26	4.10	3.46	3.33	3.26	3.35
T_7	3.18	3.21	3.35	3.24	3.03	3.03	2.93	2.99
Mean	3.57	3.68	3.84	3.69	3.77	3.63	3.47	3.73
CD (p=0.01)	0.42	0.48	0.48		0.93	0.87	1.19	

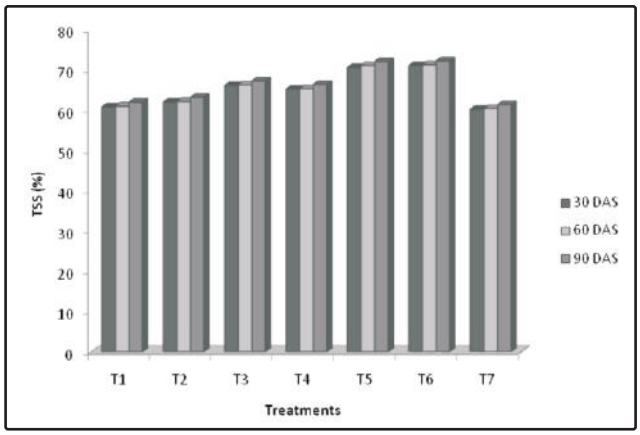

Fig. 2. Changes in TSS (%) of tamarind syrup blended with ginger during storage

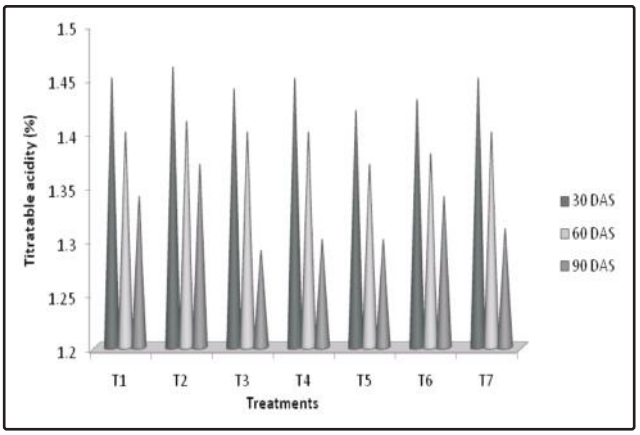

Fig. 3. Changes in Titratable acidity (%) of tamarind syrup blended with ginger during storage

T_3, T_4 at 60 days after storage. At 30 DAS maximum score for taste was observed in T_6 (3.93), which on par with T_4 , T_2), whereas least score was recorded in T_1. Similarly maximum score was in T_5 which was on par with T_6 and T_4. The treatment T_5 consisting of 40 per cent juice + 70 per cent TSS scored maximum overall acceptability. This might be due to better consistency, acceptable color and sugar acid blend leading to highly acceptable. Similar results have been obtained by (Kotecha and Kadam, 2003) in tamarind RTS, syrup (Table 4 and 5).

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Effect of Drying Methods on Organoleptic Evaluation of Peach Cultivars during Storage

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Abstract **:** The three different cultivars of fresh peach viz. Shan-e-Punjab, Flordasun, Early Grande, were dried by different drying methods viz. sun drying, solar drying, oven drying and osmo air drying. Sensory evaluation of dehydrated peach slices revealed that Early Grand (Osmo air drying) recorded highest scores for colour (8.18), taste (7.81), texture (7.70) and overall acceptability (7.85). The highest score for flavour (7.79) was recorded in Shan-e-Punjab (Osmo air drying). The oven drying method showed better acceptability as compared to solar and sun drying methods. Early Grande, Flordasun, Shan-e-Punjab, cultivars of peach can be suitably used for preparation of dehydrated peach product using osmo air drying and oven drying methods. The osmo dehydrated peach can be kept for more than 135 days without affecting the quality attributes.

Key Words**:** Organoleptic evaluation, Osmo air drying, Oven drying, Solar drying, Sun drying

In India, total production of peach was estimated to about 1,50,000 metric tonnes (FAO, 2006). The present area under peach cultivation is about 1827.48 ha with an annual production of 1988 metric tonnes in J and K (Anonymous, 2011). Peaches are excellent source of carbohydrates, organic acids , pigments, phenolics, vitamins, potassium, iron, fiber, flavonids and anthocyanin. The availability of fruit (seasonal commodities) can be extended by the process of dehydration which act as a preservation technique. Many studies have been done on the influence of drying condition of fruit product. However, effect of drying techniques on nutritional quality of dehydrated products has been given little attention. The aim of this work is to study the effect of various drying methods on nutritional quality of dehydrated cultivars of peach during storage.

MATERIAL AND METHODS:

Three commercial cultivars of Peach viz., *Shan-e-punjab, Flordasun and Early Grande* were selected for the present study. Peach fruits were dipped in boiling lye solution (2.0 per cent NaOH) for three minutes and were washed thoroughly. Subsequently, fruits were dipped in 5.0 per cent citric acid solution for five minutes and again washed in running water. Peach fruits were cut into 4 to 6 pieces. The peach slices were divided into four equal lots, cut slices were spread on trays and then subjected to different drying methods viz. sun drying, solar drying, oven drying and osmo air drying. To assess consumer preference, sensory evaluations of experimental samples was conducted at different intervals of storage by semi trained taste panel of 7-8 judges and were evaluated for colour, texture, taste, aroma and overall acceptability. The judges scored the quality characteristics of each sample on nine-point hedonic scale. The product with an overall score of 5 or above was considered acceptable.

RESULTS AND DISCUSSION

The sensory scores of colour decreased significantly in all treatments after 135 days of storage but scores were found to be within acceptable limits. At initial day the maximum score of 8.50 was observed in Early Grande (Osmo-air drying) followed by Flordasun (Osmo-air drying). After 135 days of the storage period, scores decreased to 7.90 in Early Grande (Osmo-air drying) and 7.20 in Flordasun (Osmo-air drying). The decrease in the scores during storage may be attributed to carotenoid degradation and non enzymatic browning as reported earlier (Dutta et al. 2006). The change in colour may be attributed to the loss of SO_2 in samples resulting in non-enzymatic browning to some extent and also some changes in other chemical constituents of the fruits during the storage period (Sharma, 2002). A gradual decrease in texture was observed during storage in all the treatments. The maximum score of 8.10 was recorded in Early Grande (Osmo-air drying) followed by 8.01 in Flordasun (Osmo-air drying). After 135 days of the storage period, scores decreased to 7.22 in Early Grande (Osmo-air drying) and 7.38 in Flordasun (Osmo-air drying). The change observed in texture during storage may be attributed to the degradation of pectin materials present in the fruits and also due to moisture pickup by the products (Sharma, 2002). A significant decrease of taste was observed with the advancement in storage period. At initial day, the maximum

Table 1. Effect of treatments and storage period on colour and Texture of dehydrated peach slices

Treatment	*Storage days*									
	Colour					*Texture*				
	0	45	90	135	Mean	0	45	90	135	Mean
T_1-Shan-e-Punjab (Sun drying)	7.50	7.30	6.50	6.00	6.83	6.50	6.30	6.20	6.00	6.25
T_2-han-e-Punjab (Solar drying)	7.45	7.00	6.80	6.30	6.89	7.00	6.75	6.50	6.10	6.59
T_3-Shan-e-Punjab (Oven drying)	7.90	7.65	7.25	6.65	7.36	6.60	6.40	6.30	6.20	6.38
T_4-Shan-e-Punjab (Osmo-air drying)	8.00	7.90	7.60	7.20	7.68	8.00	7.70	7.35	7.00	7.51
T_5-Early Grande (Sun drying)	7.15	7.00	6.75	6.45	6.84	6.40	6.25	6.15	6.05	6.21
T_6-Early Grande (Solar drying)	6.50	6.30	6.15	6.05	6.25	6.70	6.60	6.40	6.30	6.50
T_7-Early Grande (Oven drying)	7.40	7.20	7.00	6.60	7.05	7.10	6.95	6.60	6.45	6.78
T_8-Early Grande (Osmo-air drying)	8.50	8.30	8.00	7.90	8.18	8.10	7.63	7.83	7.22	7.70
T_9-Flordasun (Sun drying)	7.00	6.90	6.70	6.25	6.72	6.38	6.20	6.08	6.02	6.17
T_{10}- Flordasun (Solar drying)	7.10	6.70	6.65	6.40	6.71	6.95	6.72	6.55	6.45	6.67
T_{11}-Flordasun (Oven drying)	7.60	7.40	7.10	6.90	7.25	7.50	7.12	6.92	6.75	7.07
T_{12}-Flordasun (Osmo-air drying)	8.10	7.90	7.60	7.20	7.70	8.01	7.51	7.44	7.38	7.59
Mean	7.52	7.29	7.01	6.66		7.10	6.84	6.69	6.49	
CD (p=0.05)										
Treatment			0.05					0.05		
Storage			0.05					0.05		
Interaction			0.09					0.09		

Table 2. Effect of treatments and storage period on Flavour and Taste of dehydrated peach slices

Treatment	Storage days									
	Flavour					Taste				
	0	45	90	135	Mean	0	45	90	135	Mean
T_1-Shan-e-Punjab (Sun drying)	6.50	6.40	6.03	6.05	6.25	6.50	6.30	6.25	6.15	6.30
T_2-han-e-Punjab (Solar drying)	6.90	6.70	6.40	6.10	6.53	7.00	6.50	6.30	6.20	6.50
T_3-Shan-e-Punjab (Oven drying)	7.10	6.60	6.50	6.20	6.60	7.10	6.70	6.45	6.30	6.64
T_4-Shan-e-Punjab (Osmo-air drying)	8.20	7.90	7.62	7.45	7.79	8.00	7.50	7.30	7.00	7.45
T_5-Early Grande (Sun drying)	6.30	6.20	6.12	6.00	6.16	6.40	6.25	6.17	6.05	6.22
T_6-Early Grande (Solar drying)	6.60	6.30	6.10	5.95	6.24	6.20	6.30	6.20	6.10	6.20
T_7-Early Grande (Oven drying)	7.00	6.85	6.71	6.57	6.78	7.20	6.50	6.40	6.15	6.56
T_8-Early Grande (Osmo-air drying)	8.00	7.77	7.69	7.50	7.74	8.50	8.00	7.50	7.23	7.81
T_9-Flordasun (Sun drying)	6.40	6.28	6.17	6.09	6.24	6.90	6.75	6.75	6.50	6.73
T_{10}- Flordasun (Solar drying)	6.62	6.54	6.38	6.18	6.43	7.20	6.87	6.63	6.45	6.79
T_{11}-Flordasun (Oven drying)	7.40	6.90	6.86	6.73	6.97	7.50	7.00	6.70	6.59	6.95
T_{12}-Flordasun (Osmo-air drying)	8.10	7.79	7.63	7.52	7.76	8.12	7.71	7.41	7.20	7.61
Mean	7.09	6.85	6.68	6.53		7.22	6.87	6.67	6.49	
CD (p= 0.05)										
Treatment			0.05					0.05		
Storage			0.04					0.04		
Interaction			0.08					0.07		

Table 3. Effect of treatments and storage period on Overall acceptability of dehydrated peach slices

Treatment	Overall acceptability				
	Storage period (Days)				
	0	45	90	135	Mean
T_1-Shan-e-Punjab (Sun drying)	6.75	6.58	6.25	6.05	6.41
T_2-han-e-Punjab (Solar drying)	7.09	6.74	6.50	6.18	6.63
T_3-Shan-e-Punjab (Oven drying)	7.18	6.84	6.63	6.34	6.74
T_4-Shan-e-Punjab (Osmo-air drying)	8.05	7.75	7.47	7.16	7.61
T_5-Early Grande (Sun drying)	6.56	6.43	6.30	6.14	6.36
T_6-Early Grande (Solar drying)	6.50	6.38	6.21	6.10	6.30
T_7-Early Grande (Oven drying)	7.18	6.88	6.68	6.44	6.79
T_8-Early Grande (Osmo-air drying)	8.28	7.93	7.76	7.46	7.85
T_9-Flordasun (Sun drying)	7.17	6.87	6.71	6.45	6.80
T_{10}- Flordasun (Solar drying)	7.10	6.81	6.65	6.45	6.75
T_{11}-Flordasun (Oven drying)	7.50	7.11	6.90	6.72	7.06
T_{12}-Flordasun (Osmo-air drying)	8.21	7.98	7.41	7.17	7.69
Mean	7.30	7.03	6.79	6.55	
CD(p=0.05)					
Treatment			0.04		
Storage			0.04		
Interaction			0.08		

score of 8.50 was recorded in Early Grande (Osmo-air drying) and the minimum score of 6.20 was recorded in Early Grande (Solar Drying). After 135 days of storage, the values decreased to 7.23 in Early Grande (Osmo-air drying) and to 6.10 in Early Grande (Solar Drying) . The sensory scores of flavour decreased significantly in all the treatments after 135 days of storage but scores were found to be within acceptable limits. At initial day the maximum score of 8.20 was observed in Shan-e-Punjab (Osmo-air drying) and minimum in 6.30 in Early Grande (Sun drying). After 135 days of the storage period, scores decreased to 7.45 in Shan-e-Punjab(Osmo-air drying) and 6.00 in Early Grande (Sun Drying) respectively. The mean values of flavour showed decrease from initial value of 7.21 to 6.61 per cent after 135 days of storage. A significant decrease in overall acceptability was observed in all the treatments with the progress of storage period. At initial day, the highest score of 8.30 was recorded in Early Grande (Osmo-air drying) followed by 8.12 in Flordasun (Osmo-air drying) and the minimum score of 6.20 in Early Grande (Solar drying). After 135 days of storage the values decreased to 7.23 in Early Grande (Osmo-air drying), 7.20 in Flordasun (Osmo-air drying) and 6.10 in Early Grande (Solar drying). Early Grande, Flordasun, Shan-e-Punjab, cultivars of peach can be suitably used for preparation of dehydrated peach product using osmo air drying and oven drying methods. The osmo dehydrated peach prepared from Early Grande cultivar is most acceptable based on sensory evaluation. The storability study revealed that osmo dehydrated peach were of good shelf life and can be kept for more than 135 days without affecting the quality attributes.

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Studies on Optimization of Ripening Techniques for Tomato

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Abstract : The present studies were conducted to obtain information about the effect of ethephon and ethylene gas on ripening and quality of winter tomato using hybrid Avinash-3. The mature green tomatoes were treated with different concentrations of aqueous solution of ethephon (500, 1000 and 1500 ppm) for 5 minutes and kept in storage room at 20±1°C and 90-95% RH. The tomato fruits harvested at green mature stage get successfully ripened in 9 days with application of ethephon (500, 1000, 1500 ppm) but the rotting was more than 14 per cent till 9th day which makes fruits unmarketable. Therefore, the application of ethephon for ripening is not a good option. The another treatment comprised of exposing the mature green tomatoes to ethylene gas (100 ppm) inside the ripening chamber for 24 hours (20±1°C and 90-95% RH) and thereafter kept in the ripening chamber maintained at 20±1°C and 90-95% RH and this treatment resulted in adequate ripening of fruits after 9 days with uniform red colour, desirable firmness, minimum rotting and acceptable quality and therefore this treatment is better over ethephon. In control fruits similar results of ripening, firmness, rotting and quality were observed as in case of ethylene gas (100 ppm) treatment but the fruits get longer time (11 days) to uniformly ripen.

Key Words: Ethephon, Ethylene gas, Ripening, Tomato, Quality

Tomato (*Solanum lycopersicum* L.) is most important vegetable crop of the world including tropical, sub-tropical and temperate regions. It serves as an anti-oxidant as the â-carotene functions to help prevent and neutralize free radical chain reactions and ascorbic acid is an effective scavenger of superoxide, hydrogen peroxide, singlet oxygen and other free radicals.

The colour and quality of ripe tomatoes are important considerations to the consumer and hence to the commercial grower. Tomato ripening is characterized by loss of chlorophyll and rapid accumulation of carotenoids, particularly lycopene, as chloroplasts are converted to chromoplasts. However, ripening is a problem in tomato during winter months (December- Mid February) due to foggy weather and low temperature which does not allow tomatoes to mature themselves on the plant. The low temperature also slows down the degradation of chlorophyll and synthesis of lycopene. Ripening agent like calcium carbide is often utilized in India to speed up the ripening process during winter months. As the use of calcium carbide is prohibited in India due to health reasons (PFA 2003), an alternative of this chemical is required. In this direction, ethylene gas and ethephon chemical have been found to accelerate the ripening of mature green tomato fruits and has already been used commercially in other countries for uniform and early ripening of tomatoes (Gonzalez 1999; Sargent 2005). But in Indian context, there is need to standardize the method of ripening of winter tomatoes by use of ethylene gas and by use of safe chemicals like ethephon so that uniform ripened tomato can fetch remunerative price in the domestic and export markets. Considering these points in mind, the present studies were undertaken.

MATERIAL AND METHODS

The tomato fruits of cv. Avinash-3 (Syngenta India Pvt. Ltd.) were harvested at mature green stage in the first week of February from the field and were pre-cooled by using forced air cooling system. After pre-cooling, the bruised and diseased fruits were sorted out and healthy, uniform sized fruits were selected for the present study. Ten tomato fruits were randomly taken from the lot of experimental fruits and their physico-chemical properties were assessed before giving the ripening treatments. Tomato fruits were divided into five lots. The first lot was exposed to ethylene gas (100 ppm) inside the ripening chamber for 24 hrs (20 ± 1°C and 90-95% RH) using portable ethylene generator (Model 9002, Ventech Agrionics, South Africa). The 2nd, 3rd and 4th lot was treated by immersion in a solution of ethephon {(2-chloroethyl) phosphonic acid}at three concentrations of 500, 1000 and 1500 ppm for 5 minutes. The 5th lot was not treated and kept as control. The surface of fruit was air dried and kept in plastic crates and stored at 20 ± 1°C and 90-95% RH in walk-in ripening room. The data on various physico-chemical attributes were recorded from 3rd day after treatment at one day interval for the period of 13 days.

Total soluble solids (TSS) concentration of fruit flesh was determined by an Erna Hand refractometer (Tokyo, Japan) and results are reported as °Brix at 20°C. Titratable

acidity (TA) in pulp was assayed based on the method of Bassetto *et al.* (2005). Briefly, 10 g of fresh fruit sample was diluted with 90 mL of water, titrated with 0.1 N sodium hydroxide to pH 8.1 and expressed as a percentage of citric acid. The lycopene content and ascorbic acid contents were determined as per AOAC (1990). The fruit firmness of randomly selected fruits (three from each replication) was measured with the help of Texture Analyzer (Model TA-Hdi, Make Stable Microsystem, UK) using stainless probe of 2 mm diameter and results were expressed in g force. The per cent loss in weight after each storage interval was calculated. The physiological loss in weight was calculated on fresh weight basis by following formula: (A - B) /A x 100 where a is the fruit weight just before storage and B is the fruit weight after special storage period. For colour determination, the reflectance spectra were measured at 2 different points on the fruit surface and then the mean reflectance spectrum was obtained. These measurements were taken with colour difference meter (model: Mini Scan XE Plus, Hunter Lab, USA) and expressed as L, a, b Hunter colour values (Hunter 1975).The ripening percentage of the fruits was estimated by counting the total number of ripened fruits on the basis of their appearance and desirable colour with the help of tomato colour chart and results were expressed in per cent. The rotting percentage of the fruits was also estimated. Ripening percentage is calculated by the following formula: A / B x 100, where A is the number of rotten fruits and B is the total number of fruits. The experiment was laid out in completely randomized design with 3 replications and each replication comprised of 5 kg fruits. The studies were conducted continuously for 2 years.

RESULTS AND DISCUSSION

Physiological loss in weight (PLW) : There were significant differences among the various ripening treatments with regard to physiological loss in weight (Table 1), which, in general increased during ripening period. The lowest mean PLW was observed in the untreated (control) fruits which were followed by the ethylene gas treatment (100 ppm) (4.55%) and these were statistically significant as compared to other treatments. The highest mean PLW was observed in fruits treated with 1500 ppm ethephon. As the ethephon concentration increased, the ripening percentage increased due to the rise in the respiratory climacteric, thus the loss of moisture from the fruits increased owing to more weight loss of fruits as compared to control. The increase in PLW during ripening of tomato fruits with ethephon and ethylene gas application may be due to upsurge in respiration rate of the fruits (Dhall and Singh 2013). The interaction between treatment and ripening period were found to be significant.

Fruit firmness: The fruit firmness of tomato fruits during ripening period was significantly affected by the different treatments. The fruit firmness, in general, followed a declining trend with advancement in ripening period (Table 1). During ripening period of 13 days, the fruit firmness values had decreased from the initial value of 1050.22 to 774.59 g force in the fruits treated with 1500 ppm ethephon, whereas the corresponding value in case of control fruits was recorded to be 944.93 g force. It was also observed that the firmness of fruits decreased with increase in the concentration of ethephon (500-1500 ppm) during ripening period and all the ethephon treatments were significantly different from each other. The fruits treated with ethylene gas (100 ppm) and untreated fruits had significantly higher firmness as compared to different concentrations of ethephon during complete ripening period. This reveals that untreated (control) fruits and ethylene gas (100 ppm) treatment delays the softening process in tomato fruits. On the other hand the fruits treated with 1500 ppm ethephon experienced the faster loss of firmness during ripening period, thereby leading to excess softening and shriveling of fruits. The interaction between treatment and ripening period was found to be non-significant. The loss of pectin substances in the middle lamella of the cell wall is perhaps the key steps in the ripening process that leads to the loss of cell wall integrity thus cause loss of firmness and softening (Gonzalez 1999).

Ripening : The ripening of tomato fruits increased during the ripening period in all the treatment (Table 1). The ethylene gas treatment registered the highest ripening percentage (98.02%) while the lowest was recorded in control (89.42%) during 13th day of ripening period. There is increase in the ripening percentage of fruits as the concentration of the ethephon increased from 500 to 1500 ppm during ripening period (13 days) but at that time it also resulted more than 28 per cent rotting which makes the fruits unmarketable. Enhanced ripening with the post-harvest application of ethephon is due to binding of ethylene to receptor which forms an activated complex leading to a wide variety of physiological responses including ripening (Dhall and Singh, 2013). The ethylene gas (100 ppm) resulted quicker and uniform ripening in 9 days with minimum rotting and was . similar to control fruits on 11th day of ripening. The interaction between the treatments and ripening period was found to be significant.

Rotting : The rotting of tomato fruits during ripening period was significantly affected by the different treatments (Table 1). The rotting percentage increased with increase in ripening period. The highest rotting was observed in 1500 ppm ethephon while lowest (< 10%) in control and ethylene gas treated fruits during ripening period of 11 days and all the

Table 1. Effect of ethephon treatments and ethylene gas on chemical properties of tomato during storage (20±1°C and 90-95% RH)

Treatment	3D	5D	7D	9D	11D	13D	Mean	LSD (p = 0.05)
				Physiological loss in weight (%)				
Ethephon 500 ppm	1.57	3.00	5.27	5.90	6.93	7.23	4.98	Treatment (T)= 0.12
Ethephon 1000 ppm	2.13	4.37	5.43	6.33	7.23	7.57	5.51	Storage periods (S)=0.14
Ethephon 1500 ppm	2.33	4.57	5.87	6.57	7.80	8.23	5.90	T x S = 0.31
Ethylene gas 100 ppm	1.40	2.97	4.50	5.50	6.02	6.90	4.55	
Control	0.87	1.93	2.63	3.73	4.30	5.10	3.09	
Mean	1.66	3.37	4.74	5.61	6.46	7.01		
				Fruit firmness (g force)				
Ethephon 500 ppm	924.72	903.85	859.22	808.38	750.85	719.97	827.83	Treatment (T)= 15.89
Ethephon 1000 ppm	910.42	897.22	835.35	779.01	724.88	701.22	808.02	Storage periods (S)=18.80
Ethephon 1500 ppm	900.91	875.73	803.67	746.60	670.60	650.03	774.59	T x S = NS
Ethylene gas 100 ppm	963.62	935.26	906.96	851.62	813.02	782.67	875.53	Initial value at
Control	1039.51	990.42	975.64	940.66	881.24	842.08	944.93	harvest = 1055.22 g force
Mean	947.84	920.50	876.17	825.25	768.12	739.19		
				Ripening (%)				
Ethephon 500 ppm	22.28	40.60	60.94	77.08	84.81	88.22	62.32	Treatment (T)= 1.24
Ethephon 1000 ppm	25.40	42.12	67.39	79.25	86.06	90.99	65.20	Storage periods (S) = 1.47
Ethephon 1500 ppm	27.66	45.12	73.81	86.55	90.07	94.31	69.59	T x S = 3.28
Ethylene gas 100 ppm	25.33	43.15	77.81	87.12	96.33	98.02	71.29	
Control	18.24	35.40	58.91	74.21	84.21	89.42	60.07	
Mean	23.78	41.28	67.77	80.84	88.30	92.19		
				Rotting (%)				
Ethephon 500 ppm	5.21	7.51	11.24	15.32	19.39	28.81	14.58	Treatment (T) = 0.14
Ethephon 1000 ppm	7.81	9.32	14.01	18.90	22.91	30.56	17.25	Storage periods (S)= 0.16
Ethephon 1500 ppm	8.00	9.98	18.21	23.83	29.34	37.89	21.21	T x S= 0.36
Ethylene gas 100 ppm	3.12	5.12	7.80	8.45	9.98	13.24	7.95	
Control	3.28	4.52	6.65	7.95	9.72	12.73	7.48	
Mean	5.48	7.29	11.58	14.89	18.27	24.65		

treatments were statistically different from each other. The rotting with higher dose of ethephon is obvious due to faster respiration rate leading to over softening and spoilage of fruit (Dhall and Singh 2013). The interaction between treatment and ripening period was found to be significant. As the concentration of ethephon increased (500-1500 ppm), the rotting and ripening percentage also increased simultaneously. The rotting percentage is more than tolerable limits in all the ethephon treatments which make the fruits unmarketable after 7 days. The highest rotting in ethephon dip may be due to direct contact of fruits with water because some unnoticeable injuries and bruises on fruit surface may absorb the water during dipping which later on became the entry point for the fungal infection. Similar types of results were corroborated by Jeong *et al.* 2002.

Total Soluble Solids (TSS) : The ethylene gas treated fruits recorded maximum average TSS content (4.89%) followed by 1500 ppm ethephon (4.85%) and both are significantly different from each other (Table 2). It was further observed that TSS content increased slowly and steadily in all the treatments during the ripening period. The increase in TSS during ripening may result due to water loss and hydrolysis of starch and other polysaccharides to soluble form of sugar. Mostly, all the treatments showed a non-significant difference among themselves with regard to TSS. The significant differences were observed among the ripening days upto the 11th days of ripening. In all the ethephon treatments, there was decrease in the TSS content on 13th day which may be due to advanced ripening stage which resulted in the substantial utilization of sugars and hence the reduced TSS was observed. The interaction between treatments and ripening period was non-significant. The similar results were

Table 2. Effect of ethephon treatments and ethylene gas on chemical properties of tomato during storage (20±1°C and 90-95% RH)

Treatment	3D	5D	7D	9D	11D	13D	Mean	LSD (p = 0.05)
				Total soluble solids (%)				
Ethephon 500 ppm	3.70	4.40	4.73	5.07	5.21	5.27	4.73	Treatment (T)= 0.11
Ethephon 1000 ppm	4.10	4.50	4.63	4.98	5.25	5.21	4.78	Storage periods (S)=0.13
Ethephon 1500 ppm	3.94	4.47	4.77	5.33	5.37	5.23	4.85	T x S = NS
Ethylene gas 100 ppm	3.80	4.63	5.03	5.25	5.30	5.32	4.89	Initial value at harvest = 3.40%
Control	3.50	4.07	4.67	4.97	5.13	5.27	4.60	
Mean	3.81	4.41	4.77	5.12	5.25	5.26		
				Titratable acidity (%)				
Ethephon 500 ppm	0.77	0.66	0.55	0.42	0.32	0.29	0.50	Treatment (T)= 0.01
Ethephon 1000 ppm	0.76	0.67	0.57	0.44	0.33	0.28	0.51	Storage periods (S)=0.02
Ethephon 1500 ppm	0.76	0.71	0.56	0.43	0.33	0.28	0.51	T x S = 0.03
Ethylene gas 100 ppm	0.79	0.73	0.58	0.43	0.31	0.24	0.51	Initial value at harvest = 0.73%
Control	0.76	0.67	0.54	0.41	0.27	0.21	0.48	
Mean	0.77	0.69	0.56	0.43	0.31	0.26		
				Ascorbic acid (mg/100g)				
Ethephon 500 ppm	11.70	12.09	13.20	14.80	16.90	18.70	14.57	Treatment (T)= 0.01
Ethephon 1000 ppm	12.40	13.80	16.70	18.20	19.50	21.80	17.07	Storage periods (S) =0.02
Ethephon 1500 ppm	12.80	13.50	15.80	16.90	18.80	20.10	16.32	T x S = 0.03
Ethylene gas 100 ppm	12.50	15.09	17.89	19.50	21.20	23.50	18.28	Initial value at harvest = 11.50 mg/100 g
Control	11.90	12.80	13.30	14.10	15.50	17.30	14.15	
Mean	12.26	13.46	15.38	16.70	18.38	20.28		
				Lycopene content (mg/100g)				
Ethephon 500 ppm	5.97	7.30	8.74	9.49	10.79	12.22	9.09	Treatment (T) = 0.11
Ethephon 1000 ppm	6.70	7.79	8.41	9.81	11.50	12.86	9.51	Storage periods (S)= 0.13
Ethephon 1500 ppm	6.97	7.70	9.10	10.89	12.09	13.63	10.06	T x S= 0.28
Ethylene gas 100 ppm	6.66	7.49	9.42	10.89	13.19	14.72	10.40	
Control	6.49	7.19	7.91	9.12	10.49	12.11	8.89	
Mean	6.56	7.49	8.72	10.04	11.61	13.11		

observed by Mahajan *et al.* 2008 and Kulbushan 2010.

Titratable acidity: Titratable acidity of tomato showed a liner declining trend during ripening and was found to be maximum (0.51%) in 1500 and 1000 ppm ethephon which was closely followed by 500 ethephon (0.50%) (Table 2). The mean acidity content of 1000 and 1500 ppm ethephon treatment were at par with each other and significantly differs from the ethylene gas (100 ppm) treatment. The minimum mean acidity was noted in the control fruits i.e. 0.48 per cent. A significant difference in the acid content of the fruits was observed among the different ripening days. The amount of acidity in tomato fruit decreases gradually during the entire period of ripening which may be attributed to utilization of organic acid in pyruvate decarboxylation reaction occurring during the ripening process of fruits. The increased membrane permeability allows the acids, stored in cell vacuoles to be respired at faster rate. These observations are in agreement with the findings of Gonzalez 1999 in tomato. The interaction between treatment and ripening period was found to be significant. Similar results were also observed by Kulkarni *et al.* 2004 and Mahajan *et al.* 2008.

Ascorbic acid: The ascorbic acid content registered increase with the advancement of ripening period (Table 2). The highest mean ascorbic acid was observed in ethylene gas (100 ppm) treatment (18.28 mg/100 g fruit weight) whereas minimum mean ascorbic acid (14.15 mg/100 g fruit weight) in the untreated (control) fruits. The interaction between treatment and ripening period was found to be significant. The increase in the ascorbic acid content may be attributed to the higher synthesis of some metabolic intermediary substances which promoted the greater synthesis of the precursor of ascorbic acid. Similar results were also reported by Mahajan *et al.* 2008 with use of ethephon.

Lycopene content: A perusal of data revealed that the lycopene content increased with increase in ripening period (Table 2). All the treatments (except 500 ppm ethephon with 1000 ppm ethephon) showed a significant difference among themselves with respect to lycopene content. The significantly highest mean lycopene content (10.40 mg/100g

Table 3. Effect of ethephon and ethylene gas on c**olour (L, a ,b)*** of tomato during storage (20±1°C and 90-95% RH)

Ripening periods (days)	Treatments														
	Ethephon 500 ppm			Ethephon 1000 ppm			Ethephon 1500 ppm			Ethylene gas 100 ppm			Control		
	L	a	b	L	a	b	L	a	b	L	a	b	L	a	b
3	52.80	-2.74	23.09	51.92	-3.20	24.01	54.41	-3.10	24.87	52.38	-1.07	22.38	51.10	-5.48	24.22
5	50.10	6.37	19.90	49.59	7.92	20.20	50.72	8.27	20.40	47.82	8.00	19.00	49.26	-1.93	22.18
7	45.31	13.39	19.13	44.09	13.89	18.11	46.69	14.10	18.80	43.22	13.71	18.69	46.75	8.59	19.89
9	40.71	18.35	15.12	39.81	19.99	17.71	44.21	20.74	16.97	39.11	19.05	15.11	43.68	12.59	17.42
11	35.83	22.38	12.90	37.98	22.99	15.29	40.20	23.40	14.76	38.59	22.92	12.73	41.44	18.62	15.65
13	33.61	25.41	10.21	35.82	25.88	9.23	35.83	25.62	11.46	34.23	25.48	10.25	40.02	24.87	12.49

* 'L' measures lightness and varies from 100 for perfect white and zero for black; 'a' measures redness when +ve greenness when –ve ; 'b' measures yellowness +ve and blueness when -ve

fruit weight) was observed in ethylene gas (100 ppm) treatment whereas minimum mean lycopene content (8.89 mg/100 g fruit weight) in control fruits. A perusal of data shows that during ripening period of 13 days, the mean lycopene content were 9.09, 9.51 and 10.06 in the fruits treated with 500 ppm ethephon, 1000 ppm ethephon and 1500 ppm ethephon, respectively. The interaction between treatment and ripening period was found to be significant. The lycopene content increased with duration of days for which the fruits were kept for ripening. Similar results were also corroborated by Mandal *et al.* (2008) in tomato.

Fruit colour: Regarding fruit colour, there was consistent increase in redness value (a) and decrease in yellowness value (b) of fruit pericarp with the advancement in the ripening period for all the treatments (Table 3). The fruits treated with ethylene gas (100 ppm) developed uniform red colour after ripening period of 9 days whereas in control fruits the similar results were obtained after ripening period of 11 days. All the ethephon treatments resulted in significant improvement in tomato colour during the ripening period of 9 days but the rotting was also more than 15 per cent during the 9th day which makes these ethephon treatments unsuitable for ripening. Ethylene gas and ethephon treatments are known to accelerate the chlorophyll degradation or synthesis of carotenoids by stimulating the synthesis of chlorophyllase enzyme in calamondin tissue which is responsible for chlorophyll degradation and expression of â-carotene pigments (Mahajan *et al.* 2008). The ethylene gas (100 ppm) treatment resulted uniform development of red colour after 9 days of ripening with less than 10 percent rotting. The control fruits also results uniform development of red colour but after 11 days of ripening at 20±1°C and having less than 10 per cent rotting. Similar results were also observed by Mahajan *et al.* 2010.

From the present study, it is concluded that the application of ethephon for ripening is not a good option as it results in non-uniform ripening and more than 14% rotting of fruits on 9th day after treatment. The tomato fruits can be successfully ripened in 9 days (with less than 8.45% rotting) with ethylene gas treatment. The control fruits also imparted similar results of ripening, firmness, rotting and quality as observed with ethylene gas treatment but the fruits get longer time (11 days) to ripen.

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Development of Risk Assessment Index to Evaluate Cardiovascular Diseases Among Young Adult Males in Punjab

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***Abstract*:** The present study was carried out to develop a risk assessment index for the evaluation of cardiovascular diseases (CVD) risk in young adult males (aged 25-40 years) from three distinct income groups *viz* Low (LIG), Middle (MIG) and High Income Group (HIG). The components/variables which featured in the risk assessment index were age, family medical history, body mass index, waist-hip ratio, smoking, alcohol, tobacco intake, diabetes, hypertension, physical activity, dietary pattern, vegetables and fruits consumption, type and amount of fat consumed. Consequently, a high percentage of subjects from LIG were categorized as low risk group, whereas high percentage of subjects in HIG and MIG were categorized in medium risk group.

***Key Words*:** Anthropometric measurements, Dietary habits, Life style pattern, Risk assessment index

Cardiovascular diseases (CVD) have emerged as the most important cause of premature disability and death all over the world. Genetic susceptibility and being a male makes one more prone to develop these diseases in middle age (Ezzati, *et. al.* 2002). Indians had more common involvement at younger age with CVD (WHO, 2002). The disease is having an increasing prevalence among the youth, especially from Punjab, where the mortality rate due to heart ailments is highest in the country accounting for about 49 percent of all deaths due to CVD (Singh, 2000). Punjabi diet is very rich compared to that of south Indians. So for this reason more youths from the state are affected by heart ailments. High levels of fat in the diet are linked with high blood pressure which, in turn, can lead to stroke and coronary heart disease. Although the prevalence of all risk factors increases with age, even in the 20-29 years age group, 12 percent of the Indians suffer from hypertension and 30 percent are overweight. As they reach their 30s, almost a fifth of them are hypertensive and half of them are overweight (Jeemon and Reddy, 2010).

Major CVD risk factors- high blood pressure, high cholesterol levels, low HDL cholesterol, insulin resistance and diabetes are also escalating in the young adult males and correlate positively with the increase in CVD (Sugasri and Lakshmi, 2012). It is well known that CVD is an unavoidable effect of socio-economic development. It is therefore, important to concentrate on modifiable risk factors which can reduce the risk of developing heart disease. The assessment of risk has been a key element in efforts to define risk factors for CVD, and to assess potential targets of therapy for the prevention of CVD (Lloyd-Jones, 2010). Hence, the present study has been planned to develop a risk assessment index for the evaluation of CVD risk in an asymptomatic individual in order to provide the basis for targeted preventive efforts based on that individual's predicted risk.

MATERIAL AND METHODS

Selection of the subjects: The industrial area of Ludhiana city was chosen for the study by purposive sampling method. The preliminary survey conducted in industrial area brought out that there existed three distinct income groups *viz.* Low income group (LIG) (Rs. 10-20,000/month), Middle Income Group (MIG) **(**Rs. 20-40,000/month) and High Income Group (HIG) (>Rs. 40,000/month). Therefore, a total of 90 young adult males in the age group of 25-40 years were selected randomly with equal number (n=30) from three different income groups working in the industries.

Background and lifestyle information: The detailed background information of the subjects regarding age, education, family composition and medical history were collected using the pre-tested interview schedule. The information regarding lifestyle pattern & habits i.e. smoking, alcohol consumption and tobacco intake of the subjects were also collected.

Physical activity and dietary pattern: Physical Activity Diary Method (PADM) was used to record the time spent on different activities. Physical Activity Ratios (PAR) given by FAO/WHO/UNU was used to assess the physical activity level (PAL) of the subjects (FAO, 2004). Dietary survey was carried out to get information about the type of oil consumed and total quantity of visible and invisible fat consumed by

subjects. The 24 -hour food recall method was used to assess the dietary intake of the selected subjects.

Clinical profile: The height and weight were taken using standard methods to calculate body mass index (BMI) of the selected subjects. Waist and hip circumference were recorded using standard methods to calculate waist –hip ratio (WHR). Blood analysis was done by standard methods for the estimation of glucose level, triglycerides (TG), total cholesterol (TC) and high density lipoprotein cholesterol (HDL-C) by automated methods. Serum low density lipoprotein cholesterol (LDL-C) was calculated from primary measurements using the empirical formula according to which LDL cholesterol = Total cholesterol- (HDL cholesterol + VLDL cholesterol) whereas very low density lipoprotein cholesterol (VLDL-C) was estimated as triglyceride divided by 5. Systolic (SBP) and diastolic blood pressure (DBP) were also recorded using a sphygmomanometer.

Development of Risk Assessment Index: The risk factors contributing to the occurrence of cardiovascular diseases among young adults were identified and Risk Assessment Index (RAI) was formulated. The components/variables which featured in the risk assessment index were age, family medical history, BMI, WHR, smoking, alcohol, tobacco intake, diabetes, hypertension, physical activity, dietary pattern, vegetables and fruits consumption, type and amount of fat consumed. A modified RAI using score method (Parvathi, *et. al.* 2001) was formulated (Fig. 1). Further, the subjects were divided into low, medium and high risk groups based on the scores obtained. Each concept was awarded a score based on the data obtained from the findings. Respondents who scored less than 15 scores were categorized in low risk group, individuals who scored between 16 and 25 was allotted in the medium risk group and young adults who obtained a score of 26 or more was categorized in high risk group.

RESULTS AND DISCUSSION

Age and family medical history : The distribution of subjects according to age revealed that majority of the subjects in all the income groups i.e. 43 percent in LIG, 66 percent in MIG and 60 percent in HIG belonged to the age group of 25-30 years while 33, 20 and 27 percent subjects of LIG, MIG and HIG respectively belonged to age group of 30-35 years. Only few subjects fall in the age group of 35-40 yrs 23 percent LIG, 13 percent both MIG and HIG (Table 1). It was found that majority of family members of HIG and MIG subjects suffered from chronic diseases as obesity (43 and 40%), diabetes (53 and 50%), hypertension (50 and 56%), hypercholesterolemia (33 and 30%) and heart attack (26 and 23%) as compared to LIG subjects. Among LIG subjects obesity and diabetes was found to be highly prevalent among family members (26 and 20 %) followed by hypertension (16 %) and hypercholesterolemia (6%). A study also reported higher lipid levels in Punjabis due to their genetic tendency (Nayar, 2002).

Life style pattern: In case of physical activity of the subjects, the performance of activities ranged from regular, seldom to no activity (Table 2). As LIG subjects were professionally indulged in labor work so majority of subjects (83%) in this group never perform special physical activity whereas 67 percent of subject in HIG and 53 percent in MIG do physical activity regularly and seldom. Regular physical

Table 1. Age and family medical history of selected subjects (N=90)

Particulars	LIG (n=30)	MIG (n=30)	HIG (n=30)
Age(years)			
25-30	13(43)	20(66)	18(60)
30-35	10(33)	6(20)	8(26)
35-40	7(23)	4(13)	4(13)
Family Medical History*			
Obesity	8(26)	12(40)	13(43)
Diabetes	6(20)	15(50)	16(53)
Hypertension	5(16)	17(56)	15(50)
Heart Attack	0(0)	7(23)	8(26)
Hypercholesterolemia	2(6)	9(30)	10(33)

LIG-low income group, MIG-middle income group and HIG-high income group
Figures in parenthesis indicate percentage, *Multiple response

Table 2. Life style pattern of selected subjects (N=90)

Particulars	LIG (n=30)	MIG (n=30)	HIG (n=30)
Physical Activity			
Regular	0 (0)	7(23)	6(20)
Seldom	5(16)	9(30)	14(46)
Never	25(83)	14(46)	10(33)
Smoking	14(46)	18(60)	21(70)
Frequency of Smoking			
2-3 times a day	9(30)	11(36)	14(46)
Weekly	3(10)	4(13)	4(13)
Fortnightly	2(6)	3(10)	3(10)
Tobacco intake	26(86)	0 (0)	0 (0)
Frequency of Tobacco intake			
2-3 times a day	23(76)	0 (0)	0 (0)
Once a day	3(10)	0 (0)	0 (0)
Alcohol consumption	22(73)	23(76)	25(83)
Frequency of Drinking			
Daily	10(33)	11(36)	14(46)
Twice a week	7(23)	6(20)	3(10)
Weekly	5(16)	4(13)	6(20)
Monthly	0 (0)	2(6)	2(6)

LIG-low income group, MIG-middle income group and HIG-high income group
Figures in parenthesis indicate percentage

Variables	Scores
1. Age	
25-30 yrs	(1)
30-35 yrs	(2)
35-40 yrs	(3)
2. Family History	
No family history	(0)
# II degree relative suffer from cardiovascular diseases	(1)
single parent has cardiovascular disease problem	(2)
both parent have cardiovascular disease problem	(3)
3. Body Mass Index	
18.50-24.99	(0)
25.00-29.99	(1)
≥30	(2)
4. Waist Hip Ratio	
0.85-0.90	(0)
0.90-1	(1)
>1	(2)
5. Smoking	
Non smoker	(0)
Fortnightly	(1)
Weekly	(2)
2-3 times a day	(3)
6. Alcohol	
Non user	(0)
Weekly	(1)
Twice a week	(2)
Daily	(3)
7. Tobacco	
Non user	(0)
Twice a week	(1)
Daily	(2)
2-3 times a day	(3)
8. Diabetic	
Normal level	(0)
Borderline	(1)
High risk	(2)
9. Hypertension	
Normal level	(0)
Borderline	(1)
High risk	(2)
10. Physical Activity	
Regular	(0)
Seldom	(1)
Never	(2)
11. Diet habits	
Vegetarian	(0)
Non-vegetarian	(1)
12. Fruit consumption	
100 g/day	(0)
<100 g/day	(1)
No fruit in a day	(2)
13. Vegetable consumption	
500 g/day	(0)
<500 g/day	(1)
No vegetable in a day	(2)
14. Fat consumption	
<60 g/day	(0)
60-70 g/day	(1)
>70g	(2)
15. Type of fats and oils consumed	
Olive oil/Rice bran oil+Mustard oil+Desi ghee	(0)
Mustard oil+Desi ghee+Any vegetable oil	(1)
Mustard oil	(2)
Mustard oil+Dalda	(3)

Fig. 1. Risk Assessment Index

activity aids in the prevention of several chronic diseases like cardiovascular disease, diabetes, cancer, hypertension, obesity, depression and osteoporosis and premature death (Sharma, *et. al.* 2008). Further, it was observed that smoking pattern was higher among HIG (70%), as compared to MIG (60%) and LIG (46%) subjects. The frequency of smoking was as high as 2-3 times a day in 46, 36 and 30 percent of subjects in HIG, MIG and LIG respectively. The data further revealed that only LIG subjects (86.67%) were in the habit of chewing tobacco and frequency observed was 2-3 times a day in 76 percent and once a day in 10 percent of the subjects. Cigarette smoking has proved as a powerful risk factor in CHD, stroke, hypertension and diabetes (Soler and Ruiz, 2010).

The data revealed that 83 percent of HIG followed by 76 percent of MIG and 73 percent of LIG subjects were in the habit of drinking alcohol (Table 2). There was not much difference found in the drinking pattern of alcohol in all the three groups. The observation on the frequency of drinking reported daily to weekly in majority of subjects i.e. 46, 36 and 33 percent were recorded to drink daily followed by twice a week (10, 20 and 23 %) and weekly (20,13 and 16%) in HIG, MIG and LIG respectively. Similarly, higher alcohol consumption among HIG (54 %) compared to MIG (42 %) and LIG (39%) was also reported by Saini (1996). Alcohol is a source of empty calories and can be turned into fat, adding weight to the body. Excessive alcohol consumption affects blood vessels and heart muscles thus causing cardiac myopathy (Ghafoornissa and Krishnaswamy, 2000). Punjabis were first turning into patients of CHD due to excessive use of alcohol. Use of alcohol was increasing among the young generation, making them more prone to CVD (Nayar, 2002). The study conducted by Standberg, *et. al.* (2004) reported similar mortality (25.26%) in non-alcoholics and moderate alcohol consumer groups but much greater in heavy drinkers.

Dietary pattern: Dietary habits of the subject revealed that the majority of the subjects in MIG (47%) and HIG (43%) were non- vegetarian followed by ova- vegetarian (33 and 27%) and vegetarian (30 and 20%) whereas majority of LIG subjects were vegetarian (40%) followed by non vegetarian (33%) and ova vegetarian (27%). The majority of the selected subjects in all the income groups consumed vegetables and fruits 500 and 100 g per day respectively (Table 3). The data on the variety of fat and oil being used by the subjects revealed that all the income groups used a variety of fats and oils which varies from two-four (Table 3). Majority of the LIG subjects (87%) were using mustard oil + hydrogenated fat whereas very few (13%) subjects used to consume *desi ghee* along with these two oils. Further, it was observed that majority of the MIG subjects i.e. 86 percent used to consume sunflower/soyabean oil along with mustard and *desi ghee* and 7 percent use additional olive oil and 7 percent prefer rice bran oil in addition to above combination. The data highlighted that majority of HIG subjects (63%) used to have a blend of four fats/oils like sunflower oil/soyabean oil + ricebran oil/olive oil + mustard oil + *desi ghee* whereas 37 percent of the subjects in this group used to consume combination of the oils like sunflower/ soyabean oil + mustard oil + *desi ghee.* Mustard oil was the common oil among all the income groups whereas other vegetable oil varied as per their financial status.

Clinical profile: The analysis of BMI showed that 83 percent of LIG subjects were having normal BMI (18.50-24.99 kg/m^2) as compared to HIG (63%) and MIG (60%). A higher percentage of HIG (37%) and MIG (33%) subjects were reported to be overweight (BMI: 25.00-29.99 kg/m^2) as compared to LIG (17%) subjects. The obesity (BMI: $\geq$30 kg/m^2) was found only in 6 percent of MIG subjects (Table 4). It may be concluded that records of overweight was higher in HIG and MIG as compared to LIG and more of LIG subjects had normal BMI. Schulze and Hu (2005) reported that excess adiposity was most important predictor of diabetes and CVD. It was further observed that WHR was higher in HIG subjects when compared to standard value of < 1.0.

The data pertaining to blood glucose and blood pressure revealed that 10 and 20 percent of the subjects in HIG group were at high risk of diabetes and hypertension respectively. A previous study found a strong association between lipoprotein concentration in diabetics and high BMI and increased WHR (Arora, *et. al.* 2002). Further, hypertension indicated the heart failure in 91 percent cases of men (Levy, *et. al.* 2004). Majority of the subjects in all income groups had normal levels of blood glucose and blood pressure. The data revealed that 6 and 3 percent of the subjects in HIG and MIG group had blood cholesterol above 200mg/dl respectively whereas none of the subject from LIG had elevated blood cholesterol. Blood cholesterol in the range of 180-200 mg/dl was found in 10 percent of the MIG and six percent of both LIG and HIG subjects. The problem of raised TG was found to be higher in HIG group (6 %) with TG level above 150mg/dl and 16 percent subjects had their TG level in between 125-150mg/dl. Whereas, three percent of MIG subjects had their TG level above 150mg/dl and13 percent of subjects had their TG level in between 125-150mg/dl (Table 4).

Among LIG subjects none of the subject had their TG level >150mg/dl and only three percent subjects had their level in between 125-150mg/dl. LDL-cholesterol more than 130mg/dl was found higher in HIG (8 %) subjects as

Table 3. Dietary pattern of selected subjects (N=90)

Particulars	LIG (n=30)	MIG (n=30)	HIG (n=30)
Dietary habits			
Vegetarian	12(40)	6(20)	9(30)
Non- Vegetarian	10(33)	14(46)	13(43)
Ova- Vegetarian	8(26)	10(33)	8(26)
Vegetable consumption			
500 g/ day	22 (73)	23 (76)	20 (66)
<500 g /day	6(20)	5(16)	6(20)
No vegetable in a day	2 (6)	2 (6)	4 (13)
Fruit consumption			
100 g/ day	21 (70)	23 (76)	26 (86)
<100 g /day	7 (23)	4 (13)	4 (13)
No fruit in a day	2 (6)	3 (10)	0 (0)
Type of fats and oils consumed			
Mustard oil			
Mustard oil+ hydrogenated fat	0 (0)	0 (0)	0 (0)
Mustard oil+ hydrogenated +*desi* ghee	26 (86)	0 (0)	0 (0)
Sunflower oil + Mustard oil +*desi* ghee	4 (13)	0 (0)	0 (0)
Soyabean oil+ Mustard oil+ *desi* ghee	0 (0)	14(46)	6(20)
Sunflower oil+ Olive oil+ Mustard oil+ *desi*	0 (0)	12(40)	5(16)
ghee	0 (0)	0 (0)	4(13)
Soyabean oil + Olive oil+ Mustard oil+ *desi*	0 (0)	2(6)	3(30)
ghee	0 (0)	2(6)	7(23)
Soyabean oil +Rice bran oil +Mustard oil+	0 (0)	0 (0)	5(16)
desi ghee			
Sunflower oil +Rice bran oil+ Mustard oil+			
desi ghee			
Fat consumption			
<60 g/ day	15 (50)	20 (66)	21(70)
60-70 g /day	6(20)	4(13)	5(16)
>70g / day	9(30)	6(20)	4(13)

LIG-low income group, MIG-middle income group and HIG-high income group
Figures in parenthesis indicate percentage

compared to MIG (10 %) and LIG (3%) subjects. HDL-cholesterol less than 50mg/dl was found in six percent of HIG subjects as compared to three percent in MIG subjects while no subject in LIG had their HDL-C level <50mg/dl (Table 4).

Risk assessment index: On the basis of collected data the subjects were further divided in low risk group (LRG), medium risk group (MRG) and high risk group (HRG) (Table 5). Among low income group subjects 53 percent falls in the category of LRG on the basis of calculated scores, 40 percent subjects fall in MRG and 7 percent subjects fall in HRG. In the middle income group 43, 47 and 10 percent subjects were found to be in the LRG, MRG and HRG category respectively whereas in high income group 40, 50 and 10 percent subjects were observed to be in the LRG, MRG and HRG category respectively. This indicated that HIG and MIG subjects were at more risk of developing CVD as compared to LIG subjects.

The percentage of subjects in high risk group (HRG) having scores of 26-35 were higher from MIG (10%) and HIG (10%) subjects as compared to LIG (7%) subjects. Similarly more percentage of subjects in medium risk group were from HIG (50%) and MIG (47%) as compared to LIG (40%) whereas in low risk group with 5-15 scores includes more of LIG (53%) subjects as compared to MIG (43%) and HIG (40%) subjects.

It was concluded that high percentage of subjects from low income group were categorized as low risk group, whereas high percentage of subjects in high and middle income group were categorized in medium risk group. So, the formulated risk assessment index can be made available to the young adults in educational institutions, work areas, and

Table 4. Clinical profile of selected subjects (N=90)

Particulars	LIG(n=30)	MIG (n=30)	HIG(n=30)
Body Mass Index (Kg/m^2)			
18.50-24.99	25(83)	18(60)	19(63)
25.00-29.99	5(16)	10(33)	11(36)
≥30	0 (0)	2(6)	0 (0)
Waist Hip Ratio			
0.85-0.90	28 (93)	23 (76)	21 (70)
0.90-1	2(6)	7(23)	9(30)
>1	0 (0)	0 (0)	0 (0)
Diabetic			
Normal level (70-110 mg/dl)	27 (90)	26 (86)	26 (86)
Borderline (110-140 mg/dl)	1(3)	2(7)	1(3)
High risk (>140 mg/dl)	2(6)	2(7)	3(10)
Hypertension			
Normal level (120/80 mm Hg)	22 (73)	22 (73)	21 (70)
Borderline (>120/80 mm Hg)	4(13)	5(16)	3(10)
High risk (<140/90 mm Hg)	4(13)	3(10)	6(20)
Blood Cholesterol			
>200 mg/dl	-	1 (3)	2 (7)
180-200 mg/dl	2 (6)	3 (10)	2 (7)
Blood Triglycerides			
>150 mg/dl	-	1 (3)	2 (7)
125-150 mg/dl	1 (3)	4 (13)	5 (16)
LDL-Cholesterol			
>130 mg/dl	1 (3)	3 (10)	4 (8)
HDL-Cholesterol			
< 50 mg/dl	-	1 (3)	2 (6)

LIG-low income group, MIG-middle income group and HIG-high income group
Figures in parenthesis indicate percentage

Table 5. Risk Assessment Index of selected subjects (n=90)

Scores	Risk group	LIG (n=30)	MIG (n=30)	HIG (n=30)
5-15	Low Risk Group (LRG)	16 (53)	13 (43)	12 (40)
16-25	Medium Risk Group (MRG)	12 (40)	14 (47)	15 (50)
26-30	High Risk Group (HRG)	2 (6)	3 (10)	3 (10)

LIG-low income group, MIG-middle income group and HIG-high income group
Figures in parenthesis indicate percentage

entertainment spots for self –assessment which will help them to make positive health changes and lead a healthier life.

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Relationship of Personality Traits of Self Help Groups and Women Empowerment in Punjab

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***Abstract*:** The present study was conducted in twelve self help groups of six districts of Punjab to examine the socio-personal and psychological traits of the self help groups and its impact on the women empowerment in Punjab. Majority of the respondents of *Majha*, *Malwa* and *Doaba* regions of Punjab were young, matriculates, labourers, belonged to SC category, had family size of 4-6 members and earned up to Rs. 65000 per annum. Annual income, mass media exposure, extension contacts, scientific orientation, group cohesiveness, education, economic motivation, achievement motivation and risk bearing capacity had positive and significant relationship with the women empowerment while age, family size and social participation had no effect on empowerment of women. Multiple regression analysis showed that socio-personal and psychological traits such as education, mass media exposure, economic motivation and achievement motivation were found to be significant. All the traits jointly explained 47.9 per cent variation in the women empowerment of self help groups. It indicates that apart from these traits, there are other factors like group interaction, group cooperation, interpersonal traits, group decision making, group leadership etc. that also affecting the women empowerment.

***Key Words*:** Impact, Self help groups, Socio-personal and psychological traits, Women empowerment

Women are the basic fabric of any family and society. The development of women alone would determine the success of major part of Indian workforce (Kasthuri *et al* 2014). But majority of the women living in rural areas are illiterate and are below poverty line having poor economic status. There is need to change their capacity to work, increase knowledge, enrich their skills and improve their economic status by providing them the required resources. The popular meaning of the term "empowerment" is enjoyment of certain rights by women, but generally signifies a little more than feeling better or more powerful **(**Kumar and Vorglese, 2005). Women empowerment is essentially a transition from a position of enforced powerlessness to one of power and promotes women's inherent strengths and positive self-image. Empowerment through self help groups is a process where women work collectively and their participation made a significant impact on their empowerment both in social and economic aspects (Lakshmi and Vadivalagan, 2012). The empowerment of women is one of the vital issues in the progression and improvement of countries all over the world. Since sufficient data on the contribution of socio-personal and psychological traits on the empowerment of women is not available, therefore, the present study has been undertaken to study the socio-personal and psychological traits of members of the self help groups and determine the impact of the socio-personal and psychological traits of the beekeepers on the women empowerment.

MATERIAL AND METHODS

The selection of self help groups was made after procuring a list of women self help groups operating in different parts of Punjab from different sources viz. regional office of National Bank for Agriculture and Rural Development (NABARD) Chandigarh, regional office Milkfed Chandigarh and self help groups formed under Agricultural Technology Management Agency (ATMA). Multi stage sampling design was used for selection of respondents and two districts from each cultural zone viz Pathankot and Amritsar *(Majha*), Jalandhar and Hoshiarpur (*Doaba),* Moga and Ludhiana (*Malwa*) were selected randomly. In each disrtrict, 12 functional women self help groups were selected by using probability proportion to number (PPS) of self help groups in each district. A sample of 200 women belonging to the selected self help groups namely Mian Mamli (20), Nari Shakti (15), Amar Das (18), Guru Ram Das (14), Maha Laxmi (15), Durga (15), Chetna (15), Sada Shiv Modern (30), Assal (15), Veer Honey (14), Baba Budha (16) and Bibi Rajni (13) were selected.The data were collected with the help of interview schedule from the members of self help groups and analysed with the help of statistical tools viz. frequency, percentages, cumulative cube root method, range method, correlation coefficient and multiple regression analysis.

RESULTS AND DISCUSSION

Socio-personal characteristics of the respondents

Majority of the members of three zones viz. *Majha, Malwa* and *Doaba* belonged to the age group of 25-35 years. This may be due to the reason that young women are energetic and having strong urge to achieve their goal, therein participating actively in the group. Similar findings were reported by Singh (2012), Kalra *et al* (2012) and Kondal (2014) who stated that majority of the respondents in their study were from young age group. More than half of the

respondents on an average were literate having educational qualification up to Matric. The findings were in line with the study conducted by Geethamma (2007) and Sharma *et al* (2012). Seventy per cent of the family members of all cultural zones were labourers and may be due of the fact that these respondents were poor and having dire need to earn their livelihoods. The similar views were also shared by Reddy and Reddy (2012) and, Sharmila (2014).

More than 2/3rd on an average of the members of self help groups from all the cultural zones belonged to SC category. It may be due to the reason that these women were poor and joined the group to improve their economic conditions.

An overview of the family type publicized that majority (74%) of the respondents of all the groups of cultural zones on an average belonged to nuclear family. It is attributed to the fact that joint family is losing its importance and people are more likely to live independently. The results were in track with the findings of Latha and Chandrakumar (2012), Khangjarakpam (2013), Sharmila (2014) and Baite (2013). Majority of the members (70%) of three cultural zones had a family size of 4-6 members followed by 6-8 members. Similar findings were reported by Kalra *et al* (2012) and Sharmila (2014). On the other hand, results of Khangjarakpam (2013), Baite (2014) and Kasthuri *et al* (2014) also found family size of 6-8 members.

Majority of members of these zones earned up to Rs.65 thousand per annum. This may be to due to the reason that most of the members of self help groups belonged to poor families. The results were supported by the findings of Kondal (2014) and Sharmila (2014). A scrutiny of the data in Table 1 indicated that major portion (80%) of *Majha, Malwa* and *Doaba* zones on an average had high level of social participation**.** This may be due to reason that most of the

Table 1. Socio-personal characteristics of the respondents

Socio-personal characteristics	Category	Majha (n=62)		Malwa (n=58)		Doaba (n=80)		Overall (n=200)	
		f	%	f	%	f	%	f	%
Age (years)	25-35	31	50.00	27	46.55	44	55	102	51.00
	36-45	18	29.03	16	27.58	26	32.5	59	29.50
	46-55	13	20.96	15	25.86	10	12.5	39	19.50
Education	Illiterate	7	11.29	6	10.34	7	8.75	20	10.00
	Primary	8	12.90	7	12.06	5	6.25	20	10.00
	Middle	11	17.74	16	27.58	13	16.25	40	20.00
	Matric	29	46.77	24	41.37	54	67.5	107	53.50
	Secondary	6	9.67	3	5.17	0	0	9	4.50
	Graduates	1	1.61	2	3.44	1	1.25	4	2.00
Occupation	Labour	50	80.64	44	75.86	62	77.5	156	78.00
of family	Artisans	2	3.22	5	8.62	17	21.25	23	11.50
	Government service	4	6.45	3	5.17	0	0	7	3.50
	Private Service	6	9.67	6	10.34	0	0	12	6.00
	Business	0	0	0	0	1	1.25	2	1.00
Caste	General	12	19.35	10	17.24	12	15	34	17.00
	Schedule Caste	37	59.67	42	72.41	58	72.5	137	68.50
	Backward Caste	13	20.96	6	10.34	10	12.5	29	14.50
Family type	Nuclear	45	72.58	41	70.68	62	77.5	148	74.00
	Joint	17	27.41	17	29.31	18	22.5	52	26.00
Family size(members)	4-6	41	66.12	44	75.86	56	70	141	70.50
	6-8	21	33.87	14	24.13	24	30	59	29.50
Family income	Upto Rs.65000	24	38.70	22	37.93	36	45	82	41.00
(Rs/annum)	65000-110000	23	37.09	20	34.48	30	37.5	73	36.50
	Above 110000	15	24.19	16	27.58	14	17.5	45	22.50
Social participation	Low (0-2)	61	98.38	42	72.41	57	71.25	160	80.00
	Medium (2-4)	1	1.61	14	24.13	22	27.5	37	18.50
	High (4-6)	0	0	2	3.44	1	1.25	3	1.50
Extension contacts	Low (0-2)	0	0	0	0	12	15	12	6.00
	Medium (2-4)	30	48.38	16	27.58	38	47.5	84	42.00
	High (4-6)	32	51.61	52	89.65	30	37.5	104	52.00
Mass media exposure	Low (0-2)	13	20.96	25	43.10	34	42.5	72	36.00
	Medium (2-4)	22	35.48	17	29.31	36	45	75	37.50
	High (4-6)	27	43.54	16	27.58	10	12.5	53	26.50

respondents were member of Panchayat, Mahila mandals, NGOs and Welfare societies.

The present study also indicates that frequency of contact made by the respondents with the extension personnel was 'medium' in *Doaba* zone whereas members of other two zones namely *Majha* and *Malwa* were found to be 'high' for seeking information regarding self help groups. The comparable findings were reported by Kakade (2010) and Kalra *et al* (2012) who also stated that extension agents were the major sources of information.

Mass media exposure was medium in *Malwa* (29.51%) and *Doaba* (45%) except *Majha* region whose respondents (43.54%) were high mass media exposure. Almost similar findings were reported by Khangjarakpam (2013) and Baite (2013) . Majority of the respondents (75.5%) of three zones had high scientific orientation while a major proportion (82.50%) of the respondents of all the three zones of Punjab were having high risk bearing capacity. This showed that majority of the respondents were oriented towards risk and had courage to face the emerging problems while starting an enterprise. More than eighty per cent of the respondents of three cultural zones were having high group cohesiveness. It may be due to reason that all the groups were fairly attached to one another and shared group goals.

Further probing into the data of economic motivation revealed that large majority (82%) on an average were having high economic motivation followed by medium (15.50%) and low (2.50%) respectively.

Relationship between women empowerment index and various socio-personal and psychological traits of the respondents

The annual income, mass media exposure, extension contacts, scientific orientation, group cohesiveness, education, economic motivation, achievement motivation and risk bearing capacity had positive and significant relationship with the women empowerment. The results indicated that all these characteristics of the members had significant impact on the women empowerment in Punjab. It is due to the fact that all these characteristics are the indicators of development. The findings of the study are in conformity with the findings of Kalra *et al*. (2012) and Rathod *et al*. (2013). Data further indicated that there was no significant difference in all the three categories of age ranging from 25-55 years. Similarly both the family size groups of 4-6 and 6-8 members had no significant relationship with the women empowerment.

Data further indicated that social participation of the members with other organization like Panchayat, Co-operative society, Agriculture Technology Management Agency (ATMA), Mahila Mandals etc. had showed no

Table 2. Psychological traits of the respondents

Psychological characteristics	Category	Majha (n=62)		Malwa(n=58)		Doaba (n=80)		Overall (n=200)	
		F	%	f	%	f	%	f	%
Scientific orientation	Low (2- 4)	4	6.45	3	5.17	4	5.00	11	5.50
	Medium (4-6)	10	16.12	15	25.86	13	16.25	38	19.00
	High (6-8)	48	77.41	40	68.96	63	78.75	151	75.50
Risk bearing capacity	Low (0-5)	5	8.06	5	8.62	7	8.75	17	8.50
	Medium (5-10)	4	6.45	5	8.62	9	11.25	18	9.00
	High (10-15)	53	85.48	48	82.75	64	80	165	82.50
Group cohesiveness	Low (10-15)	1	1.61	0	0	2	2.5	3	1.50
	Medium (15 - 30)	13	20.96	9	15.51	12	15	34	17.00
	High (31 - 35)	48	77.41	49	84.48	66	82.5	163	81.50
Economic motivation	Low (8-10)	2	3.22	1	1.72	2	2.5	5	2.50
	Medium (11 - 15)	8	12.90	8	13.79	15	18.75	31	15.50
	High (16-25)	52	83.87	49	84.48	63	78.75	164	82.00
Achievement motivation	Low (0-3)	6	9.67	3	5.17	3	3.75	12	6.00
	Medium (4 - 6)	46	74.19	43	74.13	55	68.75	144	72.00
	High (7-9)	10	16.12	12	20.68	22	27.5	44	22.00

Table 3. Relationship between women empowerment index and various socio-personal and psychological traits of the respondents n=200

Independent variables	Coefficient of correlation (r)
Age	0.127 ^{NS}
Education	0.303**
Family size	0.032^{NS}
Annual income	0.184*
Social participation	0.056^{NS}
Mass media exposure	0.420*
Extension contact	0.150*
Scientific orientation	0.191*
Economic motivation	0.285**
Group cohesiveness	0.165*
Achievement motivation	0.329**
Risk bearing capacity	0.450**

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

Table 4. Contribution of socio-personal and psychological traits on women empowerment

Independent variables	Regression coefficient (b)	Standard error	't' value
Education (X_2)	1.106	0.346	3.197**
Annual income (X_4)	0.00000318	0.00000041	0.781^{NS}
Social participation (X_5)	0.526	0.665	0.792^{NS}
Mass media exposure (x_6)	1.265	0.225	5.616**
Extension contact (X_7)	0.068	0.261	0.264^{NS}
Scientific orientation (X_8)	0.351	0.187	1.87^{NS}
Economic motivation (X_9)	1.285	0.289	4.448**
Group cohesiveness (X_{10})	-0.093	0.108	-0.861^{NS}
Achievement motivation (X_{11})	1.497	0.394	3.79**
Risk bearing capacity (X_{12})	-0.055	0.032	-1.73^{NS}

R^2 =0.479 * Significant at 5 per cent level ** Significant at 1 per cent level

significant effect on women empowerment of SHG.

Contribution of socio-personal and psychological traits on women empowerment

The education, mass media exposure, economic motivation and achievement motivation had significant relationship with women empowerment (Table 4). The regression coefficient indicated that with the unit increased in the value of education, there would be 1.106 unit increased in the value of the empowerment of women. Similarly, with the unit increased in the value of mass media exposure, economic motivation and achievement motivation, there would be 1.265, 1.285 and 1.497 unit increased respectively in the value of women empowerment. The data further indicated that all the traits jointly explained 47.9 per cent (R^2 = 0.479) variation in the women empowerment of self help groups. The efforts should be made to develop these traits among women during formation stage of group.

It would be concluded that significant relationship was observed between education, annual income, mass media exposure, extension contacts, scientific orientation, economic motivation, achievement motivation, risk bearing capacity, group cohesiveness and empowerment of women which are considered as important indicators for the successful functioning of self help groups. Multiple regression analysis showed that the variables namely education, mass media exposure, economic motivation and achievement motivation had significant regression coefficient with empowerment of women. The data further indicated that all the traits jointly explained 47.9 per cent variation in the women empowerment of self help groups. Thus, the results of the study indicated that these variables had significantly contributed towards the empowerment of women. The study recommended that the characteristics of the members such as education, annual income, social participation, mass media exposure, extension contact, economic motivation, group cohesiveness, achievement motivation and risk bearing capacity were the important indicators for the effective functioning of self help groups. Therefore, these traits need to be enhanced and given importance for the successful performance of the group.

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Pattern of Litter Fall in *Pinus roxburghii* Sarg. Forest in Kumaun Himalaya, India

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***Abstract*:** The present paper reports on the leaf litter, wood litter, miscellaneous litter and total litter fall in *Pinus roxburghii* forest of the Kumaun Himalaya. Peak values of leaf, wood and miscellaneous litter fall occurred in June, June and May respectively. The total annual litter fall was 693.3 g m^{-2}, of which leaf, wood and miscellaneous litters accounted 80.72%, 17.57% and 1.72% respectively. Monthly leaf litter fall, wood litter fall and total litter fall was positively related to the monthly temperature of the site. Seasonal litter fall was also found significantly related to the temperature.

Key Words: Kumaun Himalaya, Leaf litter fall, Miscellaneous litter fall, Total litter fall, Wood litter fall

Forest is the greatest achievement of ecological evolution – the largest, most complex, most self perpetuating of all ecosystems; of which the organic continuity rests upon a delicate network of interdependent relationships. Litter fall because of its intrinsic nature to all vegetation represents an innate part in the organic continuity and the self perpetuating nature of forests, being the major pathway of nutrients return to the soil has an important influence on soil formation because it is a major component in the circulation of mineral elements and contains many complex organic compounds which vary in biological degradability. The litter on the forest floor plays a significant role in determining the moisture status, runoff pattern and liberation of mineral elements accumulated in the aerial parts of the vegetation and represents an essential link in organic production–decomposition cycle and is thus a fundamental ecosystem process The present paper describes the pattern and quantity of leaf litter, wood litter, miscellaneous litter and total litter fall in *P. roxburghii* forest of the Kumaun Himalaya.

MATERIAL AND METHODS

Study site

Location : The study was conducted in Kuamun Himalaya, India (29°21'N, 79°23'E, and elevation 400–900 m amsl) (Fig. 1).

Climate : The climate is characterized by a summer monsoon and the year has four distinct seasons viz., monsoon (July to September), post-monsoon (October to November), winter (December to January) and summer (April to mid-June). Climatic data for 2008–2009 were obtained from the O/I Agromet Observatory, Pantnagar (40 km away from the study site; Fig. 1). The average annual rainfall in the *P. roxburghii* (Chir) pine forest is 556.75mm, 60% of which was occur in the rainy season and the mean daily temperature ranges from 7°C to 37°C (Fig. 2).

Soils : Shiwalik Himalayan rocks are relatively very young and consist of sandstones conglomerate beds, quartzite and more or less unconsolidated segments made up of cobbles, shingles pebbles, gravels and boulders. Shiwalik rocks are usually in contact with the sediments of the Indo-Gangetic plain along prominent fault zones. Sand predominates in the soil (60-74%), while the silt and clay contents are 9-26% and 3-11%, respectively. Organic matter ranges between 1.1 % and 3.2% and available C between 1.2% and 3.0%, the soil pH ranges between 5 and 6.

For studying litter production in chir pine forest three plots of 31.5 X 31.5m (992m^2) were selected on site. The litter was measured by placing five litter traps (1x1m^2) on the forest floor randomly at each site. Each trap was 2mm mesh nylon, supported by wooden sides with 25cm height. Litter from these traps was collected separately in paper bags and brought in to laboratory where the sample was sorted out in to three main categories viz. (i) leaf litter (ii) wooden litter (<2cm Diameter) and (iii) miscellaneous litter and dried in shade. Litter sampling study was done during May 2008 to April 2010. The air-dried leaves were thoroughly mixed and 10gm samples were enclosed in 20 x 20cm nylon bags. Mesh size was 10mm. Thirty six litter bags were placed on the forest floor in the beginning of the rainy season of 2008. No spatial displacement of bags due to wind action, etc. was noticed during the study. The bags were removed at monthly intervals. At each sampling time, retrieved bags were brought back to the laboratory, extra material was removed and the wet weight of the material measured. The material was

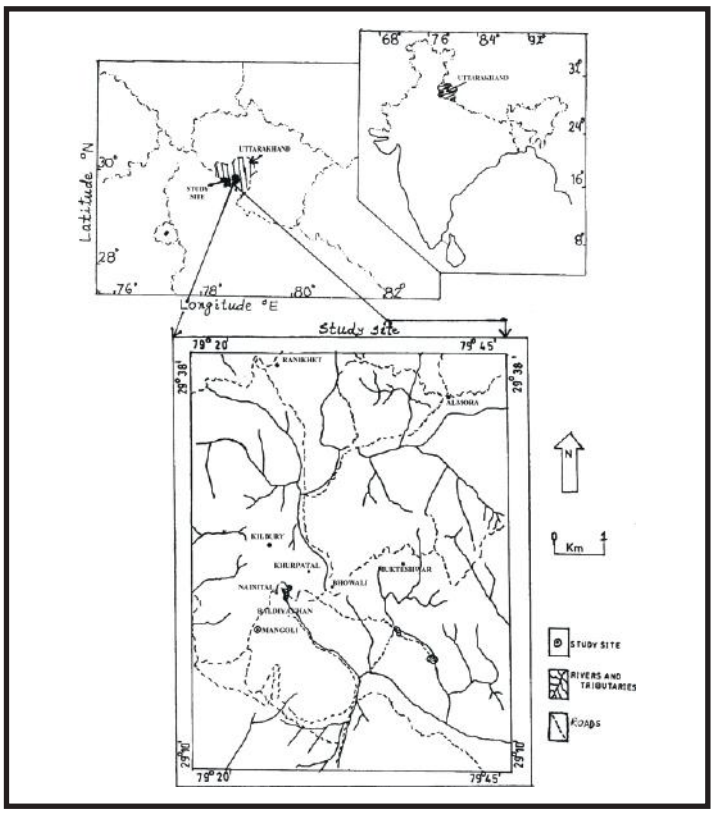

Fig. 1. Location of study site in Kumaun Himalaya, India. Altitude of certain localities are given in meters

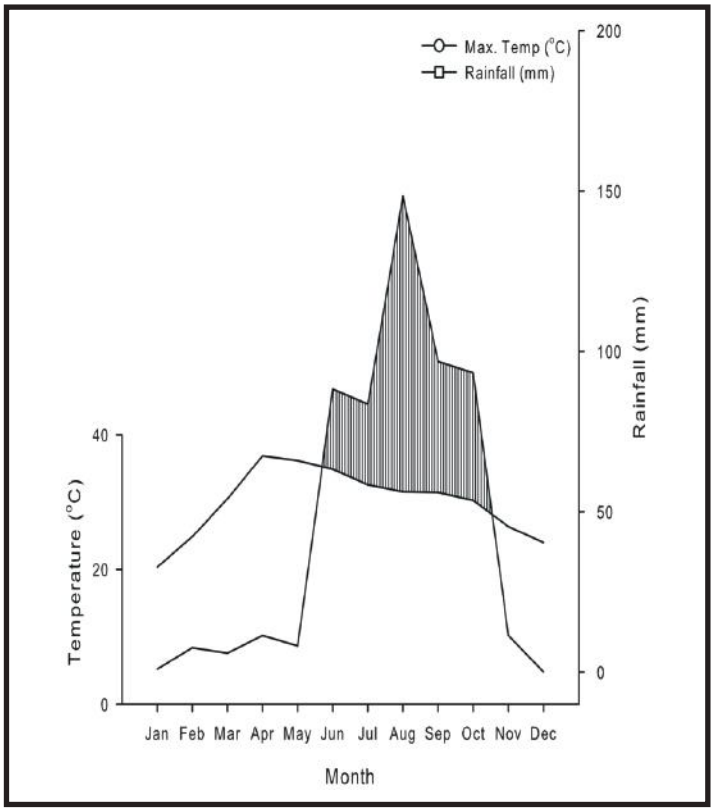

Fig. 2. Rainfall and mean monthly temperature for the experimental site in Kumaun Himalaya, India

reweighed after oven drying at 60°C till to constant weight.

RESULTS AND DISCUSSION

In *P. roxburghii* forest leaf litter fall was greatest in the summer season (51.5%), followed by the monsoon (29.7%), winter (12.3%) and post monsoon seasons (6.5%). The contribution of leaf litter to total annual litter production was highest during summer months; the leaf litter accounted for 26.6% (June) to 6.1% (April) of the respective total monthly fall (Fig .3 & Fig. 4). The leaf fall was positively related with rainfall according to the following regression:

$Y = 25.51 + 0.399\,X$; ($r=0.61$, $p < 0.05$)

Where, Y = average leaf fall (gm^{-2} per month) and X = mean monthly rainfall (mm)

The contribution of wood litter to total annual litter production was highest during summer seasons; the wood litter accounted for 17.4% (June) to 7.9% (April) of the respective total monthly fall. The wood fall was greatest in the summer season (38.9%), followed by the monsoon (31.5%), winter (21.4%) and post monsoon seasons (8.1%) (Fig. 4 and Table 2). The wood fall was positively related with rainfall according to the following regression:

$Y = 7.095 + 0.571\,X$; ($r=0.68$, $p < 0.05$)

Where, Y = average wood fall ($g\ m^{-2}$ per month) and X = mean monthly rainfall (mm)

Two peaks in miscellaneous litter fall occurred in month of September and March. The contribution of miscellaneous litter to total annual litter production was highest during summer seasons; the miscellaneous litter accounted for 18.6% (May) to 9.5% (April) of the respective total monthly fall. The miscellaneous fall was greatest in the summer season (39.6%), followed by the winter (35.5%),

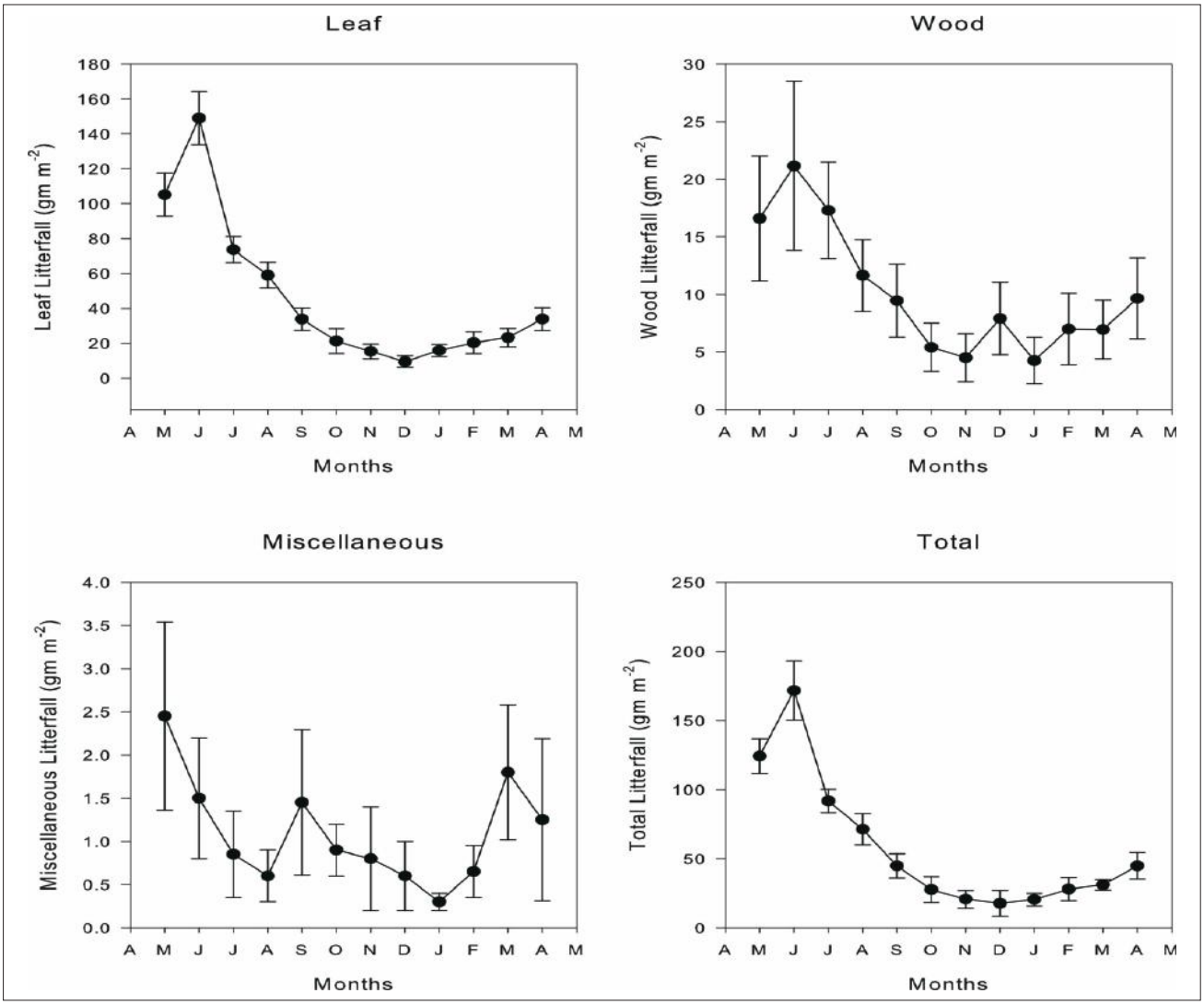

Fig. 3. Monthly leaf, wood, miscellaneous and total litter fall ($g\ m^{-2}$) in chir pine forest

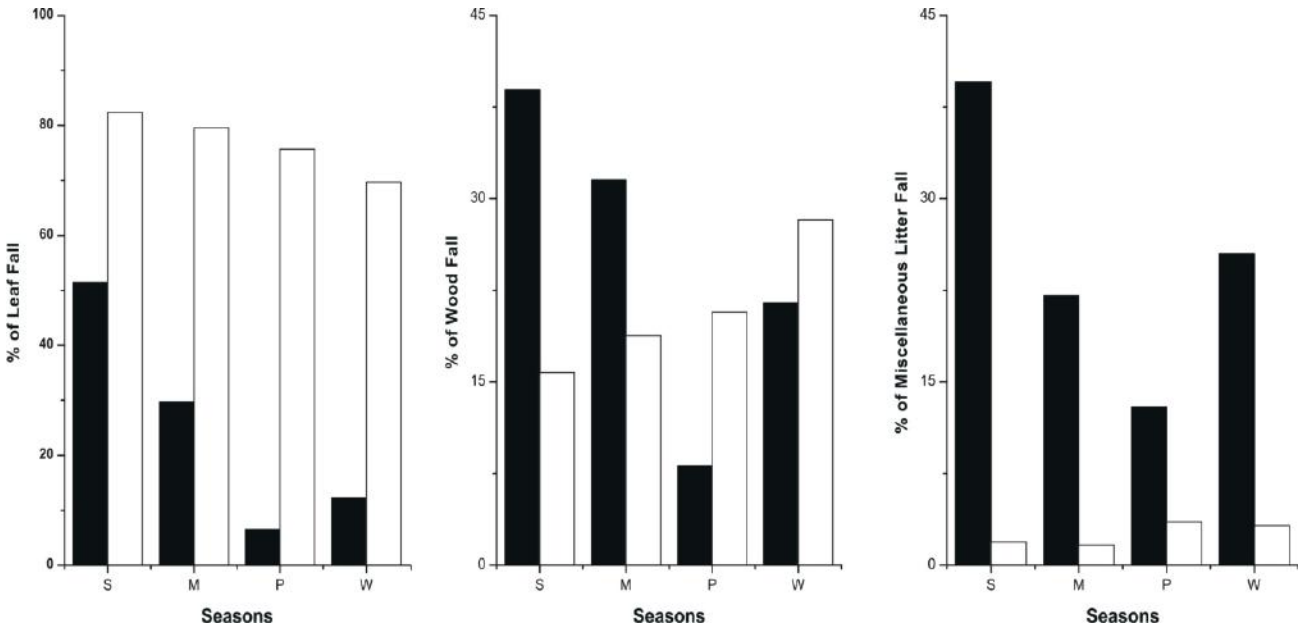

Fig. 4. Contribution of different seasons to annual litter fall (S = summer, M = Monsoon, P = post monsoon, W = winter) in chir pine forest. The black bar represents percentage of total annual litter production of respective category and black bar represents percentage contribution by different components in respective months

monsoon (22.1%) and post monsoon seasons (12.9%) (Fig. 4). The relationship between the litter fall and mean monthly temperature was found significant (Table 1). The contribution of leaf fall to total annual litter in respective month was highest during summer months; the leaf litter accounted for 75.6% (April) to 86.8% (June). The wood fall contribution was highest during winter months; the wood litter accounted for 220.9% (January) to 44.8% (December) and highest during post monsoon in Miscellaneous litter. The miscellaneous litter accounted for 3.3% (October) to 3.9% (November) (Fig. 4).

Litter Decomposition

The moisture content of decomposing leaf litter was positively related, according to the following regression:

$Y = 1.619 + 0.046\ X$ ($r = 0.\ 0.75$, d.f. = 11, $P < 0.01$)

Where, Y = % weight loss per 60 days and X = % moisture content on each 60th day.

Being an evergreen species, *P. roxburghii* had year-round litter fall; however, this was concentrated during April-May in response perhaps to warm, drier conditions prevailing during this period. The annual leaf fall here is about 6.93 t ha^{-1} compared to mean values of 0.7 to 2.2 (arctic), 2.5-3.0 (cool temperate), 3.5-3.6 (warm temperate) and 6.6-6.8 t ha^{-1} (equatorial forests) as reported by O'Neill and DeAngelis (1980). The annual estimated wood litter fall was 1.22 t ha^{-1}. This value lies within the range of 0.6-1.9 t ha^{-1} yr^{-1} reported for different forest types in Central Himalaya (Mehra and Singh, 1985). Thus the woody component was 18% of the total litter

Table 1. Coefficients of correlation, slope and intercepts of the relationships between litter fall per month (Y, gm^{-2}) and mean monthly temperature (X, °C) of *Pinus roxburghii* forest

Litter type	Intercept	Slope	r
Leaf	-41.316	3.367	0.773**
Wood	-1.928	0.461	0.831**
Miscellaneous	-0.294	0.051	0.807**

** Significant at $P < 0.01$

Table 2. Seasonal pattern of litter fall estimated through litter traps (g m^{-2} ± SE)

Seasons	Litter fall pattern			
	Leaf	Wood	Miscellaneous	Total
Winter	68.70 ± 3.8	26.10 ± 3.6	2.15 ± 1.9	96.95 ± 5.8
Summer	288.00 ± 9.1	47.40 ± 7.3	5.20 ± 3.2	340.60 ± 11.2
Monsoon	166.35 ± 5.7	38.40 ± 7.4	2.90 ± 2.6	207.65 ± 4.5
Post monsoon	36..55 ± 1.6	9.90 ± 1.6	1.70 ± 1.2	48.05 ± 3.6

Table 3. Annual tree litter fall (t ha^{-1}) in certain pine forests

Forest	Location	Litter fall	Reference
P. palustris	USA	4.9	Gresham (1982)
P. roxburghii	India	8.4	Mehra & Singh (1985)
P. roxburghii	India	7.3	Chaturvedi & Singh (1987)
P. roxburghii	India	6.9	Present study
P. taeda	USA	7.8	Gresham (1982)
Pine-mixed broadleaf	India	4.1	Mehra & Singh (1985)
Pine-mixed oak	India	6.3	Mehra & Singh (1985)

fall. The annual litter production in the present study (6.93 t ha^{-1}) lies between the warm temperate and equatorial forests (Table 3). The range of values is rather wide, from 3.5-18.0 t ha^{-1}, with a majority of values between 4-6 t ha^{-1}. The *P. roxburghii* forests seem to deposit between 7 and 8 t ha^{-1} litter each year.

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Response of Soybean to Organics and Phosphorus Fertilization in Vertisols of Marathwada Region of Parbhani (India)

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***Abstract*:** A field experiment was conducted for two consecutive years to determine response of soybean to organic sources (FYM and Vermicompost @ 5 t ha^{-1}) and with 0, 30, 60 and 90 kg P_2O_5 ha^{-1}. The grain yield and nutrient status was significantly influenced by organics and P fertilization. The higher yield and available N, P and K status was observed by application of Vermicompost (Vc) and 90 kg P_2O_5 ha^{-1}, followed by FYM and 60 kg P_2O_5 ha^{-1}. The test weight, Oil and protein content of soybean was also influenced significantly by organics and P fertilization.

***Key Words*:** Available NPK, *Glysine max*, Grain yield, Oil, Protein content.

Among the various oil seeds crop in India soybean is third major crop next to the ground nut and mustared and plays an important role in Indian economy. Among the states Maharashtra particularly Marathwada region also dominant in soybean production. The Parbhani is one of the major District of this region comprises vertisol as dominant soil orders. The soils are commenly medium to deep, alkaline in reaction, low to medium in fertility status especially N and P. The main reason for the low P status in these soils are high content of clay, calcium carbonate content, have higher amount of phosphate adsorption capacity. These need an additional dose of P fertilization to obtain good yield (Tekchand and Tomer 2009). However, not only addition of P but it is imparative need of upgrading P use efficiency as P use efficiency hardly goes up to 15-20 per cent (Raju *et al*., 2005). One of the best stratergies to imporving of available P and productivity by annual crop grown in vertisols is use of adequate rate of P in combination with organic sources. The application of recommended dose of NPK fails to sustain the crop productivity and nutrient use efficiency, but combined use of organic sources FYM, could obtain higher yield and besides improvement in nutrient use efficiency and soil fertility (Swarup 1998). Keeping this view the present investigation was carried with an objective to study the effect of organics and P fertilization on Yield and available nutrient status in soybean crop.

A field experiment was conducted for two consecutive years at, Marathwada Krishi Vidyapeeth, Parbhani (Maharashtra) India. The experiment was in split plot design comprising of 12 treatments. The main treatment comprises control (no organic source), FYM and Vermicompost (Vc) @ 5 t ha^{-1} + PSB and sub-treatments includes four P levels 0, 30, 60 and 90 kg P_2O_5 ha^{-1}. The PSB (phosphate solubilizing bacteria) seed treatment was done to soybean seed only with three main treatments. The treatments were replicated thrice. The experimental soil was clay (Vertisols) having pH 8.17 , organic carbon 3.80 g kg^{-1}, $CaCO_3$ 7.18 %, low in available N (131 kg ha^{-1}), P (5.84 kg ha^{-1}) and high in K (680 kg ha^{-1}). The available N was estimated by alkaline permanganate method as suggested by Subbiah and Asija (1956), P was determined by using 0.5 M sodium bicarbonate as an extractant as outlined by Olsen *et al*. (1954), and K was determined by neutral normal Ammonium Acetate as an extractant and measured on flame photometer (Jackson 1973). The oil and protein content was estimated as per the standard methods AOAC (1955).

Available N: The available N was increased significantly due to application of organic sources and P fertilization (Table 1). The application of vermicompost @ 5 t ha^{-1} showed highest values of available N at 30, 60 DAS (days After Sowing) and at harvest. The application of 90 P_2O_5 ha^{-1} recorded highest available N at 30, 60 and at harvest. It was attributed to ths addtion of organic sources stimulates the growth and activity of microorganisms. This effect is further enhanced by the addtion of N resulting in root and shoot growth (Babhulkar *et al*., 2000).

Available P: The availble P was maxiumum with the addition of Vermicompost @5 t ha^{-1} at 30, 60 DAS and at harvest. The application of 90 kg P_2O_5 ha^{-1} showed significantly highest values of available P compares to rest of the 0, 30 and 60 kg P_2O_5 ha^{-1} .The available P status increased with increase in the application of P may be due to the promotion of solubilization of P caused by addition of humic substances excreted by roots in soil (Bhakre and Sonar 2002).

Available K: The application of organic sources significantly increased available K in soil (Table 1). The significant highest available K status was due to the application of vermicompost @ 5 t ha^{-1} at 30, 60 DAS and at harvest over FYM and control during both the years. The available K in soil was maxiumum with the application of 90 kg P_2O_5 ha^{-1} over the rest of the P levels. The similar trend was also noted by Chaturwedi and Chandel (2005).

Table 1. Effect organics and P levels on availability of nutrients,yield and quality parameters of soybean (pooled data)

Treatment	Available N (kg ha^{-1})			Available P (kg ha^{-1})			Available K (kg ha^{-1})			Yield		Qualit Parameters		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	Grain	Straw	Test Weight (g)	Protein (%)	Oil (%)
O_0: Control	146.2	166.7	125.1	6.53	6.53	6.93	717.75	674.15	641.32	12.1	19.3	11.36	30.04	18.66
O_1:FYM 5 t ha^{-1}+ PSB	151.0	172.2	129.6	7.45	7.18	7.34	721.4	678.2	645.0	14.3	22.3	11.82	31.25	19.46
O_2:Vermicompost 5 t ha^{-1} +PSB	157.0	175.8	138.5	8.05	7.75	7.62	723.4	680.9	647.4	17.14	27.2	12.31	31.73	19.82
CD (p=0.05)	2.08	2.50	6.94	0.54	NS	NS	NS	NS	NS	2.0	3.0	0.36	0.24	0.13
P levels (P_2O_5kg ha^{-1})														
P_0: 0	144.1	164.6	124.9	5.18	4.89	5.05	710.5	671.0	637.7	10.8	16.7	10.91	29.32	18.67
P_1: 30	127.4	168.7	128.3	6.49	6.53	6.43	721.5	678.1	645.1	12.7	20.3	11.46	30.33	19.15
P_2: 60	154.1	174.0	132.9	8.06	7.90	8.03	724.7	678.5	645.4	16.4	24.9	12.23	31.77	19.67
P_3: 90	159.5	178.9	138.2	9.65	9.29	9.14	726.6	683.2	650.2	18.0	29.8	12.72	32.62	20.20
CD (p=0.05)	2.81	4.19	3.10	1.44	1.30	1.00	5.33	4.06	3.37	1.1	2.62	0.34	0.182	0.099
Interaction:														
O x P														
CD (p=0.05)	NS	NS	NS	NS	2.25	NS	NS	NS	NS	NS	NS	NS	0.31	0.17

NS- non significant, DAS- Days After Sowing, Vc- Vermicompost

Economic yield: Application organic sources significantly increased the grain and straw yield of soybean (Table 1). The application of vermicompost @ 5 t ha^{-1} resulted in maximum in grain and straw yield of soybean than in FYM and control . The maximum grain and straw yield of soybean was with an application of 90 kg P_2O_5 ha^{-1} while, it was decreased as the P levels altered to 60 , 30 kg P_2O_5 ha^{-1} The interaction of organics and P levels could not influence the garin and straw yield significantly. The significant increase in the yield of soybean was due to organics may be attributed to organic matter not only produces the organic acids which dissolve the essential nutrients during decomposition, but also provide substrates for microbial growth (Tanwar and Shaktawat, 2003). These results also infirmity with the results repoted by Patil *et al*., (2005).

Quality parameter: The application of vermicompost @ 5 t ha^{-1} showed significant increase in the test weight, oil and protein content of soybean. Among the P applied 90 kg P_2O_5 ha^{-1} showed marked incresed in test weight (100 seed weight), oil and protein content of soybean. The significant effect of organics and P levels on test weight due to organic sources and high P levels might be due to better translocation of P resulting in bold seeds Gupta *et al*. (2006). Similar findings also noted by Sinde *et al*. (2007) and Bairagi *et al*. (2007). The high protein content of soybean seed with increase the level of P may be ascribed to enhancement of N centent of soybean seed due to increase in P supply.Meena *et al*. (2006) also reported that the P being an energy sourse also plays in imported role in protein synthesis and enhanced the biosynthesis of polypeptides and nuclic acids that resulted in an increase in protein content.

Vermicompost application and P fertilization significantly increase the soybean grain yield in vertisols. The available N, P and K also increased due to the addition of Vermicompost and 90 kg P_2O_5 ha^{-1}.The test weight oil and protein content also enhanced due to high dose of P. Hence it is beneficia to integrate the use of organics and P fertilization to enhance the yield and sustainability of soil fertility.

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Effect of Storage Temperature, Growth Regulators and Chemical Solutions on Seed Germination in *Chila (Wendlandia exserta Roxb.)*

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Abstract: The impact of storage temperature on germination was minimum (19.96%) in **0ºC** to maximum in **10ºC** (23.41%). The effect of chemical treatments on germination varied from 3.74% percent in control to 38.48 percent in 100ppm GA_3. The seeds germination duration (11.82 days) was significantly low under storage temperature of 0**ºC**. The higher value of 53.64percent for germination energy was at room temperature in 100ppm NAA. The interaction of storage temperature with various treatments was found significant for initiation of germination with maximum 15.11days with 100ppm ethrel at room temperature. The interaction between storage temperature and various chemical treatments for germination per cent and germination energy was found to be non-significant.

***Key Words*:** Germination attributes, Growth regulators, Storage temperature, *Wendlandia exserta*

Chila (*Wendlandia exserta* Roxb. DC.) belongs to family Rubiaceae is well distributed throughout the sub-Himalayan tract up to 1400m elevation, in outer Himalaya, Chotanagpur and parts of Indian peninsula. It is also prominent in Shivalik hills where the area is vulnerable to landslides. It is gregarious in areas where soil is exposed due to disturbances or on abandoned agriculture and since the species is light demander it prefers to grow in loose soils which are exposed to direct sunlight. The tree flower in March-April and the seeds of the species are very minute and mature in May-June. The species is good for soil conservation and can be utilized for wasteland management. This tree species is silviculturely useful in re-clothing the bare hill slopes and newly exposed (clearings) as well as geologically vulnerable areas. The wood of this species is used for construction purposes and is an important fuel wood species in villages. Due to its heavy lopping and other constructional uses, its regeneration is very poor. For large scale success there should be adequate means of increasing its propagation potential through seeds and vegetative means. The most obvious challenge at present is how to meet growing demand for forest products, at the same time safe-guarding the ability of forests to provide a range of environmental services including the conversation of biological diversity, mitigation of global climatic change, arresting desertification and protection of soil and water recourses. Keeping in view the importance of the species present work entitled "Effect of storage temperature, growth regulators and Chemical solutions on seed germination in *Chila (WENDLANDIA EXSERTA ROXB.)*" is undertaken to study the effect of growth regulators, nutrients and storage conditions on germination attribute of *Wendlandia exserta*.

The study was conducted in the nursery of department of Silviculture in Dr. Y S Parmar University of Horticulture and Forestry, Nauni, Solan. The inflorescence/flower of chila was collected during April, 2010 from mature trees growing in Bhojnagar forest area in Dharampur range of Solan Forest Division. The dried inflorescence was brought to the laboratory, where the seeds were extracted and separated and counted. Three storage temperatures viz., room temperature (S_1), 10ºC (S_2), 0ºC (S_3) were chosen in which the seeds were kept for 2 months and then treated with different chemical solutions and growth regulators treatments i.e., Control, Water (100ppm), IAA (100ppm), IBA (100ppm), NAA (100ppm), GA_3 (100ppm), Kinetin (100ppm), 1% KNO_3, Ethrel (100ppm), 1% $MgSO_4$. IAA and IBA solutions were dissolved by adding 80-90% alcohol and then water was added. NAA and Kinetin was dissolved with 0.1N NaOH/HCl and GA_3 was dissolved in small quantity of acetone and then water was used as a solvent. Ethrel, KNO_3 and $MgSO_4$ solutions were made in water. For germination test, fifty seeds were exposed to each treatment and divided into three replications in root trainers .The germination was recorded for 28 days and the germination parameters were calculated.

The germination was 19.96 per cent at 0ºC and 23.41 percent per cent at 10ºC against 2008 at room temperature with significant difference , being significantly higher at 10ºC as compared to room temperature. The germination percent varied from minimum 3.74% in control to maximum 38.48% in 100ppm GA_3 (T_5). The impact of GA_3 was maximum followed by IBA but at par with T_5 (32.08%), NAA (27.30%), IAA (23.04%), KNO_3 (27.15%) on mean germination per cent of seeds. Initiation of germination (Number of days of germination) was affected significantly by storage temperature, growth regulators and salt solutions i.e. chemical treatments. The seeds took significantly minimum time of 11.82 days for germination under storage temperature of 0ºC (S_3) followed by 13.13 days in S_2 (10ºC)

and 13.51days at S_1 (room temperature). Maximum number of days for initiation of germination i.e.14.67were observed in T_9 (1% KNO_3) which was at par with GA_3 (T_5), followed by 100 ppm NAA (T_6) and IAA (T_3).

The impact of storage temperature was not significant but the higher value of germination energy (41.67%) was obtained at room temperature (S_1). Maximum percentage of germination energy (53.64%) was observed in (T_6) i.e. 100ppm NAA followed by KNO_3 (46.92%) and IBA (43.45%) which were significantly at par with GA_3 (42.39%) and Kinetin (44.94%) whereas, control gave minimum germination energy i.e. 20.43%.

The interaction between storage temperature and various chemical treatments on germination per cent was found to be non-significant. The mean values of interaction varied from 1.44 in control to 41.22% in 100ppm GA_3 (T_5S_3) at storage temperature of 0ºC followed by room temperature. But the interaction between storage temperature and various treatments was found significant for initiation of germination. The values varied from minimum 7.11days in control at **0ºC** (**T_1S_3**) to maximum of 15.11days in 100ppm Ethrel at room temperature (T_8S_1). The higher value of interaction for initiation of germination of 15.11days was found at par with 14.89 days in both $MgSO_4$ ($T_{10}S_2$) as well as GA_3 (T_5S_2). It can be inferred from the given table that growth regulators and salt solutions brought non-significant differences with storage temperature on germination energy. GA_3, KNO_3 and NAA exhibited significantly higher germination percent, initiation of germination and germination energy, respectively. However, minimum values were obtained in control conditions. These observations are in agreement with the findings of Ghyare (2005) and Rambabu *et al.* (2005), Lavania *et al.* (2006). These workers found significant increase in germination per cent with the treatment of GA_3. Sankhyan *et al.* (2004) studied the effect of growth regulators (IAA, IBA, GA_3, Kinetin, NAA and Ethrel) and salt solutions (KCl, KNO_3, $ZnSO_4$, KH_2PO_4, $FeSO_4$ and $MgSO_4$) on the germination of seed of *Hippophae tibetana*

Table 1. Effect of storage temperature, growth regulators and chemical solutions treatments and interaction on germination attributes of *Wendlandia exserta* seeds

Chemical solutions (T)	Storage Temperature (S)											
	Germination Percent				Initiation of germination				Germination Energy			
	Room temperature (S_1)	10ºC (S_2)	0ºC (S_3)	Mean	Room temperature (S_1)	10ºC (S_2)	0ºC (S_3)	Mean	Room temperature (S_1)	10ºC (S_2)	0ºC (S_3)	Mean
Control (T_1)	5.44 (9.91)	1.44 (4.43)	4.33 (7.58)	3.74 (7.31)	8.00 (2.62)	14.67 (3.95)	7.11 (2.38)	9.93 (2.98)	24.87 (23.25)	16.67 (15.00)	19.76 (18.57)	20.43 (18.94)
Water (T_2)	9.67 (14.92)	13.67 (18.83)	7.78 (11.69)	10.37 (15.15)	13.11 (3.64)	9.78 (2.97)	10.22 (3.03)	11.04 (3.21)	33.00 (29.84)	40.17 (35.77)	26.46 (24.22)	33.21 (29.95)
100ppm IAA (T_3)	20.67 (26.38)	26.44 (28.58)	22.00 (25.98)	23.04 (26.98)	14.67 (3.95)	14.44 (3.93)	12.67 (3.58)	13.93 (3.82)	43.22 (41.05)	37.67 (34.27)	41.01 (38.04)	40.64 (37.78)
100ppm IBA (T_4)	33.00 (34.78)	32.11 (33.95)	31.11 (33.18)	32.07 (33.97)	14.00 (3.87)	8.44 (2.68)	14.67 (3.95)	12.37 (3.50)	43.67 (41.33)	40.84 (39.63)	45.84 (42.59)	43.45 (41.18)
100ppm GA_3 (T_5)	35.89 (36.65)	38.33 (38.1)	41.22 (39.88)	38.48 (38.23)	14.22 (3.90)	14.89 (3.98)	14.00 (3.87)	14.37 (3.91)	42.69 (40.78)	45.51 (42.39)	38.97 (38.51)	42.39 (40.56)
100ppm NAA (T_6)	23.44 (27.24)	29.11 (31.72)	29.33 (31.56)	27.30 (30.17)	14.44 (3.93)	14.44 (3.93)	14.00 (3.87)	14.29 (3.91)	58.77 (51.99)	49.70 (44.83)	52.45 (46.46)	53.64 (47.76)
100ppm Kinetin (T_7)	16.67 (22.94)	21.22 (27.11)	12.11 (16.00)	16.67 (22.02)	14.22 (3.90)	14.22 (3.90)	10.22 (3.02)	12.89 (3.61)	43.11 (41.01)	48.20 (43.93)	43.49 (36.18)	44.93 (40.37)
100ppm Ethrel (T_8)	16.33 (21.81)	20.11 (23.14)	11.44 (15.79)	15.96 (20.25)	15.11 (4.01)	10.89 (3.23)	10.22 (3.02)	12.07 (3.42)	45.19 (40.42)	35.05 (32.61)	37.04 (32.34)	39.09 (35.12)
1% KNO_3 (T_9)	25.44 (29.67)	28.78 (31.94)	27.22 (31.09)	27.15 (30.90)	14.44 (3.93)	14.67 (3.95)	14.89 (3.98)	14.67 (3.95)	46.10 (42.71)	49.13 (44.48)	45.52 (42.41)	46.92 (43.20)
1% $MgSO_4$ (T_{10})	14.22 (19.60)	22.89 (27.90)	13.00 (16.25)	16.70 (21.25)	12.89 (3.61)	14.89 (3.98)	10.22 (3.02)	12.67 (3.54)	36.11 (33.40)	50.09 (46.63)	23.54 (22.52)	36.58 (34.18)
Mean	20.08 (24.39)	23.41 (26.58)	19.96 (22.90)		13.51 (3.74)	13.13 (3.65)	11.82 (3.37)		41.67 (38.58)	41.30 (37.95)	37.41 (34.18)	
CD (0.05)	T=5.02	S=2.75	T*S=NS		T*S=0.45				T*S=NS			

Figures in the parenthesis indicate the arc sine transformed values

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Effect of Ridge and Furrow System on Growth Characters and Yield of Rainfed Soybean (*Glycine Max*) in Madhya Pradesh

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***Abstract*:** Field experiments were conducted **in** Dhar district of Madhya Pradesh during 2011 and 2012 to assess the effect of ridge and furrow planting on growth characters and yield of soybean crop. The ridge and furrow planting was better in term of growth parameters, seed yield and straw yield in comparison with normal flat bed sowing for soybean crop.Economic analysis revealed that the net profit (Rs. 28150 ha^{-1}) was recorded higher under ridge and furrow planting compared to normal flat bed sowing (Rs. 17889 ha^{-1}) for soybean crop in pooled data analysis.

Key Words: Plant population, Ridge and Furrow, Soybean, Vertisols

The rainfed agriculture suffers from a number of hydro-physical and socio-economic constraints, which affect the productivity of rainy and post-rainy season crops. These include erratic and undependable rainfall, excess and deficient moisture with in a season, harsh thermal regime, soil loss, low level of input use and technology adoption and resource poor farmers (Gupta, 2002). The inherent characteristics relevant to soil management being low in infiltration rate, poor drainage leading to run off soil loss and a narrow moisture range for optimum tillage operations (Painuli *et al.*, 2002). *In-situ* conservation of rainwater at farm level with excess water being drained out into community drainage channels or recharging ground water for supplemental irrigation for post rainy season crops. By adopting holistic approach to the management of rainwater like BBF landform system, crop productivity is substantially increased, decreased run-off, increased rainfall infiltration and decreased soil loss (Singh *et al.*, 1999; Wani *et al.*, 2003). The strategy for soil moisture management is therefore; to maximize use of rainfall by increasing infiltration and moisture retention, encourage surface drainage and reducing runoff and soil erosion for optimizing the performance of high yielding improved varieties. *In-situ* rainwater management can be carried out either through land configuration techniques or adoption of suitable tillage practices or through crop residue management. Some of the efficient land configuration techniques for rainfed agro-ecological regions that encourage surface drainage and recharge of soil profile with rainwater and reducing runoff and soil erosion are broad-bed and furrow (BBF), ridge and furrow, tied ridging, raised and sunken bed, compartmental bunding, etc. These techniques encourage surface drainage, recharge soil profile by rain water and reduce soil erosion and runoff losses to certain amount favoring better soil environment. Jat and Singh (2003) reported higher biological yield and highest net and gross return from land configuration treatment as compared to conventional system.Dikey *et al* (2013) concluded that furrow opening after three rows performed better in terms of seed yield and economics of soybean cultivation which could be recommended against uncertainty in rainfall patterns including the extremes of rainfall events. Jha *et al.* (2014) concluded that conventional tillage+ raised bed+ open drainage channel treatment is suitable for better seed & straw yield, and that the no till treatment combined with drainage methods can improve soybean root growth and nodule number. Singh *et al*. (2011) further showed that mortality rate of soybean plants sown with a tractor-drawn BBF seed drill for Vertisols was reduced in the range of 14–19 % as compared to flat bed under the vagaries of monsoon which subsequently resulted in yield enhancement to the extent of 18.65% .Considering the above facts, attempt was made to study the effect of ridge and furrow system on the growth characters and yield of soybean in tribal area of Dhar district of Madhya Pradesh.

The field experiments were conducted at the farmer's fields during *kharif* 2011 and 2012 in the village Bagadia and Bhilbarkheda in Dhar district of Madhya Pradesh with five replications to assess the effect of ridge and furrow planting on growth characters and yield of soybean crop.

Soybean variety JS 93-05 was used in *kharif* 2011 and 2012.The soybean was sown in 30th June 2011 and harvest on 2nd October 2011 and soybean was sown in 4th July 2012 and harvest on 6th October 2012. To make the ridge and furrow system an extra sweep blade (punji) was attached on the back tines of seed-cum-fertilizer drill machine and

width of sweep blade (punji) depends upon the row to row distances (Bhargav *et al.2013)*. In the present study, 22.5 cm sweep blade was attached for row to row distance of 35 cm. The tractor operated ridge and furrow seed cum fertilizer drill is capable of making ridges and furrows in which seed is placed on the ridges and the furrows allow draining of the excess water. The furrows are useful to drain out excessive rainwater during heavy storms and for storing rainwater in furrows for enriching soil moisture through percolation in case of deficit rainfall and the soil moisture thus stored sustain the crop during dry spells (Singh *et al*., 2011).

The observations like plant population, plant height, number of branches per plant, root length, root width, number of root nodules per plant, number of pods per plant, pod length, number of seed per pod, seed yield weight per plant and seed index were recorded from 5 plants randomly selected from each treatment from each replication. Besides these, seed yield, straw yield, harvest index and economics of treatments were also calculated for continuously two years 2011 and 2012.The data collected on various characters of soybean crop was processed and subjected to statistical analysis by 't' test. All the growth and yield attributes of soybean crop were pooled for both the years and analyzed.

The results on validation of ridge and furrow seed cum fertilizer drill brought out that the plant population of soybean was significantly higher when the crop was planted using the machine as compared to planting on flat land by normal seed drill. Analysis of weather data revealed that the rainfall during season (June–October) was 774.4 mm in 2011 and 737.8 mm in 2012. The plant population 18.65 % higher on planting soybean using ridge and furrow seed cum fertilizer drill machine as compared to planting on flat land with normal seed drill. This indirectly indicated that use of ridges and furrow promotes better germination and emergence of the crop as compared to planting by normal seed drill. Plant growth parameters were found significantly better in ridge and furrow planting as compared to normal flat bed sowing and pooled data of growth characters of soybean is presented in Table 1.The increase in plant growth might be due to proper drainage of excess rainfall through furrows in ridge and furrow planting of soybean.

Root is a major part of the soybean crop which provides anchoring and active participation in nutrient, moisture uptake and play effective role in fixation of atmospheric nitrogen. For root studies, observation on root length, root width and number of root nodules per plant were recorded and analysed statistically through the t test (Table 1). Root characters of soybean crop was significantly higher in ridge and furrow planting as compared to normal flat sowing in which number of root nodules per plant was 18.75 % more in ridge and furrow planting and these root nodules are responsible for the fixation of atmospheric nitrogen in the soil.

The yield attributes and economics parameters of soybean crop were presented in Table 2. The number of pods per plant, pod length, number of seeds per pod, seed yield, straw yield and net monetary returns were statistically higher in the ridge and furrow system compare to normal flat bed sowing**.** The analysis showed that there was no significant difference on seed index due to treatments was observed. The highest productivity of 1500 kg ha^{-1} observed in the ridge and furrow system whereas lowest under normal flat bed sowing (1182.5 kg ha^{-1}) in pooled data.The net return is the best index of profitability of soybean crop production and higher net return (Rs 28150 per ha) and B: C ratio (2.565) was recorded under ridge and furrow system whereas lowest net return of (Rs 17889 per ha) and B: C ratio (1.89) was recorded under normal flat bed sowing.

Ralli and Dhingra (2003) reported higher nodule count and nodule dry weight under ridge sowing when compared with flat sowing. Verma (2008) reported that ridge and furrow sowing and broad bed and furrow sowing produced significantly higher growth parameters, yield and yield attributes and root parameters as well. The economics of treatments showed that the gross as well as net monetary returns were also recorded under ridge and furrow planting. Ram *et al*. (2011) also reported that net returns and B:C ratio recorded highest in raised bed sowing relative to flat bed

Table 1. Growth character of soybean for ridge and furrow system and flat bed sowing (Pooled Mean data)

Parameters	Ridge and furrow system	Normal flat bed sowing	% Increase over flat bed	CD at 5%
Plant population (No.m^{-2})	47.40	39.95	18.65	S
Plant height (cm)*	68.80	61.15	12.51	S
No. of branches per plant*	5.41	5.13	5.46	S
Root length (cm) **	24.81	17.47	42.01	S
Root width (cm)**	1.33	1.12	18.75	S
Number of root nodules per plant**	31	27.05	14.60	S

*= at harvest; **= 60 DAS

Table 2. Yield attributes and economics of soybean in field plot from ridge and furrow system and flat bed sowing ((Pooled Mean data)

Parameters	Ridge and furrow system	Normal flat bed sowing	% Increase over flat bed	CD at 5 %
Number of pods per plant	48.8	35.45	37.66	S
Pod length (cm)	4.78	4.355	9.76	S
No. of seeds per pod	2.66	2.31	15.15	S
Seed yield weight per plant (g)	5.95	4.53	31.35	S
Seed Index (g)	11.475	11.365	0.97	NS
Seed yield (kg ha^{-1})	1500	1182.5	26.85	S
Straw yield (kg ha^{-1})	1815.5	1513	19.99	S
Harvest index (%)	45.22	43.87	3.08	S
Net monetary returns (Rs.ha^{-1})	28150	17889	57.36	S
Benefit: cost ratio	2.565	1.89	35.71	S

sowing Similar findings were also reported by Bhargav *et al.*(2013) and Jadhav *et al.*(2012) for soybean crop.

The maximum seed yield of soybean was recorded when grown on ridge and furrow system of planting as compared to conventional method of sowing i.e. flat bed sowing. Effect of ridge and furrow planting system on the growth parameters of soybean was found better in comparison with normal flat bed sowing. The results of experiment indicate that for achieving maximum productivity from soybean in Vertisols, the crop should be sown by ridge and furrow planting system.

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Rationalizing Pest Management in Mustard-Through Emphasizing Under-Storey Repellent Crop and Safer Insecticides

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***Abstract*:** A safer pest management approach having components like repellent crop (coriander and holy basil), physical barriers and some safer chemicals, were evaluated against mustard pests. The treatment effectively suppressed population build up of aphid (about 4% infestation), webber and diamondback moth (both, about 3% infestation), sponsored good yields and was safer to non-target organisms like predatory fauna and pollinators. Chemical check showed at par efficacy with the safer treatment but its benefit-cost ratio was inferior and was also quite unsafe for beneficial creatures.

Key Words: Pest management, Mustard, Pests, Repellent Crop, Safer Insecticides

Mustard suffers from infestation of a number of pests but critical one that may lead to crop failure is the aphid, *Lypaphis erysimi* Kalt. It is a major pest of brassica crops in areas with sub-tropical and tropical climates and in India avoidable losses in yield can be about 95% (Dhaliwal *et al*., 2004; Kular and Kumar, 2011). Due to the hyper-sensitive nature of the aphid problem in mustard, the management approaches primarily emphasized on the application of synthetic organic pesticides. Apart from aphid, some other pests like leaf webber, diamondback moth, saw fly etc. have also been reported to cause substantial yield losses in mustard. Keeping this perspective in view, a pest management module was designed which emphasized on the role of repellent crop in deterring pest arrival and /or population development on mustard. An assessment was also made on the impact of the pest management modules on non-target beneficial creatures of the mustard ecosystem.

The experiments were carried out in farmlands in the new alluvial zone of West Bengal, India during *rabi* seasons of 2012 and 2013 in randomized block design with five treatments including one treated check, replicated four times in plots of 5m x 4m size. Crops were sown on 7th November and the crop growing period was continued for 90 days. Standard agronomic practices were followed to ensure optimal crop stand. The whole crop except in T5 was provided with yellow sticky traps set above canopy level, repellent crop strips: 20cm-wide strips of coriander and basil (1:1) between rows of mustard plants, maintenance of plant sanitation - removal of broken or twisted branches, reflective aluminum-colored polythene mulches between rows, maintained only up to 30 days after sowing (DAS). Red colored nylon net cover (top) was provided for the entire experimental field and foliar treatments were applied as MV sprays @500 litres/ha., including for T5. The different treatments were-

T1 (sustainable) – (a) Prophylactic application of leaf extract mixture (1:1) of *Alstonia* and *Calotropis* @100 ml/litre, three sprays at weekly interval starting from 15 DAS (b) one spray each with emamectin benzoate @ 12g ai/ha at 43DAS and cartap hydrochloride @ 250g ai/ha at 65DAS

T2 (plant extract-based) - (a) Prophylactic application of *Alstonia*-*Calotropis* leaf extract mixture (1:1) @100 ml/litter, three sprays at weekly interval starting from 15 DAS and again three sprays at weekly interval starting from 55DAS

T3 (*Calotropis* based) - (a) Prophylactic application with *Calotropis* leaf extract @100ml/litre, three sprays at weekly interval starting from 15 DAS, again three sprays at weekly interval starting from 55DAS

T4 (*Alstonia* based) - (a) Prophylactic application with *Alstonia* leaf extract @100ml/l, three sprays at weekly interval starting from 15 DAS, again three sprays at weekly interval starting from 55DAS

T5 (Chemical check) – alternated sprays of thiamethoxam and profenophos both @2ml ai/ litter at 15 days interval starting from 15 DAS.

For Preparation of leaf extract of *Alstonia* and *Calotropis*: Five kg fresh leaves were crushed in a blender and added to five litters of hot water (100°C) (1:1 w/v). This mixture was kept in the shade for twenty four hours. A clear extract was obtained by sieving. This extract was used as a stock solution.

Observations on aphids were taken at 10-day-interval starting from 15 days after sowing (DAS) from randomly selected ten plants per plot. Aphid numbers were

counted from 10cm shoot terminals and for leaf webber and diamond back moth, all the leaves of 10 randomly selected plants per plot were examined for damage and larval population. The natural enemies were also recorded from 10 plants in each replication while pollinators, bumble bee (*Bombus* sp.) and honey bee (*Apis* sp.) were recorded from the entire plot starting from 30 DAS at 15 day-intervals. Natural enemies included general predators like spiders (six species: *Marpissa calcuttaensis* Tikader*, Phidippus sp., Argiope pulchella* Thorel*, Oxyopes sp., Lycosa pseudoannulata* (Bosenberg and Strand)*, Leuchge sp.*), coccinellids (five species: *Coccinella septumpunctata* L., *Coccinella transversalis* Fabr. *Menochilus sexmaculatus* Fabr. and two *Coccinella* spp.) and syrphid (one species: *Syrphus* sp.). Records were also taken on yields to differentiate the treatments as well as to calculate the benefit-cost ratio.

All the treatments were effective against the important pests of mustard though the efficacy level varied significantly (Table 1). Sustainable treatment (T1) was the best treatment in checking the growth and development of the aphid populations and their resultant impact on the intensity of infestation and extent of damage (mean aphid/plant: 1.6 – 12.5, mean infested plant: 4.2 – 5.6 % as observed on different DAS). Chemical check (T5) was statistically at par with it. However, aphid populations were exterminated from both T1 and T5 as observed on 75 DAS and 65 DAS, respectively. The other foliage pests, diamond back moth (DBM) and leaf webber, appeared in small numbers (Table 1) and treatments effectively checked their population development. Mean number of DBM and leaf webber/plant varied between 0.16 - 0.37 and 0.11- 0.37 respectively, in treatments T1, T2, T3 and T4 while in T5 (chemical check) it was 0.26/plant (DBM) and 0.28/plant (leaf webber). These two species exhibited inter-specific competition and did not infest the same plant at a time. Similar behavior was also recorded in case of three-candidate-pest-frame: aphid, webber and DBM. DBM or webber did not prefer aphid infested plants, though some stray cases were recorded. DBM and webbers were found mainly during flushing or rossette phase (upto about 5 weeks after sowing) and blossoming (upto about 35 – 45 DAS). Plant-extract based treatments (T2: *Alstonia* + *Calotropis*, T3: *Calotropis*, T4: *Alstonia*) were also effective against all the pests encountered (aphid, DBM and webber) but all the three treatments were statistically inferior to both sustainable treatment (T1) and chemical check (T5). Effects of the treatments were well-reflected in the yield parameters and yields (Table 1). The highest yield of 1070 kg/ha was registered in sustainable treatment (T1) and it was marginally better than chemical check. The highest benefit-cost ratio of 1.64 was also recorded in this treatment while chemical check registered a BCR of 1.42. The highest number of siliqua (212/plant) was also recorded in sustainable treatment (T1) and chemical check (T5) was at par with it. Phytochemical-based treatments (T2, T3, and T4) failed to offer satisfactory protection and yields were reduced drastically. There were 5 species of coccinellids, 6 species of spiders and one species of syrphid (*Syrphus* sp.) in the experimental fields. Sustainable (T1- *Alstonia*-*Calotropis* + Emamectin benzoate + Cartap hydrochloride)) as well as phytochemical-based treatments (T2 – *Calotropis* + *Alstonia*, T3 - *Calotropis*, and T4 - *Alstonia*) were safe to the natural enemies and there was a steady status of the generalist predators (Table 2). All these treatments were significantly superior to chemical check in terms of safety to predatory coccinellids, spiders and syrphid as indicated by the critical difference values. However, T1, T2, T3 and T4 were statistically at par. T1 did not adversely affect natural enemy populations. All the plant-extract based treatments were also found safe to visiting bee populations (*Apis* sp. and *Bombus* sp.) as was shown by the mean values (Table 2). These treatments were statistically at par with each other but significantly superior to chemical check which recorded significantly less number of honey bees. Chemical check (T5) was statistically at par with other treatments in terms of safety to bumble bee.

The plant species coriander and holy basil contain a number of flavonoids, saponins, phenols, terpenes, sterols and essential oils which produce the characteristic aroma for them (Ramesh *et al*., 2005; Nambiar *et al*., 2010). Volatiles or allelochemicals secreted by plants either attract or repel insect pests and influence their landing response (Finch and Collier, 2003). It is assumed that, in the present study, the allelochemicals secreted by mustard, basil and coriander got mixed up in the air and the pest populations failed to detect the host plants which resulted in inferior landing response; that means, coriander-basil combination successfully acted as repellent crop group. Red-colored nylon net was included as the component primarily for three reasons: disruption in the host selection process by the insects which are attracted by green canopy, encouraging inappropriate landing and as physical barrier to flying adults. Visual stimuli appeared to have been interrupted by red color and those still managing to reach over the field, at least part of the population, failed to land on to the crop plants. This contributed to inferior landing response and lower count of the pest populations. Aluminium-colored reflective polythene mulches simply discouraged the flies through reflection. It might also have

Table 1. Effect of the treatments on the damage caused by aphid, DBM and leaf webber in mustard (pooled data of two years)

Treatment	Mean aphids/plant (DAS)*				Mean percent aphid infested plants (DAS)*				DBM infested plant (%)**	webber infested plant (%)**	Yield (kg/ha)
	25	45	65	85	25	45	65	85			
T1	9.2 (3.11)	1.2 (1.30)	1.6 (1.37)	0.0 (0.71)	4.2 (2.16)	4.2 (2.16)	4.3 (2.19)	0.0 (0.71)	3.3(10.47)	3.3(10.47)	1070
T2	12.3 (3.57)	28.8 (5.41)	32.2 (5.71)	28.7 (5.40)	9.2 (3.11)	16.4 (4.11)	19.5 (4.47)	22.5 (4.79)	5.3(13.31)	5.3(13.31)	652
T3	10.6 (3.33)	32.2 (5.71)	35.2 (5.97)	32.4 (5.73)	10.6 (3.33)	18.5 (4.35)	21.6 (4.70)	24.5 (5.00)	6.6(14.89)	6.6(14.89)	618
T4	11.2 (3.42)	33.4 (5.82)	36.1 (6.04)	33.3 (5.81)	11.3 (3.43)	19.1 (4.42)	21.5 (4.69)	24.9 (5.03)	7.3(15.68)	6.6(14.89)	595
T5	6.2 (2.58)	2.6 (1.76)	0.0 (0.71)	0.0 (0.71)	3.9 (2.09)	3.6 (2.01)	0.0 (0.71)	0.0 (0.71)	3.3(10.47)*	3.3(10.47)	1050
CD (p=0.05)	1.7	2.7	3.2	1.3	2.87	2.84	3.22	1.62	1.84	1.82	13

*Figures in parentheses are $\sqrt{n}$+0.5 transformations DAS – days after sowing **Figures in parenthesis are arcsine$\sqrt{p}$ transformations

Table 2. Effect of the treatments on the natural enemy and bee populations in mustard ecosystem (pooled data of two years)

Treatments	Mean coccinellids per plant*	Mean spiders per plant*	Mean syrphids per plant*	Honey bee per plot (mean of three observations)	Bumble bee per plot (mean of three observations)
T1	3.6 (2.02)	4.6(2.25)	1.3(1.34)	7.5(2.82)	1.9(1.54)
T2	3.4 (1.97)	4.6(2.25)	1.5(1.41)	6.8(2.70)	2.1(1.61)
T3	3.5(2.00)	4.4(2.21)	1.5(1.41)	7.5(2.82)	1.9(1.54)
T4	3.3(1.94)	4.4(2.21)	1.5(1.41)	7.7(2.86)	1.9(1.54)
T5	0.7(1.09)**	0.7(1.09)	0.0(0.71)	2.6(1.76)	1.6(1.44)
CD (p=0.05)	1.4	1.3	NS	2.3	0.4

*mature and immature stages were counted altogether **Figures in parentheses are $\sqrt{n}$+0.5 transformations

played a disruptive role in host selection process like the red-nylon net. Yellow sticky traps were set above canopy level to catch alate aphids. In brief, the treatment compliments either discouraged the insects to move into field or removed them at the very beginning of the population build up. It means, inferior landing response coupled with inappropriate landing response, interruption in host selection process, antifeedant and repellent action of phytochemicals, physical removal through sticky trap and net barrier resulted in suppression of pest populations and their damages. Extracts of *Calotropis* and *Alstonia* are known to contain some biologically active principles (alkaloids and glycosides) and for this reason these have shown repellency, antifeedancy and direct toxicity against a number of insects (Chakraborti and Sarkar, 2011; Das *et al*., 2008; Ramos *et al*., 2006; Lhinhatrakool and Sutthivaiyakit, 2006). Chemical check appeared unsafe for the generalist predators like spiders, coccinellids, syrphids and also to honey bees. Chemical method worked well against the pests in the present study but the pest management approach in mustard needs to be rationalized to reinstate the homeostasis. Results showed that the rationally designed pest management module for the mustard pests which emphasized on exploiting the *repellent crop theory* was effective, sustainable, safer, and cost-effective and in general agreement with some earlier works (Ramanjaneyulu *et al*., 2009).

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Integrated Management of *Meloidogyne incognita* in Wilt Disease Complex of Muskmelon

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Abstract: Studies were conducted under pot conditions to determine the comparative efficacy of carbofuran @ 2kg a.i./ha, thiram @ 3g/kg of seed, *Trichoderma harzianum* @ 15g/kg of soil and *Tagetes patula* (green manuring @ 10% w/w) alone and in combination against root-knot nematode *Meloidogyne incognita* and wilt fungus *Fusarium oxysporum* in muskmelon wilt disease complex. Significant increase in growth parameters was observed in all treatments as compared to untreated uninoculated plants. Individual applications of carbofuran @ 2kg a.i./ha and green manuring with *T. patula* significantly decreased root knot nematode population. Application of thiram alone did not reduce nematode population. Comparatively, higher increase in growth parameters and greater decrease in RKN population in soil and roots was observed in integrated treatments. Integration of *T. patula*, thiram and carbofuran or integration with *T. harzianum* was found to be most effective in management of root-knot disease disease and wilt complex.

Key Words: *Fusarium oxysporum*, Integration, *Meloidogyne incognita*, *Tagetes patula*, Wilt complex

Role of plant parasitic nematodes in agricultural production has remained underestimated due to their soil borne nature, microscopic size and hidden mode of life and non-typical visible feeding symptoms on the plants. Breakdown of resistance to wilt or advancement of wilt symptoms has been reported in presence of plant parasitic nematodes (France and Abawi, 1994). Management of disease complexes is cumbersome as even low densities of fungi or nematode can result in a disease complex of significant importance (Bowers *et al.,* 1996). Wilt disease complex is destructive and failure of crop has been reported in most of muskmelon growing regions of state. Chemical management is hazardous and alternative control measures need to be explored. Management of wilt disease by single approach is difficult and uneconomical so the integration of bioagents, botanicals and fungicides may be efficient and ecofriendly. Thus, for the effective management of disease complex, it is pertinent to study root knot nematode and its association with fungus in muskmelon due to their simultaneous existence with minimal use of chemicals. The present studies were carried out to assess the efficacy of an integrated management strategy for *M. incognita* in wilt disease complex of muskmelon with combined use of bioagent, botanical and chemicals.

Studies on management of root-knot nematode and wilt disease complex of muskmelon were conducted in the pothouse of Department of Plant Pathology, PAU, Ludhiana. For the trial one botanical-*Tagetes patula*, one bioagent-*Trichoderma harzianum*, two chemicals viz., thiram and carbofuran were applied singly or in combinations. Earthen pots of 10 inch diameter were filled with sterilized soil. *Tagetes patula* seeds were sown in pots and incorporated in soil and pots 50 days after sowing @ 10% w/w. Incorporation of marigold (*T. patula*) was done ten days before transplanting of muskmelon seedlings. Carbofuran @ 2kg a.i/ha was added at the time of sowing. Muskmelon seeds were treated with thiram @ 3g/kg before sowing. Seedlings of muskmelon were transplanted @ 2 seedlings/pot and simultaneous inoculations with one J_2/g of soil and fungal culture @ 8g/kg of soil to each pot was done. For nematode inoculations, pure culture of RKN *Meloidogyne incognita* (from single egg mass) was maintained in pots on brinjal. Healthy egg masses were collected from roots of eggplant, cleared of soil and kept for hatching. Freshly hatched juveniles were used for experiments. Fungus was isolated from diseased plants, identified as *Fusarium oxysporum* f. sp. *melonis* and maintained on Potato Dextrose Agar (PDA) medium. For the pot experiments, *F. oxysporum* was multiplied on sterilized sand-maize medium. Each treatment was replicated three times in completely randomized design.

Observations were taken on seventy day old crop of muskmelon on plant growth parameters, nematode population in soil and roots and wilt disease intensity. Plant growth parameters *viz*., shoot length (cm), root length (cm), fresh shoot and root weight (g) were recorded. Nematode population in soil/250 cc was estimated. Nematode population in roots was taken as root galling index (RGI), which was graded on a scale of 0-5 (Hussey and Janssen,

2002). Disease severity of plants in pots was computed on 0 to 4 scales.

Growth parameters of muskmelon in *M. incognita* and *F. oxysporum* f. sp. *melonis* inoculated pots: Significant increase in growth parameters of muskmelon plants was observed in pots, which were treated as compared to untreated inoculated pots. Of the individual treatments, maximum increase in shoot length (75.5cm) and shoot weight (55.3g) was observed with *T. patula* (Fig. 1) and it was statistically at par with carbofuran @ 2kg a.i/ha. Increase in shoot length in integrated treatments was significantly higher than individual applications of different treatments. Maximum increase in shoot length (78.8cm) was observed in integrated treatment of *T. patula* + thiram + carbofuran, which was statistically at par with integrated application of *T. patula* + thiram + *T. harzianum*.

Root length (19.3cm) and weight (9.8g) were significantly higher in *T. patula* (GM) and carbofuran @ 2kg a.i/ha when they were applied alone as compared to control (Fig. 1.). Increase in root length was higher in integrated treatments (32-46 per cent) as compared to the individual treatments (28-38 per cent). Maximum increase (20.8cm) in root length was observed in *T. patula* + thiram + carbofuran (T10) treatment. Root weight (11.1 g) was also observed to

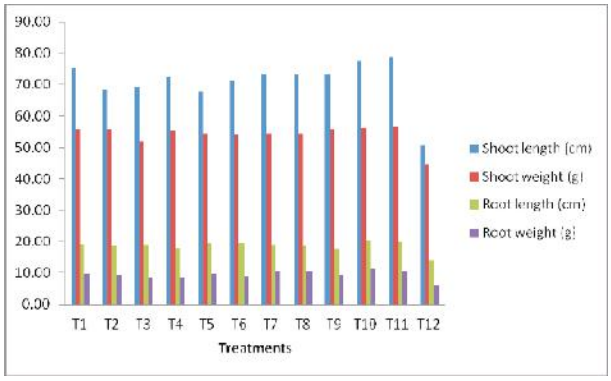

Fig. 1. Effect of different treatments singly and in combination on shoot length, shoot weight, root length and root weight of muskmelon crop

*See Table 1 for treatment details

be higher *in T. patula + thiram + T. harzianum*.

Nematode population and wilt disease intensity: In individual application of the treatments, root knot nematode population in soil/250cc significantly decreased in *T. patula* (GM) and carbofuran @ 2kg a.i/ha. Bioagent (*T. harzianum*) when applied alone; did not significantly reduce RKN population while thiram had no significant effect on nematode population. Greater reduction in nematode population was observed in integrated treatments as compared to individual applications. In integrated treatments, maximum and significant decrease in nematode population was observed in *T. patula* + thiram + carbofuran and was statistically at par with integrated treatment of *T. patula* + thiram + *T. harzianum*, *T. patula* + thiram and *T. patula* + *T. harzianum*. Application of *T. harzianum* alone did not significantly reduce nematode population but its integration with *T. patula* decreased nematode population in soil significantly.

Nematode infestation in roots was assessed as root galling index (RGI). RGI significantly decreased in individual application of *T. patula* (GM) and carbofuran @ 2kg a.i/ha. *T. harzianum* but when applied alone, did not significantly reduce RGI as compared to control, however, its integration with *T. patula* showed greater reduction of RGI. Chaitali *et al* (2003) had also observed that integration of *T. viride* with botanical was found more effective in controlling *M. incognita* and *Macrophomina phaseolina* in okra than *T. viride* alone. This reduction in nematode infestation in soil as well as in galls in integrated treatment with *T. patula* may be due to the allelopathic effect of botanical. The nematicidal properties of *Tagetes* sp have been also reported by Franzener *et al* (2007). Nasira *et al* (2013) observed maximum decrease in number of galls, egg masses, soil and root population and total population of nematode in the presence of marigold. Significant increase in fresh and dry weight of root and shoot along with plant height was also recorded with marigold @ 10g/kg. Application of thiram alone had no significant effect on RGI while its integration with *T. patula* significantly reduced RGI. Greater reduction in RGI was observed in integrated treatments as compared to individual applications. Integrated treatment of *T. patula* + thiram + carbofuran showed maximum and significant decrease in RGI. Integrated treatment of *T. patula* + thiram + *T. harzianum* was found equally effective in reducing nematode population.

Observations on wilt disease intensity revealed that when applied singly, higher reduction in wilt disease intensity was observed in carbofuran (41.3 per cent) followed by *T. patula* (38.7 per cent) and thiram (37.5 per cent). Comparatively per cent wilt control was higher in integrated treatments as compared to individual treatments. Maximum disease control (49.8 per cent) was observed in *T. patula* + thiram + carbofuran treatment, which was statistically at par with *T. patula* + thiram+ *T. harzianum* treatment. Deepak and Lal (2009) had reported that carbofuran and *T. patula* are better than thiram treatment to control the disease incidence and combined treatment with carbofuran, phorate and neem kernel powder was found to reduce number of galls and reproduction rate of *M. incognita* in okra wilt complex (Sharma *et al.,* 2007). The observations are in conformity with Kamdi *et al.* (2012).

Table 1. Effect of botanicals, bioagents and chemicals singly and in combinations on root knot nematode and per cent wilt disease intensity in muskmelon

Treatments	Nematode population/ 250 cc of soil	Per cent decrease	Root-knot index (0-5 scale)	Per cent decrease	Disease intensity (%)	Per cent wilt control
T1- *T. patula* *@ 10% w/w	396.8 (5.9)	37.4	2.5	45.6	61.3 (51.0)	38.7
T2- Thiram** @ 3g/kg	585.3 (6.4)	21.7	4.0	14.5	62.5 (51.5)	37.5
T3- Carbofuran*** @ 2kg a.i/ha	398.5 (5.9)	37.1	3.0	34.8	58.7 (48.8)	41.3
T4- *T. harzianium* *** @ 15g/kg of soil	592.8 (6.4)	25.8	3.9	15.2	64.4 (53.8)	35.6
T5- *T. patula**@ 10% w/w + Thiram**@ 2g/kg	303.8 (5.7)	52.1	3.0	34.8	56.2 (48.3)	43.8
T6- *T. patula* *@ 10% w/w + Carbofuran*** @ 1kg a.i/ha	377.5 (5.9)	40.4	2.3	50.0	56.3 (48.3)	43.7
T7- *T. patula* *@ 10% w/w + *T. harzianium* *** @ 15g/kg of soil	345.0 (5.8)	45.2	2.4	47.8	56.2 (48.3)	43.8
T8- Thiram**@ 2g/kg + Carbofuran*** @ 1kg a.i/ha	442.5 (6.1)	30.1	3.1	32.6	58.5 (48.7)	41.5
T9- Thiram**@ 2g/kg + *T. harzianium* *** @ 15g/kg of soil	565.0 (6.3)	25.0	3.7	19.6	58.2 (48.4)	41.8
T10- *T. patula* * *@ 10% w/w + Thiram**@ 2g/kg + Carbofuran***@ 1kg a.i/ha	327.5 (5.8)	48.3	2.1	54.3	50.2 (49.8)	49.8
T11- *T. patula* * *@ 10% w/w + Thiram** @ 2g/kg + *T. harzianium**** @ 15g/kg of soil	323.8 (5.7)	48.9	2.4	47.8	51.2 (46.3)	48.8
T12- Untreated control	633.8 (6.4)	-	4.6	-	100.0 (82.5)	-
C.D. (P= 0.05)	(0.1)		1.0		15.3	

Figures in parentheses are arc sine transformed values; * Green manuring; **Seed treatment; ***Soil application

The present study revealed that integrated application of bioagent, botanical and chemical had more suppressive effect on nematode galling and wilt disease in muskmelon. It also helped in increasing plant growth. In integrated approach of management, the antagonistic effect of marigold not only prevented pathogen build-up with an eco-friendly approach but also helped in increasing the manurial content of soil. The application of bioagent may help in development of beneficial microflora, which may decrease the pathogen with minimal doses of chemical. Hence, the possibility of use of integrated approach with site specific application can be explored for management of root knot nematode and wilt complex in muskmelon.

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Synthesis and Antifungal Evaluation of N-benzylidenebenzene-sulfonamides

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Abstract: Series of N-benzylidenebenzenesulfonamides were synthesized by condensing 4-amino benzenesulfonamide with respective aryl aldehydes. The crude products were recrystallized and characterised on the basis of chemical analysis and spectral studies. The synthesized compounds were screened *in vitro* for antifungal potential against *Bipolaris sorokiniana*, *Alternaria alternata, Pyricularia grisea* and *Drechslera graminea*. The synthesized compounds possessed moderate to promising antifungal potential against the test fungi.

Key Words: Antifungal potential, N-benzylidenebenzenesulfonamide, Spore germination inhibition

The demand for novel chemotherapeutic antibacterial and antifungal remains attractive in the field of medicinal chemistry. Discovery of sulfonamides as antibacterial in the early 30s was the beginning of the most fascinating era of chemotherapeutic agents (Hen *et al*., 2010). Sulfonamides are a class of anti-microbial agents that have seen extensive use in medicine. Since wide use is occurring, the presence of certain residues in animal products presents a potential health hazard due to their allergenic properties (Blanchflower and Rice, 1988). To overcome this, sulfonamides are reacted with aldehydes to form their imine/ azomethine derivatives. The azomethine linkages (-HC=N-) which are obtained by the condensation of primary amines with an active carbonyl compound are known as Schiff bases. Schiff bases are a very important class of organic compounds because of their applications in many fields including biological (Ramla *et al*., 2007), inorganic (Nawrocka *et al*., 2006) and analytical chemistry (Canpolat and Kaya, 2005). Although Schiff bases have been synthesized and studied in sufficient detail, only scanty published data are available on fungicidal activity of compounds derived from 4-amino benzene sulfonamide. The presence of sulfonamide ($-SO_2-NH_2$) and azomethine linkage (C=N) in a single molecule may prove to be better fungicides. In view of the above observations, the present work is designed to evaluate the synthesized compounds as fungicides.

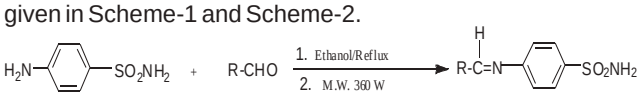
Synthesis of N-benzylidenebenzenesulfonamides:

Benzaldehyde (I) (0.25 mol) and 4-aminobenzenesulfonamide (0.25 mol) were dissolved in 10 ml of ethanol in a round bottom flask. The mixture was refluxed until a clear solution was obtained. The clear solution was cooled to get the crude solid. This crude product was then recrystallized from ethanol to obtain N-benzylidenebenzenesulfonamide (Ia). Reaction of 4-aminobenzenesulfonamide with 2-nitrobenzaldehyde (II), 3-nitrobenzaldehyde (III), 4-nitrobenzaldehyde (IV), 4-methoxybenzaldehyde (V), 3,4-dimethoxybenzaldehyde (VI), 3,4,5-trimethoxybenzaldehyde (VII), 2-hydroxybenzaldehyde (VIII), 3-hydroxybenzaldehyde (IX), 4-hydroxybenzaldehyde (X), 2-chlorobenzaldehyde (XI), 3-chlorobenzaldehyde (XII), 4-chlorobenzaldehyde (XIII), 3-bromobenzaldehyde (XIV), furfural (XV), syringaldehyde (XVI), 4-dimethylamino benzaldehyde (XVII) and vanillin (XVIII) was carried out by above procedure to give N-(2-nitrobenzylideneamino)benzenesulfonamide (IIa), N-(3-nitrobenzylideneamino) benzenesulfonamide (IIIa), N-(4-nitrobenzylideneamino) benzenesulfonamide (IVa), N-(4-methoxybenzylideneamino) benzenesulfonamide (Va), N-(3,4-dimethoxybenzylideneamino) benzenesulfonamide (VIa), N-(3,4,5-trimethoxybenzylideneamino) benzenesulfonamide (VIIa), N-(2-hydroxybenzylideneamino) benzenesulfonamide (VIIIa), N-(3-hydroxybenzylideneamino) benzenesulfonamide (IXa), N-(4-hydroxybenzylideneamino) benzenesulfonamide (Xa), N-(2-chlorobenzylideneamino) benzenesulfonamide (XIa), N-(3-chlorobenzylideneamino) benzenesulfonamide (XIIa), N-(4-chlorobenzylideneamino) benzenesulfonamide (XIIIa), N-(3-bromobenzylideneamino) benzenesulfonamide (XIVa), 4-(furan-2-ylmethyleneamino) benzenesulfonamide (XVa), 4-(4-hydroxy-3,5-dimethoxybenzylideneamino) benzenesulfonamide (XVIa), 4-(4-(dimethylamino) benzylideneamino) benzenesulfonamide (XVIIa) and 4-(4-hydroxy-3-methoxybenzylideneamino) benzenesulfonamide (XVIIIa), respectively.

In *vitro* screening for antifungal potential: Each compound (20 mg) was dissolved in Tween 20 (Polyoxyethylene sorbitan) (1 ml) and sterilized distilled water (9 ml) to prepare stock solution (2000µg ml^{-1}). The stock solution was serially diluted to obtain the required concentrations of 1000, 500, 250, 100, 50 and 25 µg ml^{-1} of the test compounds. Cavity slides were used for studying the antifungal activity. The spore suspension of test fungi were prepared in sterilised distilled water from fresh spores of *Pyricularia grisea, Bipolaris sorokiniana, Drechslera graminea and Alternaria alternata.* Suspension was filtered through three layers of sterilised cheese cloth in order to remove mycelial particles under aseptic conditions. Haemocytometer was used to form standardized spore suspension (1 x 10^6 spores/ml). Small droplets (0.02 ml) of test solution and spore suspension in equal amount were seeded in the cavity of cavity slides. These slides were kept in Petri dishes lined with moist filter paper and incubated for 24-72 hr at 24±1° C for *P. grisea, B. sorokiniana* and *D. graminea* and at 20±1°C for *A. alternata*. The germination of spores was recorded and the per cent spore germination inhibition was calculated. The results were compiled in terms of ED_{50} values (effective dose to inhibit 50% spore germination).

RESULTS AND DISCUSSION

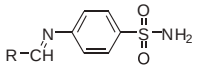
The reaction sequence for the formation of Schiff base is given in Scheme-1 and Scheme-2.



The products were characterized on the basis of spectral studies. The infrared spectra of the compounds Ia-XVIIIa showed bands in the range of 1617-60 cm^{-1} indicating the presence of azomethinic linkage. The ^1H NMR spectra of the synthesized N-benzylidenenaphthalen-1-amines in $CDCl_3$ exhibited signals at 7.58, 8.18, 8.2, 8.39, 8.39, 8.4, 8.4, 8.4, 8.7, 8.9, 8.3, 8.4, 8.4, 8.39, 8.39, 8.4, 8.18 and 8.47 for compounds Ia-XVIIIa, attributed to CH=N protons, respectively. The multisignals within the range of 6.80-9.9 are assigned to the aromatic protons of both rings. The N-benzylidenebenzenesulfonamide and its C-phenyl derivatives along with their characteristics are recorded in Table 1 and molecular ion peak with their elemental analysis are recorded in Table 2.

The synthesized compounds were screened *in vitro* for their antifungal activity against *D. graminea, A. alternate, P. grisea* and *B. sorokiniana* by applying spore germination inhibition technique. The results have been expressed in terms of ED_{50} values (Table 2). All the test compounds

Table 1. Characteristics of N-benzylidenebenzenesulfonamide and its C-phenyl derivatives



Compound	R	Molecular wt.	Yield (%)	m.p. (^{0}C)	Colour
Ia	C_6H_5	260	70	174	off white
IIa	2-NO_2 C_6H_5	305	68	180	Orange
IIIa	3-NO_2 C_6H_5	305	65	185	Cream
Iva	4-NO_2 C_6H_5	305	72	195	bright yellow
Va	4-OCH_3 C_6H_5	290	65	212	pale yellow
VIa	3,4-$(OCH_3)_2$ C_6H_4	320	63	154	Orange
VIIa	3,4,5-$(OCH_3)_3$ C_6H_3	350	77	115	mustard
VIIIa	2-OH C_6H_5	276	63	218	deep orange
IXa	3-OH C_6H_5	276	72	178	mustard
Xa	4-OH C_6H_5	276	75	190	dull yellow
Xia	2-Cl C_6H_5	294	60	200	light orange
XIIa	3-Cl C_6H_5	294	65	182	light yellow
XIIIa	4-Cl C_6H_5	294	73	198	Lemon
XIVa	3-Br C_6H_5	339	61	205	pale white
XVa		250	70	191	Black
XVIa	4-OH;3,5-$(OCH_3)_2$ C_6H_3	336	74	170	Yellow
XVIIa	4-$N(CH_3)_2$ C_6H_5	303	78	200	dull brown
XVIIIa	4-OH,3-OCH_3 C_6H_4	306	70	165	dull orange

Table 2. Antifungal activity of N-benzylidenebenzenesulfonamide and its C-phenyl derivatives

Compound	*B.sorokiniana*	*D.graminea*	*P.grisea*	*A.alternata*
I	600	375	563	250
II	93	85	47	100
III	153	100	250	136
IV	115	72	98	90
V	675	500	784	300
VI	368	675	285	58
VII	400	845	469	238
VIII	820	750	705	715
IX	725	861	82	800
X	315	120	523	83
XI	500	700	230	810
XII	*	*	*	*
XIII	250	98	720	250
XIV	659	*	757	751
XV	204	158	212	324
XVI	316	100	200	456
XVII	100	90	685	69
XVIII	261	256	712	618
**Tilt 25 EC	40	45	45	25

*more than 1000 g/ml
** Standard fungicide for *P.grisea, D.graminea, B.sorokiniana* and *A.alternata*

showed promising to moderate activity against all the test fungi.

N-(2-nitrobenzylideneamino)benzenesulfonamide (IIa) was most effective against *B. sorokiniana* with ED_{50} value 93 g/ml. Compounds like N-(3-nitrobenzylideneamino) benzenesulfonamide (IIIa) and N-(4-dimethylaminobenylid eneamino) benzenesulfonamide (XVIIa) showed promising antifungal activity with ED_{50} values of 115 and 100 µg/ml. Rest all of the compounds possessed ED_{50} value less than 900 g/ml against the test fungi. Against *D. graminea* four test compounds inflicted promising antifungal potential *viz.* N-(2-nitrobenzylideneamino)benzenesulfonamide (IIa), N-(4-nitrobenzylideneamino) benzenesulfonamide (IVa), N-(4-chlorobenzylideneamino) benzenesulfonamide (XIIIa) and N-(4-hydroxy,3-methoxybenzylideneamino)benzene sulfonamide (XVIIa) possessed with ED_{50} values 85, 72, 98, 90 g/ml respectively. N-(3-chlorobenzylideneamino) benzenesulfonamide (XIIa) and N-(3-bromobenzylidene amino) benzenesulfonamide (XIVa) were found to be inactive against this fungus. Against *P. grisea*, compound N-(2-nitrobenzylideneamino) benzenesulfonamide (IIa) showed maximum potential with ED_{50} value of 47 g/ml. Compounds N -(3,4-dimethoxybenzylideneamino)benzenesulfonamide (VIa) and N-(4-dimethylaminobenzylideneamino) benzenesulfonamide (XVIIa) were the most active ones against *A.alternata* with ED_{50} value of 58 and 69 g/ml, respectively. Compounds IVa and Xa also inflicted promising potential with ED_{50} values of 90 and 83ìg/ml respectively. N-(3-chlorobenzylideneamino)benzenesulfonamide (XIIa) found to be inactive against all the test fungi.

It is concluded from the data given in Table 2 that the substituted compounds were more potent against all the test fungi as compared to unsubstituted ones. In case of nitro substituted N-(2-nitrobenzylideneamino) benzenesulfon amides, the relative order of antifungal biopotential is according to their position of the nitro group in the synthesized compounds. Against *B.sorokiniana, A.alternata* and *D.graminea* the order of fungitoxicity was IVa > IIa > IIIa but for *P.grisea* it was IIa > IVa > IIIa. In compounds containing methoxy group as substitution the order of reactivity for *P.grisea* and *B. sorokiniana* was VIa > VIIa > Va but for *D.graminea* and *A.alternata* order of reactivity was Va > VIa > VIIa. In terms of substitutes the order of bioefficacy against all the test fungi was $–NO_2$ > $-OCH_3$ > -OH > Cl.

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Effect of Quinalphos Administration on Body Weight, Feed Intake and Cyclicity of Female Albino Rats

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Abstract: The present investigation was carried out to determine the effect of quinalphos on the body weight and ovarian cyclicity in female albino rats. Commercial quinalphos (2 mg/kg body weight) was administered orally of female albino rats for 15 and 30 days. There was significant decreases in body weight in 30 days in treated group as compared to control. The feed intake did not decrease in this group. The cyclicity was affected after one week of treatment in 20% of the rats but after four weeks the cyclicity in all the treated rats was disrupted with the diestrous stage being the most predominant phases.

Key Words: Cyclicity, Estrous, Organophosphate, Quinalphos, Albino rats

Many pesticides are now suspected of being endocrine disruptor chemicals (EDC's) and natural phytoestrogens (naturally occurring plant or fungal metabolite-derived estrogen) that act on the endocrine systems of humans and animals by mimicking, blocking and interfering in some manner with the natural instruction of hormones to cells (Colborn, 1998). Organophosphate compounds are among the pesticides which are widely used in agriculture and their usage has increased astronomically in the last decade (Zahran *et al.*, 2005).Organochlorines, pyretheroids and some organophosphates are identified to cause decrease in body weight and feed intake (Hussain *et al.,* 2009). Quinalphos (QP) is a toxic, organio phosphate insecticide used commomnly, but the effect of quinalphos on body weight, feed intake and cyclicity of females is not well defined. Therefore, in the present studies it was planned to measure body weight, feed intake and estrous cyclicity in female albino rats after short term and long term treatment of quinalphosat low residual dose level.

Three months old female albino rats (*Rattus norvigicus*) weighing 150-200 g were procured from Department of Livestock Production and Management,Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhianaand maintained under conditions of controlled temperature (75±2°F) and humidity (40-60%) with 12-hr light/dark cycle.The animals were housed in groups of three rats per cage. The rats were acclimatized for 15 days before using them for experimentation. They were provided with standard diet containing pelleted food and water *ad libitum*. The cyclicity of rats was confirmed by examining their vaginal smears daily and the ones showing two or more regular 4-5 days estrous cycle were selected for the experiment. The rats were divided into 2 groups of 8 animals each for 15 and 30 day treatment with their respective control groups. The experimental protocol met the national guidelines on the proper care and use of animals in the laboratory research. This experimental protocol was approved by the Institutional Animal Ethics Committee (IAEC).

Commercial formulation of quinalphos 25% EC was used for the present study. Adequate dilutions were made with peanut oil to achieve the test concentration of 2 mg/kg/day. The test concentration of quinalphos was calculated from the percentage of active ingredient of commercial formulation of quinalphos. Rats were tube fed orally with quinalphos for two and four weeks. Simultaneously same amount of peanut oil was also administered orally to control group of rats. All the animals (control and quinalphos treated) were observed daily for clinical symptoms like salivation, activity, irritability, faecal pellet conditions, diarrhea, eyeball movement, weakness, coarse tremor, paralysis of limb, wounds and mortality etc.

The body weight of rats was taken before the start of the treatment and thereafter was weighed weekly to determine the change in body weight after the initiation of experiment.

The rats were fed with pelleted feed obtained from *Godrej Agrovet*, Khanna. Daily 50 g of feed per animal was given to rats and after 24 hrs the remaining uneaten feed was weighed. The rats were fed for 15 days and 30 days respectively. The total feed consumed in a cage was divided by three to get the feed consumed per rat.

The estrous cycle of each rat was determined by examination of vaginal smears. daily, , The vagina was washed with the 0.9% saline solution using plastic dropper and smears were examined immediately under microscope while still wet and the cellular components were judged to

determine the various stages of estrous cycle with the criteria established by (Yener *et al.*, 2007).Proestrous**:** Epithelial cells with nuclei, Estrous: Vaginal cornification with total absence of leucocytes, Metestrous: Leucocytes with few cornified epithelial cells, Diestrous**:** Leucocytes only.

In the first and second week of treatment no toxicological effect of quinalphos was observed. However in the third and fourth week, it has been observed that the treated rats were hyperactive and aggressive with loose faecal pellets.The weight in treated animals declined from their initial weight at four week treatment, although the decline was non significant where as in the control animals, the weight increased significantly ($p< 0.05$) during the same period. The weight of treated animals after 30 days was significantly ($p< 0.01$) less than their respective control group. The net gain in the body weight in all the rats of control and treated groups increased but the increase in net body weight gain in treated rats was significantly less as compared to control rats (Table 1). As the quinalphos is known to affect the activity of AChE (acetylcholine esterase), which causes the stimulation of cholinergic synapsis, ultimately disturbing the metabolism of body hence the quinalphos can affect the body weight of the animals. In our present study it was observed the treated rats were hyperactive and aggressive hence the decrease in body weight may be related with the cholinergic stress caused by administration of QP. Decrease in body weight was observed by Srivastava and Raizada (1999) after the treatment of pregnant rats with quinalphos at dose concentration of 3 and 4.5 mg/kg body weight. The daily feed intake by rats was also observed and it was recorded that no significant effect on feed intake in treated rats was observed as compared to control rats.

The estrous cyclicity was disturbed in 2 out of eight quinalphos treated rats after one week of treatment but after two week of treatment thecyclicity was disturbed in five out of eight treated rats while at the end of the experiment it was observed that the cyclicity was not normal in all the rats of the treated group. In the present study the diestrous phase (numerous leucocytes cells) has been noticed to be more predominant in vaginal smear with reduced metestrous phase.

In the present study the quinalphos treated rats showed prolonged diestrous phase hence quinalphos may not have estrogenic activity. It may be possible that it acts on the level of hypothalamus to adversely affect the ovary, which in turn affects the estrous cycle due to hormonal imbalance in estrogen progesterone ratio. In accordance with the present study Baligar and Kaliwal (2002) also observed significant decrease in estrous cycle and duration of proestrous, estrous and metestrous with concomitant significant increase in the duration of diestrus phase when they treated rats with carbofuran. Organophosphates like methyl parathion, dimethoate and monocrotophos when given to female albino rats also resulted in disturbance of cyclicity in treated rats and caused prolonged estrous in treated rats as compared to control rats (Kaur, 2003). Although in the present study the estrous cyclicity was affected, the precise pathway of the mechanisms involved due to quinalphos administration need to be investigated.

From the present study it is concluded that administration of quinalphos caused significantly lower body weight gain and disrupted estrous cyclicity in treated rats even though the dose given was equivalent to no observed effect level.

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Table 1. Effect of quinalphos treatment on net body weight gain in treated female albino rats

	2 weeks		4 weeks	
	Control	Treated	Control	Treated
Initial wt (g)	167.5±2.08	163.75±3.09	170±0.00[a]	151.25±2.72
Final wt (g)	173.75±1.47	180.63±3.23	207.50±1.58	167.5±3.38
Net wt gain*	3.77±1.20	10.41±2.21	22.06±1.21	10.88±2.75[b]
Feed Intake*	11.71±0.00	11.73 ±0.94	11.21±0.00	10.94±0.92

All the values are Mean ± SE values of 8 animals in each group. *(g/100g bw)
Figures bearing different superscripts differ significantly (a = $p< 0.05$, b = $p< 0.01$)

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Quantitative and Qualitative Losses in Groundnut Varieties Caused *by Caryedon serratus* Olivier (Bruchidae : Coleoptera)

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***Abstract*:** Ten varieties of groundnut *viz*., M-13, RG-382, RG-425, RG-510, TG-37A, TAG-24, ICG-115, SG-84, Girnar-2 and Chandra were tested against *by Caryedon serratus* in relation to developmental period, per cent kernel damage and weight loss and bio-chemical characters. *Out of these,* none of the groundnut variety was found free from attack of *C. serratus*, however, on the basis of different parameters, the varieties SG-84, Chandra and TG-37A proved to be less susceptible and Girnar-2, RG-382, M-13 and TAG-24 were moderately susceptible, whereas, RG-510, ICG-115 and RG-425 were among the highly susceptible varieties.

***Key Words*:** *Caryedon serratus,* Developmental period, Groundnut, Varieties

Groundnut, *Arachis hypogaea* (L.) is one of the major oilseed crop of India and popularly known as peanut, monkey nut and almond of poor men. About 100 insect species have been reported to infest stored groundnut. Amongst them, *Caryedon serratus* (Olivier) (Coleoptera : Bruchidae) is a key pest posing potential threat to stored groundnut, tamarind and other leguminous seeds. Out of the total losses caused due to insect infestation, the loss due to this pest ranges from 19-60 per cent in India (Pal *et al.,* 2000). Kernels of almost all the varieties of groundnut grown in the country are infested by *Caryedon serratus* but the extent of damage is influenced by the bio-chemical characters of the variety and these make a variety resistant to insect attack. The damage potential of this pest has been the subject of considerable research mainly on the relative preference in different stored products and among the varieties of the same product. Keeping this in view an attempt has been made to study the growth and development of this pest on some promising groundnut varieties.

Growth and Development

For determining the relative susceptibility of the different groundnut varieties (M-13, RG-382, RG-425, RG-510, TG-37A, TAG-24, ICG-115, SG-84, Girnar-2 and Chandra) only sound and healthy kernels were selected after mechanical separation. The kernels were sterilized at 60^{0}C for five hrs in order to make them free from hidden infestation. Prior to the experiment, the kernels of each variety were conditioned at least for a week in an environmental chamber maintaining 28$\pm$2^{0}C temperature and 70$\pm$5 per cent relative humidity. All the varieties were inoculated simultaneously and there were three replications for each variety. To work out the development period of *C. serratus* on different varieties, 50 g of each variety was taken in plastic jar (8x7 cm) and one pair of newly emerged adults of 0-24 hrs old was released. The kernels with eggs laid on it were separated after one day and kept in specimen tubes to determine the total development period (egg to adult). The damaged kernel and weight loss were recorded after 90 days of the released of eggs. For this purpose, the sample of kernels was spread upon a white sheet and damaged kernels were counted. The loss in weight was obtained after removing all insect stages and frass. It was worked out by subtracting the final weight from initial weight and converted into per cent weight loss.

Bio-chemical characteristics of groundnut varieties

The moisture content in the collected samples was determined with the help of digital moisture meter (MAC Macro scientific works R) as per the procedure given in the manual of the equipment. Protein content was estimated by using Kjeldahl and Colorimetric method (Snell and Snell, 1949). Carbohydrates were estimated by using anthrone reagent (Hedge and Hofreiter, 1962). The oil content was estimated by Soxhlet's ether extraction method (A.O.A.C., 1955).

The average number of days taken to complete the development of the ***C. serratus*** from egg to adult stage differed significantly on different groundnut varieties (Table 1). The minimum developmental period of 40.67 days was observed on RG-510, which was at par with ICG-115 (43.00 days). The maximum developmental period was recorded on SG-84 (64.67 days), at par with Chandra (64.00 days) and TG-37A (62.33 days). However, no significant difference was observed between verities TAG-24 and M-13; Girnar-2 and

Table 1. Development period of *C. serratus and* per cent kernel damage and weight loss in different varieties of groundnut

Varieties	Developmental period (days)	Per cent kernel damage	Per cent loss in weight
M- 13	56.34	54.00 (47.29)	7.00 (15.34)
RG- 382	52.67	58.33 (49.79)	7.68 (16.09)
RG- 425	45.00	65.87 (54.25)	13.65 (21.68)
RG- 510	40.67	74.82 (59.88)	16.00 (23.58)
TG- 37A	62.33	45.68 (42.52)	3.67 (11.04)
TAG- 24	58.67	47.00 (43.28)	5.50 (13.56)
ICG- 115	43.00	68.50 (55.86)	14.28 (22.20)
SG- 84	64.67	40.00 (39.23)	2.20 (8.53)
Girnar-2	47.00	61.97 (51.93)	9.80 (18.24)
Chandra	64.00	42.97 (40.96)	2.30 (8.72)
CD (0.05)	3.58	(3.82)	(0.69)

Figures in parentheses are angular transformed values

RG-425 and RG-425 and ICG-115. From the present studies, it can be inferred that developmental period were shorter in most susceptible varieties and reverse in less susceptible varieties. The present results get substantial confirmation from the finding of Kapadia (1995) and Haritha *et al*. (1999) who also observed that development period of *C. serratus* to be greatly influenced by groundnut varieties.

The percentage of damaged kernels and loss in weight of different groundnut varieties due to groundnut bruchid varied from 40.00 to 74.82 and 2.20 to 16.00 per cent, respectively, being maximum damaged kernels and weight loss in RG-510, while minimum in SG-84 followed by Chandra. Devi and Rao (2000), Sundria *et al.* (2005) and Harish *et al*. (2012) found significant variation in kernel damage and weight loss on different groundnut varieties, support the present findings.

The data regarding the important bio-chemical characteristics (Table 2) of the groundnut kernel sample of different varieties were known to play a major role in the resistance / susceptibility. Moisture percentage in different varieties of groundnut varied from 7.12 (SG-84) to 9.38 (RG-510).

The protein content in different groundnut varieties was increased due to infestation of *C. serratus*. The highest increased of protein was observed in the variety RG-510 (5.26%), which was at par with ICG-115 (5.12%) and significant to rest of the varieties. The lowest increase of protein was in SG-84 (2.23%) followed by Chandra, TG-37A and TAG-24. However, no significant difference was observed between Chandra and TG-37A; M-13 and RG- 382; Girnar-2 and RG-425; RG-425 and ICG-115 and ICG-115 and RG-510.

Findings of the present investigations enunciated a negative effect of *C. serratus* infestation on the carbohydrate contents of groundnut kernels. Minimum reduction to the tune of 0.41 per cent carbohydrate was observed in SG-84, while maximum reduction 1.73 per cent in RG-510. The results are in conformity with the findings of Sundria (2003), who reported that a significant reduction in carbohydrate contents of groundnut kernels when artificially infested with *C. serratus*.

The oil content of different groundnut varieties was increased due to infestation of *C. serratus*. The highest increased percentage of oil was observed in the variety RG-510 (8.10%) which was at par with ICG-115 and RG-425. The lowest increase in oil content was observed in SG-84 (5.75%) which was at par with Chandra. However, no significant difference was observed between the SG-84 and Chandra; Chandra and TG-37A; TG-37A and TAG-24; RG- 382 and Girnar-2; Girnar-2, RG-425 and ICG-115 and RG-425, ICG-115 and RG-510. Sundria (2003) also observed the increase of oil percentage in damaged groundnut kernels due to infestation of *C. serratus.*

The correlation of moisture content of the kernels was observed to be significantly positive with the infestation of *C. serratus* (Table-3). Thus, the population and infestation of the pest increased with the increase in moisture contents. The correlation between protein and oil contents of kernels and infestation of *C. serratus* was found positively significant. Thus, it showed that the protein and oil contents in infested kernel increased with increase of kernel damage and weight loss in kernels. The carbohydrate content had significant positive correlation with kernel damage and weight loss. The reduction of carbohydrate content in infested kernels increased with the increase infestation of this pest. On the basis of above observations, it was observed that none of the groundnut varieties tested found completely free from the attack of *C. serratus.* However, on the basis of different parameters, tested groundnut varieties can be categorized as under:

a. Less susceptible – SG-84, Chandra and TG-37A
b. Moderately susceptible – Girnar-2, RG-382, M-13 and TAG-24
c. Highly susceptible – RG-510, ICG-115 and RG-425

Table 2. Bio-chemical characteristics of groundnut varieties

Varieties	Moisture (%)	Protien (%)			Carbohydrate (%)			Oil (%)		
		Healthy kernels	Infested kernels	Per cent increase	Healthy kernels	Infested kernels	Per cent decrease	Healthy kernels	Infested kernels	Per cent increase
M-13	8.19	22.98	23.88	3.91	13.50	13.34	1.18	49.12	52.48	6.85
RG- 382	8.28	25.37	26.43	4.17	13.20	13.03	1.28	50.18	53.86	7.34
RG- 425	8.78	24.87	26.09	4.90	13.02	12.82	1.53	50.00	53.91	7.83
RG- 510	9.38	25.46	26.80	5.26	13.28	13.05	1.73	50.33	54.41	8.10
TG- 37A	7.49	23.94	24.62	2.84	12.86	12.75	0.85	48.80	51.83	6.20
TAG- 24	7.88	24.18	25.05	3.59	12.36	12.24	0.97	48.00	51.07	6.40
ICG- 115	9.22	25.00	26.28	5.12	13.26	13.05	1.58	50.10	54.07	7.93
SG- 84	7.12	22.84	23.35	2.23	12.00	11.95	0.41	47.28	50.00	5.75
Girnar-2	8.53	24.67	25.83	4.70	13.32	13.12	1.42	49.10	52.85	7.63
Chandra	7.32	23.14	23.73	2.54	12.56	12.48	0.63	47.98	50.83	5.95
CD (0.05)	0.51	-	-	0.30	-	-	0.06	-	-	0.43

Table 3. Regression equations and correlation coefficient among the different bio-chemical parameters, kernel damage and weight loss in groundnut

Y variable	X variable	r	Regression equation
Moisture content	Kernel damage	0.987*	Y = 2.888 + 0.110 X
	Weight loss	0.990*	Y = 5.999 + 0.140 X
Protein content	Kernel damage	0.970*	Y = -3.500 + 0.153 X
	Weight loss	0.986*	Y = 0.793 + 0.197 X
Carbohydrate	Kernel damage	0.974*	Y = -1.783 + 0.0606 X
Content	Weight loss	0.979*	Y = -0.069 + 0.077 X
Oil content	Kernel damage	0.985*	Y = 0.973 + 0.124 X
	Weight loss	0.981*	Y = 4.506 + 0.157 X

r = Correlation coefficient; * = Significant at 1 per cent

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Biology of Drumstick Pod Fly, *Gitona distigma* (Meigen)

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***Abstract*:** The biology of drumstick pod fly *Gitona distigma* (Meigen) was carried out in the Bio-control laboratory, UHS, Bagalkot during 2012-2013. Incubation period varied from 2 to 3 (2.90) days under laboratory condition. The average duration of total maggot was 16.00 days. The pupal period was 7.7 days. Fecundity was 200 to 230 eggs.The total life cycle from egg to adult emergence was 28.20 days and took 35.6 days to complete total life span.

Key Words: Drum stick, Incubation period, Life cycle, Pod fly

Moringa *(Moringa oleifera* Lamk.), popularly called as the drumstick, an indigenous vegetable, has gained importance due to its nutraceutical values. It is considered now a days as an indispensable plant for health management. The drumstick pod fly, *G. distigma*, a palaearctic species has been reported for the first time from India on drumstick (Ragumoorthi and Subba Roa, 1997). This pest is reported to cause up to 70 per cent loss under poor management conditions (Ragumoorthi and Arumugum, 1992). To manage the pest effectively, studies on the weak links in its biology are helpful. Hence the present investigation was undertaken, at the University of Horticultural Sciences, Bagalkot to study the detailed biology of the pod fly.

The biology of drumstick pod fly was carried out in the Bio-control laboratory, UHS, Bagalkot during 2012. To study the biology of drumstick pod fly, the homogeneous culture was developed by collecting the pods with gummy exudation, a unique symptom of infestation by pod fly, from the field and multiplying them by following the standard rearing techniques in the laboratory as indicated by Ragumoorthi and Balasubramani (2001). The plastic trays of size 28 x 21 x 12 cm were used for this purpose which were provided with solar sterilized fine soil at the bottom for facilitating pupation and covered with muslin cloth held tightly with the help of string. To keep the pods fresh, wet cotton was wrapped on each pod at the petiole end. They were observed twice every day. Once the maggots pupated, such pupae were collected from the soil and were kept in test tubes (15 x 6cm) with mouths covered by muslin cloth for adult emergence. After emergence of adults, 10 per cent honey solution was provided as food. For further oviposition by the flies, fresh tender pods were provided every day, releasing only one pair per container for recording the fecundity. Considering the concealed nature of the pest, the biology was studied by adopting destructive and non-destructive sampling methods.

The freshly laid eggs were white and cigar shaped and were glued in between grooves of the tender pods. In field conditions, cigar shaped eggs were laid singly and also in small groups both on tender and matured pods. The size of eggs varied from 1.0 to 1.2 mm in length and 0.1 to 0.2 mm in breadth (Table 1). Incubation period varied from 2 to 3 (2.90) days in laboratory conditions of 28-35º C temperature and 50-70% relative humidity (Table 2). According to Ragumurthi and Balasubramani (2001) the incubation period varied from 2.03 to 2.66 days and fecundity was 53.90 to 62.70 eggs per female. In the present study the fecundity was 200 to 230 eggs which may be attributed to the preference of the host (Variety Bhagya of drumstick) by the pod fly and also difference in the agroclimatic conditions. Immediately after hatching from the eggs, larvae were creamy white in colour and they were apodus (maggots) and finally pupated in the soil. The length of newly hatched maggots varied from 0.3 mm to 0.5 mm and breadth was 0.1 mm to 0.3 mm. Maggots were observed to remain on the pod without movement for about 4-5 hours. The total maggot period was 16.00 days. Ragumoorthi and Balasubramani (2001) indicated total maggot period vary 15.29 to 26.70 days. The fully developed maggot came out from the pod and became sluggish and stopped feeding. It measured 7.5 to 8 mm in length and 1 to1.9 mm in breadth.

The pupa was coarctate, brown when freshly formed and later on turned to deep brown. Pupa measured about 4.0 to 4.2 mm in length and 2.0 to 2.3 mm in breadth (Table1). The pupal period was 7.7 days (Table 2). According to Ragumoorthi and Balasubramani (2001) the pupal period was 9.68 to 15.77 days. The adults lived for 6 to 7 days with

Table 1. Measurements (mm) of pod fly stages

Stages	Eggs		Maggots																	
			1st		3rd		7th		8th		10th		14th		16th		Prepupa		Pupa	
Parameter	L	B	L	B	L	B	L	B	L	B	L	B	L	B	L	B	L	B	L	B
Min	1.0	0.1	0.3	0.1	2.8	0.3	5	1	5.3	0.9	6.3	1.3	7.5	1	4.8	1.7	4.0	1.9	4.0	2.0
Max	1.2	0.2	0.5	0.3	3.1	0.5	5.4	1.3	5	1.4	6.6	1.6	8	1.9	5	2	4.2	2.0	4.2	2.3
Avg	1.1	0.1	0.4	0.18	2.94	0.41	5.16	1.14	5.14	1.1	6.46	1.44	7.76	1.64	4.9	1.88	4.1	1.95	4.1	2.15

L- Length B- Breadth

Table 2. Duration (days) of different stages of drumstick pod fly, *Gitona distigma* in the laboratory conditions (2013)

Incubation period	Total maggots period	Prepupal period	Pupal period	Adult longevity	Total life cycle *	Temperature	Relative humidity (%)
2.90 (2-3)	16 (15-17)	1.6 (1-2)	7.7 (7-8)	7.4 (7-8)	35.60 (32 38)	28-35	50-70

***** From egg to death of adult (28.20 days from egg to adult emergence) Figures in the parentheses are range values

food. The total life cycle of drumstick pod fly from egg to adult emergence was 28.20 days and took 35.6 days to complete total life span (Table 2). Ragumoorthi and Balasubramani (2001) observed the pod fly life cycle as 43.3 days. The variation in life cycle may be attributed to difference in the variety and climatic conditions.

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Host Range and Survival of *Cercospora canescens* Ell. and Mart. under Temperate Region of Jammu and Kashmir

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Abstract*: *The pathogenicity of Cercospora canescens, inciting leaf spot of greengram in Kashmir was host specific and host range was confined to blackgram and cowpea besides its natural host, the greengram. Incubation period was 6-7 days on Vigna sp. and 10 days on cowpea. While former exhibited uniform symptoms comprising of reddish brown roughly circular white centered spots, the later showed tan colour sub-circular to irregular spots devoid of whitish centre. The leaves and pods supported viable pathogen only upto March under open field conditions .

Key Words: Cercospora, greengram, perpetuation, survival, host range

Cercospora leaf spot (CLS) caused by *C. canescens* is most common and destructive disease in most *Vigna* growing areas in India (Singh and Gurha, 2007**).** In greengram, it inflicts heavy yield losses ranging from 23 to 96 per cent under natural epiphytotic conditions (Kaur, 2007). Keeping in view the importance of greengram present investigation was undertaken to reach a meaningful management programme.

Host range of *Cercospora canescens* : Seven different plant species were tested under green house conditions (28±2 ^{o}C and RH 85±5 %) for their response to the greengram isolate, *C. canescens* during May-June.).. Seeds of each test plant were direct-seeded into garden soil in plastic pots (200 inch^{-3}) andthere were three pots of each test plant arranged randomly with three plants per pot. The plants were inoculated 40 days after sowing while using a uniform spore suspension prepared afresh from young axenic culture and adjusted to 1000-2000 conidia ml^{-1} of sterile tap water (Sindhan *et al.,* 1999). A separate set of these test plant species was maintained under similar growth conditions which, however, were sprayed with sterile water instead of spore suspension. The plants were regularly observed up to 15 days after inoculation and the symptomatic leaves were detached for microscopic examination to confirm the cause of infection. The pathogen when re-isolated from allied hosts was inoculated onto the greengram to aid the host range confirmation. The time taken for manifestation of disease, i.e, incubation period, was also recorded.

Survival of *Cercospora canescens* : The symptomatic material was collected from diseased stands of greengram and kept in three different environments. The survival of *Cercospora canescens* was studied according to de-Nazareno, 1992 and Dhingra and Sinclair, 1985.

Host range of *Cercospora canescens*

Among these plant species, the pathogen colonized only blackgram and cowpea besides its natural host, greengram. Like other plant species, local cultivar of french proved non-host for *C. canescens* (Table 1). The data further shows that incubation period also varied with the host plant species. It was maximum (10 days) on cowpea as compared to 6 or 7days required on greengram and blackgram. The symptoms manifested by greengram and blackgram were alike and appeared as small dark brown dots of less than 1mm diameter which later turned into white centered reddish brown and roughly circular spots, typical of *C. canescens.* The disease symptoms produced by cowpea comprised of almost sub-circular to irregular spots with uniform tan colour and without whitish center. The pathogen when re-isolated from cowpea and blackgram caused leaf spots of greengram following inoculation under controlled conditions.

Survival of *Cercospora canescens*:

The data generated on indoor and outdoor experiments in this respect was found identical over years (Table 2). The plant parts supported pathogen throughout under controlled environment (inside room) as well as when subjected to partial (only post winter) open field conditions. In May the pathogen was not be recovered from the leaves which had totally disintegrated with only some veins left, and the pod husks which had become papery with only fibrous layer available, when exposed to complete open field conditions. The recovery of viable inocula was, therefore, affected by disintegration of plant debris (leaves and pod

Table 1. Host range of *C. canescens* causing leaf spot of greengram

Plant species	Reaction	Incubation period (days)	Remarks
Greengram	+	6-7	Appeared initially as small (0.5 -1mm diameter) dark brown dots and developed into characteristic reddish brown roughly circular spots with whitish center.
Blackgram	+	6-7	Spots similar to those on greengram.
Cowpea	+	10	Spots sub-circular to irregular with uniform tan colour and lacking whitish centers.
Chickpea, Pea, Soybean, Berseem, Beans	-		

+ and – signs represent host and non-host plant species, respectively

Table 2. Role of crop substrate vis-a-vis different environments in survival of *C. canescens*

Type of environment	Substrate	2010		2011	
		March (1st wk)	May (4th wk)	March (1st wk)	May (4th wk)
Inside room	Seeds	+	+	+	+
	Pod husk	+	+	+	+
	Leaves	+	+	+	+
Open field	Pod husk	+	-	+	-
	Leaves	+	-	+	-
Post winter open field	Pod husk	+	+	+	+
	Leaves	+	+	+	+

+ and – signs represent host and non-host plant species, respectively

husk) due to luxuriant growth of micro- and macro-organisms. The torrential rains, alternate drying and wetting of debris, and its subsequent distortion may have aided the process of disintegration under field conditions. The recovery of allied fungal species as affected by disintegration of diseased crop debris was also observed by de-Nazareno, 1992. The findings of Ahmad and Ahmad (2000) that conidia and mycelium of *C. canescens* survived in infected greengram seeds upto 8 months at room temperature and for prolonged period at storage temperature of 5 °C were almost similar to present observations. The present investigation, therefore, does not deny the availability of viable inocula under open field conditions though the leaves and pod husk failed to ensure inoculum for primary infection of *kharif* greengram. The results rather revealed that the primary inoculum was possibly produced during the favouring part of April and May which might have established on some unknown grass before main host was infected during August. Moreover, there was no sexual fruiting body associated with *C. canescens* under Kashmir conditions. It was, therefore, conclusive evidence that the fungus overwintered in all types of infected plant parts and infected seed served as the reliable and direct source of primary inoculum for subsequent infection of greengram in the following season and also the infected plant debris can serve the purpose if it reaches field during spring.

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Effect of Environmental Factors on Growth and Sporulation of Leaf Blight of Isabgol Pathogen

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Abstract: Effect of different temperature, pH levels, light intensity and media were tested against the growth and sporulation of *Alternaria alternata* causing leaf blight of Isabgol (*Plantago ovata*) under *in vitro* conditions. The maximum mycelial growth (89.00mm) and sporulation of *A. alternata* was observed at 25°C temperature and pH at 6.5 with maximum mycelial growth (855mg) and sporulation. The exposure of the light to fungus, maximum mycelial growth (80mm) and sporulation was observed at 100 Lux. Among the different media tested, it can be concluded that potato dextrose agar medium was most preferable for growth (86.00mm) and very good sporulation of *Alternaria alternata*.

Key Words: *Alternaria alternata*, Temperature, Light intensity, pH, *Plantago ovata*

Psyllium plant scientifically known as *Plantago ovata* has gained importance as a traditional medicine throughout the world due to its best medicinal properties. Locally known as Isabgol or Isabhghula recently it has gained agricultural importance because of its wide use in pharmaceutical, cosmetics and food grade industries worldwide. Mandal (2010) reported that a number of pathogens of Isabgol. *Alternaria* blight has become a serious problem in recent years and causes considerable damage every year and sometimes become very severe which results in total loss of yield. Hence, present investigations were carried out to effect of environmental factors on growth and sporulation of leaf blight of Isabgol pathogen.

The studies were conducted with a view to determine the optimum range of temperature for mycelial growth and sporulation of *Alternaria alternata*. The PDA plates were inoculated with 5 mm disc from one week old pure culture. Three plates for each treatment were kept at different temperatures *viz.,* 5, 10, 15, 20, 25, and 30°C incubators. The observations were recorded by measuring the diameter (Radial growth) of the colony of the fungus. The sporulation was measured by taking 1 cm^2 bit from the mycelial growth from each treatment and dissolved in 10 ml sterile distilled water in test tube. The spore load was observed in each treatment under microscope taking 10 observations and counting of conidia. The average number of conidia was considered in each treatment and designated very good: ++++, Good: +++, Fair: ++, Poor: + and – for no conidia formed.

In order to find out the optimum pH levels for the mycelial growth and sporulation of the test pathogen, potato dextrose broth was adjusted with pH ranges between 4.0 to 9.0 with a narrow fraction of 0.5. The liquid medium was adjusted to these levels by using buffers N/10 HCL and N/10 NaOH solutions. The pH was determined by precise pH indicator papers (Li *et al.* 1998) or Pen type digital pH meter. In each conical flask (100 ml), 20ml medium was poured and sterilized in an autoclave as stated earlier. These flasks were then inoculated with inoculum derived from 7 days old culture of *Alternaria alternata*. These inoculated flasks were then incubated at 25± 1° C. The growth in media in each replication was filtered taking What man No. 1 filter paper and prior to this weight of empty paper was recorded. After filtering the growth, the filter paper with mycelia were folded and kept in oven for drying at 40± 2° C. After complete drying these were weighed again. Each treatment was replicated thrice. The dry mycelial weight obtained through this was presented as results.

An experiment was carried out to know the effect of different light intensities on the mycelial growth of *Alternaria alternata*. Inoculated Petri plates were incubated under different wavelength of light *viz.*, 100, 125, 154, 176 and 220 Lux. The intensity was measured by putting different numbers of fluorescent light in lab and taking observations of light intensity by Lux meter to have the range of intensities. The observations were recorded by measuring the linear colony diameter of mycelial growth in mm after seven days of inoculation.

In order to find out a suitable medium for growth and sporulation of *Alternaria alternata,* the five different semi-synthetic and synthetic medium i.e. Asthana and Hawker's ,Czepek-Dox, Potato Dextrose, Richards' and Sabouraud's medium were used. The pH of all the media prepared was adjusted to 6.5 before adding agar. Each treatment (medium) under study had three replications. The growth was recorded by measuring colony diameter along two diagonals passing through the centre of the colony and the average was considered for presentation as results.

Effect of temperature: Maximum mycelial growth (89.00 mm) and very good sporulation was observed at 25ºC (Table1). However, the temperatures of 20ºC and 30ºC resulted in 76.00 mm and 72.00 mm mycelial growth with good sporulation of *Alternaria alternata* respectively, but differ significantly from the growth at 25ºC. No mycelial

growth and sporulation was observed at 5 ºC temperature at 7th day after incubation. It can be concluded that 25ºC is the optimum temperature for mycelial growth and sporulation of *Alternaria alternata*. The same optimum temperature was recorded by Ma-Guillong *et al.,* 2006 and Bochalya, 2010.

Effect of pH: Good growth was recorded at pH 5.0 to 6.5 i.e. 755 mg to 855 mg and it was maximum at pH 6.5 (Table 2). However, the growth decreased sharply at low and high pH i.e. at 4.0 - 405.5 mg and pH 9.0 – 170 mg which are two extremes. Sporulation occurred at pH between 6.0 and 6.5 while there was no sporulation at pH 8.5 and 9.0. The result indicates that the fungus grew on a wide range of pH from 4.0 to 9.0 but maximum growth was occurred at pH 6.5. This level of pH is supported by various other workers who carried out studies on *A. alternata* causing leaf blight on different crops (Maheshwari *et al*. 2000; Hubballi *et al*. 2010).

Table 1. Effect of different temperature on growth and sporulation of *Alternaria alternata in vitro* on PDA

Temperature (°C)	Mycelial growth in diameter (mm*)	Sporulation
5	0.00	-
10	45.00	+
15	62.00	++
20	76.00	+++
25	89.00	++++
30	72.00	+++
	CD (p=0.05) 4.50	
	CV% 5.35	

- = Nil, + = Poor, ++ = Fair, +++ = Good, ++++ = very good

Effect of light: The fungus could grow at all the light intensities i.e. 100 to 220 Lux at 7th day after inoculation and incubation at 25 ± 1 ºC (Table 3). Maximum mycelial growth 80.00 mm and sporulation was observed at 100 Lux followed by 125, 154 and 176 Lux. Minimum growth of the fungus i.e.44.00 mm and no sporulation was observed at 220 Lux. It can be concluded that 100 Lux was found to be optimum light intensity for mycelial growth and sporulation of *Alternaria alternata.* This indicates that *A. alternata* does not need much light for mycelial growth and sporulation. Similar results was observed by Bochalya (2010) found maximum mycelial growth and sporulation in total darkness for *Alternaria alternata*.

Table 2. Effect of different pH on growth and sporulation of *Alternaria alternata in vitro* on potato dextrose broth media

pH	Average dry mycelial weight (mg*)	Sporulation
4.0	405.50	+
4.5	730.00	++
5.0	755.00	+++
5.5	777.00	+++
6.0	840.00	++++
6.5	855.00	++++
7.0	608.00	++
7.5	560.00	+
8.0	310.00	+
8.5	205.00	-
9.0	170.00	-
	CD (p=0.05) 44.89	
	CV% 4.69	

- = Nil, + = Poor, ++ = Fair, +++ = Good, ++++ = very good

Effect of synthetic and semi-synthetic media: Among five different media, potato dextrose agar was significantly superior in supporting maximum mycelial growth at 7th days after inoculation (86.00 mm) and sporulation than other media, followed by Richard's medium and Czepek-dox media (Table 3). Minimum growth of the fungus was observed on Asthana & Hawker's i.e. 62.00 mm with poor sporulation at 7th days after incubation. Similar results were obtained by Gorwar *et al*. (2006), and Israram *et al.* (2007) that *Alternaria alternata* fungus grew well on potato dextrose agar.

Table 3. Effect of different light intensities on mycelial growth and sporulation of *Alternaria alternata in vitro on PDA*

Light intensities (Lux)	Radial mycelial growth (mm*) after 7 Days	Sporulation
100	80.00	+ +++
125	72.00	+++
154	65.00	++
176 Lux	55.00	+
220	44.00	-
	CD (p=0.05) 3.235	
	CV% 3.36	

- = Nil, + = Poor, ++ = Fair, +++ = Good, ++++ = very good

Table 4. Effect of different synthetic and semi-synthetic media on mycelial growth and sporulation of *Alternaria alternata in vitro*

Medium	Radial mycelial growth (mm*) after 7 Days	Sporulation
Potato dextrose agar	86.00	++++
Richards' medium	80.00	+++
Czepek – dox media	70.00	+++
Sabouraud's media	66.00	++
Asthana & Hawker's	62.00	+
	CD (p=0.05) 4.78	
	CV% 4.46	

+ = Poor, ++ = Fair, +++ = Good, ++++ = very good

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Correlation and Path Coefficient Analysis in Seed Yield Traits of Rice Bean in [*Vigna umbellata* (Thumb) Ohwi and Ohashi] in North Western Hills

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Abstract: The nature and magnitude of association among eight characters and their contribution towards seed yield was carried with twenty five genotypes of ricebean. Seed yield per plant showed positive and significant association with100-seed weight, pod length, seeds per pod and pods per plant. Path coefficient analysis revealed that maximum positive direct effects were exerted by pod per plant followed by 100-seed weight, pod length and seeds per pod towards seed yield per plant. Based on correlation and path analysis, number of pod per plant, 100-seed weight, pod length and seeds per pod were identified as the most important components of seed yield. This suggested that prominence should be given to these traits in selection programme for improvement of seed yield in ricebean.

Key Words: Genotypic correlation, Path coefficient analysis, Phenotypic correlation, Ricebean

Ricebean is one of the summer legumes grown under diverse conditions ranging from marginal lands to rainfed and drought prone areas. The approaches to make significant genetic improvement in ricebean need information on nature and magnitude of genetic variation in quantitative characters and their inter-relationship in population comprising diverse genotypes. The information about interrelationship between the yield and yield components facilitates the choice of suitable breeding method to be applied and selecting the parents for improving the crop. The knowledge of the interrelationship of grain yield with other important characters is necessary to determine which of these characters could be used for high grain yield. Correlation coefficient has been employed for this purpose. However, the correlation coefficient between two characters does not necessarily imply a cause and effect relationship. The inter-relationship could be grasped best if a coefficient could be assigned to each path in the diagram designed to measure the direct influence among them. Path coefficient analysis is a statistical technique of partitioning the correlation coefficients into its direct and indirect effects, so that the contribution of each character to yield could be estimated. Therefore, the present investigation was undertaken to find out the correlation and path coefficients of ricebean genotypes and identify the promising ones for important yield traits. .

Twenty-five germplasm lines of ricebean collected from different areas of Himachal Pradesh were raised in a randomized complete block design with three replications during *kharif*-2011 and 2012, in the experimental farm of Department of Organic Agriculture, CSKHPKV, Palampur, during *kharif* season. Each entry was represented by the row of 4.5 m length spaced at 30cm between the rows and 10 cm between the plants within the row. The basal dose of 25 kg N and 50 kg P_2O_5 per hectare was applied at the time of sowing. Recommended cultural practices were adopted to maintain a healthy crop growth (Dua *et al*., 2009). Data were recorded on various parameters (Table 1). Correlation coefficients and path coefficients were computed with standard methods (Al Jibouri *et al*., 1958 and Dewey and Lu, 1959).

The association analysis indicated significant positive correlation of 100-seed weight, pod length, seeds per pod and pods per plant with seed yield in both the years (Table 1). It indicates that genotypes having higher values for these traits will produce more seed yield. These findings were in agreement with the findings of Dodake and Dahat (2011) and Dash (2012). So improvement in seed yield is possible by taking above characters as criteria in selection scheme. The correlation of plant height and branches was of very low magnitude indicating absence of any influence of this character on seed yield whereas days to maturity showed significant negative correlation with seed yield.

The path analysis based on phenotypic correlation coefficient (Table 2) showed that pod per plant had highest positive direct effect followed by 100-seed weight, pod length and seeds per pod while plant height had moderate positive direct effect on seed yield. These results were in broad agreement with reports of Dodake and Dahat (2011). The correlation estimates of pods per plant, seeds per pod, pod length and 100-seed weight with seed yield were largely explained by their higher direct effect as well as high indirect effects via other traits. In 100-seed weight the significant positive correlation with yield was attributed to the high direct effect as well as the high indirect effect via pods per plant and seeds per pod. Likewise in pod length the high positive correlation with yield was due to high direct as well as indirect effect via branches per plant. For seeds per pod indirect effect via pods per plant was one of the main contributing factors towards the significant positive correlation with yield (Patyal, 2008). The significant negative association of days

Table 1. Phenotypic correlation coefficients among different yield traits in ricebean

Parameters	Days to flowering	Days to maturity	Branches/ plant	100 -seed weight	Pod length	Seeds /pod	Pods/ plant	Yield
Plant height	0.180	0.027	-0.191	-0.149	0.160	-0.110	-0.044	0.045
	0.011	-0.315*	0.032	-0.247 *	0.042	0.075	0.038	0.062
Days to flowering		0.309 *	0.288 *	0.113	0.131	-0.074	0.107	0.048
		0.194	0.001	0.110	-0.122	0.319 *	0.518*	-0.115
Days to maturity			-0.125	0.006	0.120	-0.056	0.092	-0.243 *
			-0.022	-0.012	-0.099	0.109	0.191	-0.291 *
Branches/plant				0.166	-0.242 *	0.016	0.098	0.122
				-0.061	-0.022	-0.186	-0.024	0.124
100 -seed weight					0.064	0.477 *	0.527*	0.652*
					0.021	0.333 *	0.182	0.426*
Pod length						0.139	0.181	0.242*
						0.085	0.013	0.262*
Seeds/pod							0.636*	0.705*
							0.699*	0.652*
Pods/plant								0.882*
								0.714

Significant at 5% level I: First year II: Second year

Table 2. Estimation of direct and indirect effects of yield and its components in ricebean

Parameters	Plant height	Days to flowering	Days to maturity	Branches/ plant	100 -seed weight	Pod length	Seeds /pod	Pods/ plant	Correlation with yield
Plant height	0.125	0.001	0.003	0.003	-0.035	0.019	-0.044	-0.027	0.045
	0.115	0.011	0.012	0.006	0.010	-0.075	-0.032	0.015	0.062
Days to flowering	0.002	0.078	-0.005	-0.114	0.027	0.010	-0.016	0.066	0.048
	-0.001	-0.065	-0.006	-0.192	0.056	0.043	-0.016	0.066	-0.115
Days to maturity	-0.004	-0.024	0.008	-0.056	-0.141	-0.014	0.012	-0.027	-0.243 *
	0.130	0.042	0.001	-0.010	-0.135	0.293	-0.002	-0.124	-0.291 *
Branches/plant	-0.024	0.047	-0.002	-0.015	0.063	-0.026	0.018	0.061	0.122
	-0.125	0.112	-0.015	0.024	0.120	-0.165	0.158	0.005	0.124 *
100 -seed weight	-0.019	0.009	0.005	-0.004	0.236	-0.006	0.104	0.327	0.652 *
	-0.012	0.012	0.124	-0.008	0.321	-0.535	0.214	0.310	0.426
Pod length	0.024	0.007	-0.039	0.495	-0.001	0.264	-0.373	-0.135	0.242 *
	0.126	0.120	-0.158	0.354	0.092	0.262	-0.320	-0.214	0.262 *
Seeds/pod	-0.014	-0.006	0.001	-0.001	0.112	0.001	0.218	0.394	0.705 *
	-0.039	-0.067	0.110	0.004	0.212	0.015	0.119	0.298	0.652 *
Pods/plant	-0.006	0.008	-0.002	-0.002	0.124	0.010	0.130	0.620	0.882 *
	-0.013	0.025	0.004	-0.014	0.110	0.033	0.045	0.524	0.714 *

I: First year II: Second year

to maturity with yield was the result of high negative indirect effect via 100-seed weight. These results were in agreement with Lokesh *et al*. (2003)

Path analysis revealed that number of pods per plant had high direct effect; therefore simple selection for this character would be useful to maximise seed yield. Considering all the aspects together it is apparent from path analysis that maximum effects as well as appreciable indirect influences were exerted by pod per plant, 100-seed weight, pod length and seeds per pod towards seed yield per plant. These characters also exhibited significant and positive association with seed yield per plant. Hence, they may be considered as the most important yield contributing characters and appropriate prominence should be placed on these components while breeding for high yielding types in rice bean.

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Assessment of Strength of Self-incompatibility in S-allele Lines of Cabbage (*Brassica oleracea* var. *capitata* L.)

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***Abstract*:** The present investigation deals with assessing the strength of self-incompatibility in the seeds of S-allele lines (I-4-6 and II-12-4-7) produced through temporary breakdown of self-incompatibility (SI) with the use of sodium chloride (NaCl) solution. The S-allele lines were raised from the seeds produced after NaCl solution sprays followed by manual pollination of freshly opened flowers during 2009-10. The pollinations *viz.* BP (selfing in bud stage) and OP (selfing in freshly opened flowers) were carried out manually in the test plants enclosed with insect proof nylon nets for testing their strength of self-incompatibility (SI) during 2010-11. Seed-set was recorded in BP on all the test plants confirming the viability of male and female gametes. However, no seed-set was recorded in OP treatments in each of flowering regimes *viz*. 25-50 per cent, 50-75 per cent and more than 75 per cent flowering, on the plants of S-allele lines, raised from OP seed obtained with 3 % and 5 % NaCl solution sprays. The S-allele lines, I-4-6 and II-12-4-7 were proved stable for their strength of self-incompatibility, since no seed-set was recorded in any of the OP treatments whereas variable numbers of seeds were obtained in BP treatment. This implies that NaCl sprays lead to breakdown of self-incompatibility temporarily.

***Key Words*:** Cabbage, NaCl, Self-incompatibility, Stability, Pollination

Hybrids are preferred over the open pollinated varieties because of their advantages like uniform maturity, high yield and better resistance to pest and diseases and adaptability to unfavourable weather conditions. The genetic phenomenon of sporophytic self incompatibility (SSI) and cytoplasmic male sterility (CMS) in cole crops have been proved effective in the production of hybrid seed on commercial scale. In India, the hybrids of cabbage developed in public sector through the use of SSI and CMS are KGMR-1, KGMR-5, KTCBH-51 and KTCBH-84, H-64 respectively (Anonymous, 2011). Although, sporophytic self-incompatibility system was confirmed in cabbage by Adamson (1965), but the methods of seed production by utilizing self-incompatible parental lines had been suggested by Odland and Noll much earlier in 1950 (Singh *et al.,* 2009). In 1950, Nagaoka No 1 which was the first cabbage hybrid in the world was developed using self incompatible lines in Japan. So far majority of cruciferous hybrid cultivars have been created by means of SI (Kucera *et al.* 2006). For the continuous production of hybrid seeds, maintenance of S-allele lines is one of the basic requirements. In order to make use of the genetic mechanism of self-incompatibility for the production of hybrid seeds, a few S-allele lines have already been developed in low chill requiring genotypes of cabbage at CSKHPKV, Palampur. The S-allele lines *viz.* I-4-6 and II-12-4-7 were maintained by NaCl solution sprays followed by manual pollination in open flower stage (Liao, 1995). Although the effective method of assessing the SI in S-allele lines is not investigated in India yet. So an effort has been made in present investigation for assessing the strength of self-incompatibility in the S-allele lines produced through temporary breakdown of self incompatibility with the use of sodium chloride (NaCl) solution.

An experiment was conducted at the department of vegetable science and floriculture, CSK HPKV Palampur during 2010-11. The seeds of S-allele lines of cabbage *viz.* I-4-6 and II-12-4-7 obtained during 2009-10 as a result of NaCl solution sprays (3% and 5%) followed by manual self pollination in freshly opened flowers were used to assess the strength of self-incompatibility during 2010-11. During 2009-10, the S-allele lines were maintained by three sprays of NaCl solutions at 15-20 % flowering subsequently after every four days respectively. The pollinations OP (selfing in freshly opened flowers) and BP (selfing in bud stage) were started after one day of spray to four days of spray. The S-allele lines were also maintained through manual sibmating in bud stage i.e. green bud pollination (Kaminski, 2013). The seeds of the S-allele lines obtained with NaCl solution sprays in open flower stage were then sown in the nursery beds during September, 2010 followed by transplanting on 1st fortnight of October, 2010 at 60 X 45 cm spacing. All the recommended package of practices was followed to ensure the proper growth of plants (Thamburaj and Singh, 2005). Cross cuts to heads were given from 2nd fortnight of February to early March so as to hasten the bolting. The plants were enclosed with the insect proof nylon net enclosures to prevent out crossing by pollinators. The OP and BP pollinations were carried out during three flowering regimes *viz.* 25-50 per cent, 50-75 per cent and > 75 per cent flowering. Average number of seeds per siliqua in each treatment were counted and recorded.

All the plants set seeds in BP treatment during

2009-10, confirming the viability of male and female gametes of the test plants. With the one spray of 3 % NaCl solution in the S-allele line I-4-6, seed-set in OP treatment was recorded only when the pollinations were carried out one day after spray (0.56 seeds / siliqua). With two sprays of 3 % NaCl solution seed-set in OP treatment was obtained when the pollinations were carried out two days after spray (0.16 seeds / siliqua), 3 days after spray (0.03 seeds / siliqua) and 4 days after spray (0.13 seeds / siliqua). No seed-set in OP treatment was noted in any of the plants which had been given 3 sprays of common salt (Table 1). With one spray of 5 per cent common salt (NaCl) seed-set in OP treatment was recorded only when the pollinations were carried out one day after spray (0.10 seeds / siliqua). Similarly with two sprays of 5 per cent NaCl solution some seed-set in OP treatment was obtained (0.43 seeds / siliqua) only when the pollinations were carried one day after spray. With three sprays of 5 per cent common salt no seed-set was obtained in OP treatment on any of the plants when the pollinations were carried out up to 4 days after spray. Erratic seed-set was recorded in OP treatments after common salt sprays (3 % and 5 %) may be attributed to long time lag between spray and pollinations and also to relatively lesser quantity (25 ml / plant) of NaCl solution sprayed on to the test plants of the S-allele lines. The present findings are not in accordance with Fu *et al.* (1992) who had reported higher compatibility index than the control (no spray) in the self-incompatible plants of *Brassica napus* even up to 120 hours of common salt spray. The results shows variation with the earlier findings of Kucera (1990), Kucera and Cerny (1991) who had succeeded in maintaining the self- incompatible plants/lines of cauliflower and kohlrabi respectively, with sodium chloride (3 %) solution sprays when pollinations were carried out 0.5-1.0 hour before or after NaCl spray.

In the S-allele line II-12-4-7 seed-set was recorded only with two sprays of 3% NaCl in the OP treatments when the pollinations were carried out one day after spray (1.20 seeds / siliqua) (Table 1). With one spray of 5 per cent NaCl solution in the S-allele line II-12-4-7, only 0.89 seeds / siliqua were obtained in OP treatment, when the pollinations were carried out one day after spray. No seed-set in OP treatment was noticed in any of the plants which had been given two sprays and three sprays of 5 per cent NaCl solution (Table 1). The reason of getting practically low seed-set in OP treatments on the S-allele line II-12-4-7 despite NaCl solution sprays could be due to the presence of stronger S-allele in this line as compared to the S-allele line I-4-6. Also the S-allele line II-12-4-7 was late in flowering as compared to S-allele line I-4-6 and hence the higher temperature during the flowering could be the reason to get practically low seed set in S-allele line II-12-4-7. The findings are in accordance with Liao (1995), who observed that the number of seeds produced per pod per plant depends upon the degree of inbred line and degree of incompatibility. The findings are also in accordance with Zur *et al.* (2003) who observed that high temperature halved the percentage of fertile siliques in

Table 1. Average number of seeds/siliqua in OP and BP after 3% and 5 % spray of NaCl solution in the S-allele lines I-4-6 and II-12-4-7 (2009-10)

Conc. →	3 %								5 %				
No. of sprays ↓	1 DAS		2 DAS		3 DAS		4 DAS		1 DAS		2 DAS	3 DAS	4 DAS
	OP	BP	OP	BP	OP	BP	OP	BP	OP	BP	BP	BP	BP
S-allele line I-4-6													
1	0.56	4.96	0.00	1.38	0.00	1.34	0.00	1.80	0.10	1.97	1.38	2.33	2.48
2	0.00	2.11	0.16	2.71	0.03	3.16	0.13	1.84	0.43	1.05	1.31	1.44	1.14
3	0.00	3.27	0.00	1.67	0.00	1.51	0.00	1.05	0.00	1.55	1.32	1.64	2.11
S-allele line II-12-4-7													
1	0.00	1.45	0.00	1.52	0.00	1.68	0.00	1.85	0.89	1.47	2.21	1.45	2.35
2	1.20	1.29	0.00	1.75	0.00	1.34	0.00	1.43	0.00	1.36	1.50	1.47	1.40
3	0.00	1.22	0.00	1.25	0.00	1.40	0.00	1.03	0.00	1.28	1.11	1.13	1.16

OP – Self pollination in open flower stage, BP – Self pollination in bud stage
DAS- Days after spray
Note: No seed set in OP treatment 2DAS, 3DAS and 4DAS with 5% NaCl spray in both the S-allele lines I-4-6 and II-12-4-7

Table 2. Average number of seeds/siliqua in OP and BP in the plants (2010-11) rose from the seed produced through 3% and 5% common salt solution in open flower stage (2009-10) in the S-allele lines I-4-6 and II-12-4-7

Flowering regime →		25-50%	50-75%	>75%
Spray no ↓	DAS ↓	BP	BP	BP
		S-allele line I-4-6		
One 3%,	1	7.02	3.92	6.31
Two 3%,	2	4.16	4.16	3.86
Two 3%,	3&4	7.12	4.85	3.14
One 5%,	1	2.50	2.50	3.10
Two 5%,	1	2.55	3.15	3.75
		S-allele line II-12-4-7		
Two 3%	1	3.52	2.98	5.11
One 5%	1	2.10	1.52	1.86

OP – Self pollination in open flower stage, BP – Self pollination in bud stage, DAS- Days after spray
Note: No seed set in OP treatment in all the flowering regimes in the S-allele lines I-4-6 and II-12-4-7

cabbage in green bud pollination.

During the experimental year 2010-11 the S-allele lines (I-4-6 and II-12-4-7) were tested for their strength of self-incompatibility (Tables 2). All the plants set seeds in BP treatment confirming the viability of male and female gametes of test plants. However, no seed-set was observed in OP treatments in each of flowering regimes i.e. 25-50 per cent, 50-75 per cent and more than 75 per cent flowering, in any of the test plants in both of the S-allele lines *viz.* I-4-6 and II-12-4-7.

Plants tested for their strength of self-incompatibility (2010-11) proved stable for self-incompatibility since no seed-set was obtained in any of the OP treatments whereas variable numbers of seeds were obtained in BP treatment. This implies that NaCl sprays led to breakdown of self-incompatibility temporarily.

This study indicates that S-allele lines can be easily maintained by the use of NaCl solution sprays (3% and 5%) followed by manual self pollination in freshly opened flowers. The S-allele lines were found stable for their strength of self-incompatibility, since no seed-set was recorded in the OP (selfing in open flower stage) treatments in any of the tested plants. The use of common salt (NaCl) solution sprays resulted temporary breakdown of self-incompatibility in the S-allele lines of cabbage, which will have lot of implications in the maintenance of S-allele lines, which are to be used for hybrid seed production. In future this technique can be tested in other crops and further standardization will lead to cost effective, easy method for maintenance of S-allele lines in cole crops.

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Evaluation of Turmeric (*Curcuma longa* L.) Cultivars under Hill Zone of Karnataka

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***Abstract*:** Cultivar Kanti recorded highest plant height and number of tillers, CLT-325 maximum leaf area and leaf area index at 180 days after planting. The maximum fresh rhizome yield was in Kanti (21.34 t ha^{-1}) followed by Rajapuri, CLT-325 and PTS-24. Significant variations were observed for curing percentage among different cultivars. Highest curing percentage was in Kanti followed by PTS-24, CLT-325, Alleppey and Swarna. Kanti recorded highest cured yield 5.59 t ha^{-1}, which is on par with CLT-325 and PTS-24. With respect to curcumin content cultivar PTS-24 (7.23 %) was found superior followed by Kanti (7.13 %) and were on par with each other. Considering the better performance in terms of growth, yield and quality the cultivars Kanti, CLT-325, and PTS-24 are identified as promising suitable cultivars for rain fed condition under hill zone of Karnataka.

***Key Words*:** Turmeric, Leaf Area Index, Yield, Curing percentatage, Cured yield, Curcumin content

In Karnataka, turmeric is being cultivated on an area of 15,320 hectare with an annual production of 93817 million tonnes of fresh turmeric. The Hilly Region of Karnataka comprising of Chickmagalur, Part of Belgaum, Uttar Kannada, Hassan and Shimoga are important districts growing turmeric on an area of 1655 ha which accounts more than 10.8 per cent of the state's area under turmeric (Anon., 2009). In Malnad (Hilly Region) the crop is mainly cultivated under rainfed conditions, taking the advantage of high rainfall, better distribution from June to October. The residual moisture in the soil and availability of irrigation facilities are limited during rest of the months. Therefore, grower needs a suitable high yielding short duration turmeric variety so as to harvest the crop before depletion of moisture in the soil and commencement of summer. Hence, it is very much necessary to collect and evaluate all the available cultivars in order to select suitable and high yielding cultivars for hilly region condition. Considering the importance of the turmeric, this research was conducted to find out the suitability of different cultivars for this region.

The field experiment was carried out at College of Horticulture, Mudigere, during 2011-12. Nineteen turmeric cultivars were evaluated for their performance, in randomized complete block design with three replications in open field condition. Each replication was represented by 5 rows of 2.7m length and the spacing was 30 cm between rows and plants, the net plot size was 1.2 m 2.4 m. Healthy and diseased free uniform sized fingers of 15 g with well developed buds were selected for planting. Recommended package of practices and plant protection measures were followed to raise a healthy crop (Venkatesh 1994). Protective irrigations were given at an interval of 7-10 day, after monsoon, depending upon the weather and soil moisture conditions. The curing percentage was worked out after curing and drying of the fresh turmeric. For curing one kilogram of whole finger rhizomes were used. The samples were boiled for 45 to 60 minutes and then sun dried for eight to ten days. The dry weight was recorded after sun drying and curing percentage was worked using following formula.

$$\text{Curing percentage} = \frac{\text{Dry weight of rhizome after curing (kg)}}{\text{Fresh weight of rhizome (kg)}} \times 100$$

The curcumin content was estimated by adopting the method given by Manjunath *et al.,* (1991). Cured rhizomes were grind to the fine powder and 0.1 g of grind powder was mixed with 40 ml of alcohol and was kept for 2 hr 30 minutes. Then the extract was transferred to a 100 ml volumetric flask and volume made with alcohol. Later, it was filtered and then an aliquot of 5 ml was transferred into a 100 ml volumetric flask, made the volume with alcohol and mixed the aliquot thoroughly. The absorbance of solution was measured at 425 nm against alcohol blank. Using absorbance value of standard solution, curcumin content was calculated by adopting the following formula.

$$\text{Curcumin content} = \frac{0.0002 \;\; \text{abs. of sample} \;\; 100 \times 100}{\text{abs. of standard} \;\; \text{wt. of sample} \;\; 5}$$

The significant differences were in growth parameters of different cultivars of turmeric (Table 1). At 180 DAP, the plant height was significantly higher in Kanti (41.44 cm) and on par with CLT-325. The lowest plant height (24.33 cm) was observed in Alleppey Supreme. Kanti recorded highest number of tillers (5.83) followed by PTS-24 (5.60). The lowest number of tillers was in Suguna and on par with

Table 1. Performance of turmeric cultivars for growth under hill zone of Karnataka

Cultivars	Plant height (cm)	Number of tillers per plant	Leaf area (dm^2)	Leaf Area Index
Cuddapah	37.83	3.40	28.28	3.14
Kedaram	36.42	3.37	11.80	1.31
Prabha	28.73	2.67	9.23	1.02
Suguna	27.53	2.40	10.40	1.15
CLT-325	40.77	4.63	38.52	4.28
Salem	36.61	3.61	24.52	2.72
Rajapuri	36.47	4.73	25.40	2.82
Varna	35.13	4.30	23.44	2.60
Alleppey Supreme	24.33	3.32	11.83	1.31
Alleppey	30.35	3.63	17.60	1.95
PTS-24	35.56	5.60	28.28	3.17
Swarna	32.45	4.50	13.10	1.45
Bidar-1	33.93	4.27	28.61	2.70
Prathibha	30.75	3.47	14.93	1.66
Belgaum Local	34.69	2.80	12.82	1.42
Sona	33.70	4.20	21.33	2.37
Bidar-4	31.37	3.40	23.37	2.60
Sobha	36.67	4.00	25.40	2.82
CD (p=0.05)	2.9	0.36	2.54	0.38

Prabha. CLT-325 showed maximum leaf area (38.52 dm^2) and leaf area index (4.28) followed by Kanti and PTS-24. Increase in leaf area helped in better synthesis of carbohydrates and their utilization for building up of new cells. Such variations in growth among different cultivars of turmeric were reported by several workers in turmeric grown under different agro-climatic regions (Kumar and Yadav 2001; Jagadish, 2000 and Anusuya, 2004).

The significant differences were observed with respect to number of mother rhizomes per plant, number of primary fingers per plant and number of secondary fingers per plant (Table 2). Maximum number of mother rhizomes, primary and secondary fingers were in Kanti followed by CLT-325. The minimum number of mother rhizomes, primary and secondary fingers were recorded in Suguna (1.36, 3.29 and 5.39 respectively). Among the different cultivars Rajapuri recorded maximum fresh weight (43.50 g) of the mother rhizome followed by PTS-24 (42.20 g). The lowest fresh of weight mother rhizome was in Prathibha (12.77 g). Kanti recorded maximum fresh weight of primary and secondary fingers (96.17g and 56.05 g respectively) followed by CLT-325. Maximum fresh weight of rhizome per plant was observed in Kanti (188.38 g/plant) fallowed by CLT-325. Highest fresh rhizome yield of these cultivars (Kanti, CTL-325) which could be attributed to the maximum plant height, number of tillers, leaves and LAI which are the important components of growth and had a positive and significant correlation with yield (Anusuya, 2004).

Highly significant variations were noticed for yield and quality parameters (Table 2). Maximum fresh rhizome yield was observed in Kanti (21.34 t ha^{-1}) followed by, Rajapuri, CLT-325 and PTS-24, while the lowest fresh rhizome yield was in Suguna (6.00 t ha^{-1}).

Recovery percentage (driage) is an important factor as the fresh rhizome is to be cured to obtain marketable turmeric. Highest curing percentage was recorded in Kanti (26.21 %) followed by PTS-24, CLT-325, Alleppey and Swarna. The lowest curing percentage was recorded by cultivar Sona and Cuddapah. Kanti recorded highest cured rhizome yield (5.59 t ha^{-1}) on par with CLT-325 and PTS-24, while the lowest cured rhizome yield recorded in Suguna (1.34 t ha^{-1}). Rao (1965) and Aiyadurai (1966) reported that variation in curing percentage was largely related to the varietal characters, genetic factors and environmental conditions under which they were grown and the similar variation in curing percentage was also reported by Pujari *et al.,* (1987) and Jadhao *et al.*, (2005). The variation in the cured rhizome yield is largely attributed to differences in the fresh rhizome yield as well as curing percentage. The cultivar PTS-24 was recorded superior curcumin content (7.23%), followed by Kanti, Sobha, CLT-325 and Salem. The least curcumin content was registered in Cuddapah (2.19%). Curcumin content of different cultivars varied due to genetic character of the cultivar.

Considering the better performance in terms of growth yield and quality, the cultivars *viz*., Kanti, CLT-325, and PTS-24 are identified as promising suitable cultivars for rain fed condition under hill zone of Karnataka.

Table 2. Performance of turmeric cultivars for yield and quality traits under hill zone of Karnataka

Cultivars	Mother rhizome		Primary fingers		Secondary fingers		Fresh rhizome		Cured yield (t ha^{-1})	Curing percentage (%)	Curcumin content (%)
	Number	Weight	No. /plant	Wt. (g)	No. / plant	Wt. per plant(g)	Weight (g plant^{-1})	Yield /ha (t)			
Kanti	2.00	41.30	6.30	96.17	9.23	56.05	184.29	21.34	5.59	26.21	7.13
Cuddapah	1.60	13.60	6.19	38.05	7.50	38.36	144.67	10.00	1.92	19.23	2.19
Kedaram	1.62	18.30	3.60	38.35	5.87	25.49	76.84	9.38	2.15	23.00	5.37
Prabha	1.46	17.13	3.47	38.41	5.55	23.80	68.40	8.88	1.97	22.21	5.30
Suguna	1.36	13.23	3.27	26.50	5.39	15.23	68.42	6.00	1.34	22.42	5.87
CLT-325	2.00	41.30	6.21	93.75	8.81	54.83	188.38	20.99	5.33	25.43	6.67
Salem	1.85	38.47	4.87	92.52	7.57	30.63	121.73	17.88	3.60	20.18	6.53
Rajapuri	1.86	43.50	5.76	91.47	8.65	53.02	128.97	20.04	4.23	20.37	4.33
Varna	1.67	36.60	5.13	79.93	5.80	45.50	89.33	17.97	3.46	19.30	6.20
Alleppey Supreme	1.37	15.70	3.53	36.77	5.48	22.01	68.07	8.45	1.90	22.52	5.87
Alleppey	1.64	15.20	3.75	39.53	6.17	19.60	72.33	8.20	2.07	25.35	4.07
PTS-24	1.80	42.20	5.88	93.50	8.53	51.97	174.29	20.95	5.33	25.48	7.23
Swarna	1.41	14.77	2.71	38.17	6.06	23.00	78.77	8.35	2.11	25.30	4.23
Bidar-1	1.85	40.47	6.20	80.30	7.36	44.03	125.63	18.42	4.12	22.37	2.43
Prathibha	1.53	12.77	5.94	28.63	6.43	16.06	80.27	6.27	1.53	24.33	4.23
Belgaum Local	1.66	13.60	3.61	28.53	5.86	15.63	84.45	6.61	1.52	23.02	4.13
Sona	1.63	36.28	4.80	80.37	6.15	46.50	89.40	13.60	2.55	18.78	6.07
Bidar-4	1.57	38.20	5.45	76.73	6.13	37.83	122.37	17.53	3.76	21.44	6.13
Sobha	1.68	36.20	4.98	83.50	6.40	51.13	93.07	19.28	3.83	19.86	6.83
CD (p=0.05)	0.22	3.01	0.73	3.13	0.96	1.43	2.50	0.32	0.16	1.29	0.17

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Effect of Organic Sources of Nutrients on Yield and Quality of Onion (*Allium Cepa* L.)

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Abstract: The application of recommended dose of fertilizer (i.e. 100kg N, 50kg P_2O_5 and 50kg K_2O along with 25 tonnes FYM)/ha and vermicompost(100% of N by VC) played a significant role in yield and quality parameters of onion. The fresh weight of bulb (73.87 g/plant), dry weight of bulb (7.6 g/plant), dry weight of plant (9.04 g/plant) and bulb yield (270.78 q/ha) were maximum under RDF which remained at par with application of vermicompost (100% of N by VC). However, the highest bulb diameter and total solvable solids content was with application of vermicompost (100% of N by VC).

Key Words: Biofertilizer, Bulb yield, Organic fertilizers, Onion, Vermicompost,

Onion (*Allium cepa* L.), a bulbous biennial herb of family *Alliaceae* is one of the commonest and indispensable vegetable cum condiment crops grown for local consumption, export and processing. It requires large amount of nutrients, which are generally applied by inorganic fertilizers. But due to many disadvantages of these chemical fertilizers like increase in environmental pollution, rise in micro-nutrient deficiency, nitrate accumulation in underground water and deterioration of food quality, there is need to find out alternative source of nutrients for onion cultivation. The use of organic manures like farmyard manure (FYM), vermicompost (VC) and biofertilizers (BF) are suitable substitutes which will not only fulfill the fertilizer requirement of onion crop but they are ecofriendly, low costing and non bulky agricultural inputs and helps in sustaining agriculture. Their use decreases the demand of inorganic nitrogen and phosphatic fertilizers, increase the availability of trace elements like Zn, Mn, Cu etc as well and may help to improve the yield and quality of produce. The application of 100 per cent organic nutrient source through FYM, vermicompost, neem seed cake, *Azotobacter*, PSB and trap crop gave the maximum yield of onion and also improved the fertility status of soil more than control and 100 per cent NPK recommended dose (Khang *et al*., 2011). The study was planned with the objective to study the effect of organic sources of nutrients viz FYM, VC and biofertilizers on yield and quality of onion.

The field experiment was conducted at the Students Research Farm, Khalsa College, Amritsar during *Rabi*-2012. The experimental soil was sandy loam in texture having pH 8.1 value, EC 0.21 (dsm-1), low in organic carbon (0.39%) , low in available nitrogen (178 kg/ha), medium in available phosphorus (19 kg/ha) and high in available potash (>318 kg/ha).The experiment was laid in Randomized complete block design with 4 replications and 12 treatments (Table 1). Onion seedlings were transplanted on 15 January, 2012 in well prepared plots of 1.5m x 1.5m size. Well decomposed FYM and VC as per treatment was added and mixed in soil and biofertilizers were applied as root dipping of seedlings before transplanting of onion. Cultural practices like weeding and hoeing were followed when needed in early stages of crop growth. Five plants from each plot were randomly selected and tagged for recording different observations regarding yield and quality characters. The parameters like bulb yield (q/ha) , dry weight of the plant (g), fresh bulb weight (g), dry weight of bulb (g), bulb shape index (B.S.I.), bulb size (cm), total soluble solids (%) were studied during the course of the study.

The total bulb yield was obtained after harvest of the crop. The bulbs were weighed after separating from the top. Five plants were pulled out at random from each plot and partitioned into different parts such as leaves and bulb and kept for oven drying at 65°C constant weight. After drying of samples in oven, the dry weight was recorded and than average weight was determined. Finally adding the different plant parts, the weight of dry matter per plant was calculated. The bulb shape index was worked out by dividing the polar diameter with equatorial diameters of the bulb. To calculate the bulb diameter five bulbs were selected randomly from each treatment after grading. Measured the diameter and the mean values were computed for statistical analysis. The TSS content was recorded with the help of refractometer. The average content was worked out from all the five bulbs and it was expressed in percentage.

The onion bulb yield increased with the increase in rate of organic manure application i.e VC and FYM doses, but highest yield of onion (270.78q/ha) was recorded where nutrients were applied using synthetic fertilizers i.e T_1 which remained statistically at par with treatments T_2, T_5, T_6 and T_8 but differ significantly from the remaining treatments. Earlier Meena *et al*. (2010) also reported the similar results. Dry weight of the plant increased with the increase in organic

Table 1. Effect of organic sources of nutrients on yield and quality of onion.

Treatment combinations	Bulb yield (q/ha)	Dry weight of plant (g/plant) at harvest	Fresh weight of bulb (g/plant)	Dry bulb weight (g/plant)	Bulb shape index	Bulb diameter (cm)	TSS content (%)
T_0	135.06	3.80	35.50	2.8	0.86	3.75	12.80
T_1	270.78	9.04	73.87	7.6	1.00	6.51	14.97
T_2	261.68	8.46	67.70	6.6	0.99	6.35	14.93
T_3	223.68	7.11	55.72	5.3	0.96	5.26	14.53
T_4	183.03	6.01	47.58	4.3	0.93	5.05	14.15
T_5	267.48	8.99	70.08	6.9	1.00	6.60	15.00
T_6	252.18	8.09	64.22	6.2	1.00	6.11	14.90
T_7	215.26	7.01	53.77	5.1	0.96	5.20	14.49
T_8	257.98	8.17	65.14	6.3	1.00	6.01	14.88
T_9	225.90	7.19	55.96	5.5	0.97	5.29	14.56
T_{10}	185.78	6.45	48.48	4.6	0.94	5.10	14.17
T_{11}	165.43	5.08	42.60	3.8	0.92	4.75	13.82
CD (0.05)	25.74	0.85	6.57	0.7	0.09	0.65	NS

T_0-Control; T_1- RDF (i.e. 100kg N, 50kg P_2O_5 and 50kg K_2O along with 25 tonnes FYM)/ha; T_2- (100% of N by FYM); T_3- (75% of N by FYM+BF); T_4- (50% of N by FYM+BF); T_5- (100% of N by VC); T_6- (75% of N by VC+BF); T_7- (50% of N by VC+BF); T_8- (50% of N by FYM+50% of N by VC); T_9- (37.5% of N by FYM+ 37.5% of N by VC+BF); T_{10}- (25% of N by FYM+25% of N by VC+BF); T_{11}- (BF alone)

nitrogen level. The maximum dry weight of the plant was in the treatment T_1 (9.04g) which was at par with T_5 and T_2 but was significantly better than all other treatments . These results were supported by the findings of Reddy and Reddy (2008). Different N levels either through organic or in organic sources of nutrients also affect fresh bulb weight. The treatment T_1 RDF produced maximum bulb weight (73.87g) that remained statistically at par with T_2 and T_5 and significantly better than other treatments. Alike results were also reported earlier by Ansari (2008) and Yadav and Vijaykumari (2003). Highest bulb dry weight was seen with the application of RDF T_1 (7.6 g) which was significantly better than all other treatments except T_5. Similar results were also found by Reddy and Reddy (2005).

The highest index value recorded was 1.00 resulted from the application of T_1 (RDF) that remained statistically at par with all the treatments except T_0. Shape index might have improved due to higher photosynthetic rate and better source-sink relationship. The highest bulb diameter of 6.60 cm was recorded in treatment T_5 followed by T_1, T_2, T_6 and T_8 which were statistically at par and were significantly better than all other treatments. TSS content didn't show any significant results, however maximum TSS content of 15.00 % was recorded in T_5 followed by T_1, T_2, T_6, T_8, T_9, T_3, T_7, T_{10}, T_4 and T_{11}, respectively. Aisha *et al.* (2007) also supported the same results.

The results showed significant effect of application of NPK along with FYM on yield and quality parameters of onion. The addition of vermicompost and biofertilizer also enhanced the yield and quality.

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Effect of Fertilizer Levels on Yield, Quality and Economics of Glory Lily (*Gloriosa superba* L.)

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***Abstract*:** In an experiment conducted to find the effect of different levels of fertilizers on yield, quality and economics of glory lily' The application of 15t of FYM with 150:75:120kg of NPK gave better seed yield and higher returns whereas the tuber yield is significantly higher when the crop was applied with 100:50:75kg NPK along with 15t FYM per ha. The colchicine content had shown variable response to different levels of fertilizers.

***Key Words*:** Agnishikha, Fertilizer levels, Gloriosa lily, Glory lily

Glory lily (*Gloriosa superba* L., Family: Liliaceae) is mainly cultivated for its seeds for extraction of colchicine and colchicoside forming the principal source of drugs used for treating gout, rheumatism and for inducing polyploidy in plants. The phytochemicals present in glory lily have analgesic, anti-inflammatory, antithrombotic, enzyme inhibitory, anti-venom and chemotherapeutic potential. There is very little variability available for seed yield and colchicine content in glory lily (Farooqi *et al*., 1999). Hence the only way to improve the yield is through manipulation of plant population and nutrient management under cultivation. However, in glory lily, there is no standardized scientific fertilizer recommendation available, as the work on this crop is very meager. The fertilizer dosage and frequency of application contribute more for higher seed yield. Standardization of this technology may help to improve the seed yield and alkaloid content and to increase net returns per unit area. In this regard, an experiment was conducted on effect of fertilizer levels on yield, quality and economics of glory lily.

The study was carried out at Antravalli, of Uttar Kannada district of Karnataka (14.46° North latitude and 74.4° East longitude at an altitude of 5 m above mean sea level) from June, 2012 to January, 2013. There were six treatments with different fertilizer levels (Table I). Urea, Single super phosphate and Muriate of potash were applied as sources of Nitrogen, Phosphorous and Potash, respectively. The experiment was laid out in randomized block design with four replications. Healthy tubers (weighing about 50g each) were selected for plating with spacing of 90 x 30 cm. Observations on yield parameters were recorded in five randomly selected uniform plants. The gross income was worked out based on the prevailing market price of dry seeds and tubers. Net income per hectare was calculated as the difference between gross income and cost of cultivation per hectare.

The fertilizer levels have significant effect on fresh and dry seed yield. The treatment T_6 (15t FYM + 150: 75: 120 kg NPK per ha) recorded the highest fresh and dry seed yields per ha (32.03 q and 6.57q, respectively) which was statistically on par with T_5 (15t FYM + 125: 70: 100 kg NPK per ha). The lowest dry seed yield was observed in T_1. These results are in agreement with the findings of Deivasigamani and Thanunathan (2011), Sathish (2000), Mohanaramya *et al.* (2010) and Vasanthi *et al.*, (2012) in glory lily and Sundareswaran *et al*. (2012) in ambrette. The differences in tuber yield due to fertilizer levels were statistically significant. The treatment T_4 (15t FYM + 100: 50: 75 kg NPK per ha) recorded the highest tuber yield per ha (26.61q) whereas lowest was recorded in T_3 (14.88 q per ha). The tuber yield followed the increasing trend with increase in fertilizer dose up to a certain level (T_4). Further increase in fertilizer doses decreased the tuber yield. This may be due to more of vegetative growth and seed yield in increased fertilizer doses which resulted in decrease in tuber yield. Deivasigamani and Thanunathan (2011) reported that application 100 per cent of recommended dose of nitrogen recorded higher seed and tuber yield whereas Mohanaramya *et al.* (2010) reported that 125 per cent of recommended dose of fertilizers through fertigation gave highest yields in glory lily. Colchicines content have shown the variable responses for different levels of fertilizers. The highest colchicines content (0.29%) was observed in T_3 followed by (0.28%) T_5. The lowest (0.21) was observed in T_1 . In the experiment with different fertilizer doses, the higher gross and net incomes (Rs. 5,76,350 and Rs. 4,70,444/ha respectively) were noticed in T_6 with 15 t

Table 1. Effect of fertilizer levels on yield quality and economics of glory lily (*Gloriosa superba* L.)

Treatment	Yield per ha (q)			Colchicine content (%)	Gross income (Rs/ha)	Cost of cultivation (Rs/ha)	Net income (Rs/ha)	Benefit : Cost ratio
	Fresh seed	Dry seed	Tuber					
T_1	20.99^{e}	3.56^{e}	15.39^{d}	0.21	323275	98111	225164	3.29
T_2	23.50^{d}	4.26^{d}	17.59^{cd}	0.25	384775	100709	284066	3.82
T_3	26.02^{c}	4.88^{c}	14.88^{d}	0.29	427600	102094	325506	4.19
T_4	28.58^{b}	5.73^{b}	26.61^{a}	0.27	524925	103168	421757	5.09
T_5	31.48^{a}	6.32^{a}	22.28^{b}	0.28	561300	104865	456435	5.35
T_6	32.03^{a}	6.57^{a}	20.30^{bc}	0.27	576350	105906	470444	5.44

T1: 15t FYM per ha.
T2: 15t FYM + 50: 25: 40 kg NPK per ha.
T3: 15t FYM + 75: 40: 60 kg NPK per ha.
T4: 15t FYM + 100: 50: 75 kg NPK per ha.
T5: 15t FYM + 125: 70: 100 kg NPK per ha.
T6: 15t FYM + 150: 75: 120 kg NPK per ha.

FYM +150: 75:120 kg NPK per ha

The application of 15t of FYM with 150:75:120kg of NPK gave better seed yield per ha whereas the tuber yield is significantly higher when the crop was applied with 100:50:75kg NPK along with 15t FYM per ha.

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Effect of Plant Growth Regulators on Dry Matter Accumulation, Partitioning and Fruit Retention of *Bt* Cotton

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Abstract: The present investigation was conducted in the Department of Agronomy, *PAU,* Ludhiana, to study the effect of different plant growth regulators on morpho-physiological traits of *Bt*- cotton. Amongst the treatments studied, mepiquat chloride (MC) 300 ppm followed by MC 200 ppm yielded the best result in terms of improved dry matter accumulation and it's partitioning to fruiting bodies, setting percentage, boll weight and finally seed cotton yield per plant. Maximum seed cotton yield was obtained with MC 300 ppm which was 37.20 and 33.07 per cent higher than control respectively during both the years of study. Application of cycocel (CCC) 500 ppm produced the minimum total seed cotton yield, which was significantly lesser than control. Rest of the plant growth regulator treatments failed to influence the seed cotton yield significantly.

Key Words: *Bt* cotton, Mepiquat chloride, cycocel, Morpho-physiological traits, PGRs

Cotton cultivars have indeterminate growth habit set competition for nutrients among simultaneously growing stem, developing bolls and newly formed flowers. Under luxuriant growing conditions, maintaining a proper balance between the vegetative and fruiting components of the crop is sometimes difficult to achieve and most of the photo assimilates are shifted towards vegetative growth and development (Buttar and Aggarwal, 2004). This extra-ordinary vegetative growth at the cost of reproductive growth led to fruit shedding due to disruption of a vegetative /reproductive balance. Exploitation of plant growth regulators (PGRs) have been tried by many workers to enhance cotton productivity and quality by overcoming the barriers like excessive vegetative growth, unsynchronized flower initiation, shedding of flowers and bolls, imposed by genetics and environmental factors. Growth retardants like Mepiquat chloride (MC) and cycocel (CCC) have ability to check excessive vegetative growth, elongation of main stem and fruiting branches. On the contrary, some PGRs like kinetin, gibberellic acid (GA_3) and naphthalene acetic acid (NAA) is used to reduce the shedding of squares, flowers and immature bolls. Keeping this in view, tried different growth regulators in Bt cotton to have maximum returns from the crop were evaluated.

The experiment was conducted in the Department of Agronomy, PAU Ludhiana, during *kharif* season of 2008 and 2009. The experiment was laid out in randomized complete block design with four replications comprising of twelve treatments (Table1) The field soil was loamy sand in texture, slightly alkaline in reaction (pH = 8.1), non-saline (EC= 0.25 dsm^{-1}), low in organic carbon (0.31 %) and available nitrogen (258.5 kg ha^{-1}), high in available phosphorus (24.4 kg ha^{-1}) and potassium (339.4 kg ha^{-1}). *Bt* cotton hybrid RCH-134 was raised according to package of practices recommended by PAU, Ludhiana (Anonymous, 2013). Five plants from each treatment were selected randomly and tagged to record growth and yield attributes and calculated on per plant basis. To determine dry matter accumulation and partitioning in cotton, randomly selected plants were separated into stem, leaves and fruiting bodies. The plant parts were first dried in the sun and then in the oven at 65C temperature till they attain a constant weight. Dried samples were weighed (g $plant^{-1}$).

The number of flowers appearing on the tagged plants in each plot was counted on daily basis from flower initiation till culmination of flowering period. The total number of bolls produced per plant was calculated as total opened bolls at each picking (first, second and third) included total unopened bolls at the time of last picking. Setting percentage denotes that out of total flowers formed, how many were eventually set into bolls.

Dry Matter Accumulation (DMA) and Partitioning: Dry matter accumulation (DMA) and partitioning of photo-assimilates is an important parameter to quantify vegetative and reproductive balance of cotton plants. The rate of increase in dry matter accumulation (DMA) was very sharp from 60 to 120 DAS and thereafter DMA continued to register an increase but was slow. The pooled data of two years elicited maximum increase in DMA was observed between 90 to 120 DAS which is the maximum growth period of the crop (Fig 1). The maximum rate of DMA was observed with application of GA_3 (50 ppm) and the minimum with CCC 500

ppm. The accumulation of dry matter by stem and branches followed almost the same pattern as that of total DMA. Dry matter accumulation by the leaves showed a decline from 120 DAS onwards, whereas DMA by the fruiting bodies continued to show an increase from 90 DAS onwards till maturity. The remaining plant growth regulator treatments were statistically at par with control for total DMA and partitioning.

Fruit retention and yield contributing characters: Various growth regulation treatments did not significantly influence the number of flowers per plant (Table 1). Application of MC 300 ppm recorded the maximum number of bolls per plant (56.60) followed by MC 200 ppm), which was significantly higher than control. Likewise, maximum boll setting (45.19 per cent) was also observed with treatment MC 300 ppm, which was significantly higher than control (38.82 per cent). All other growth regulator treatments were statistically at par with control for setting percentage. The significant improvement in number of bolls per plant and setting percentage with MC application was due to better partitioning of metabolites and photosynthates towards the fruiting bodies rather than vegetative parts (Gormus, 2006).

Maximum boll weight (3.35 g) was with foliar application of MC 300 ppm which was statistically at par with

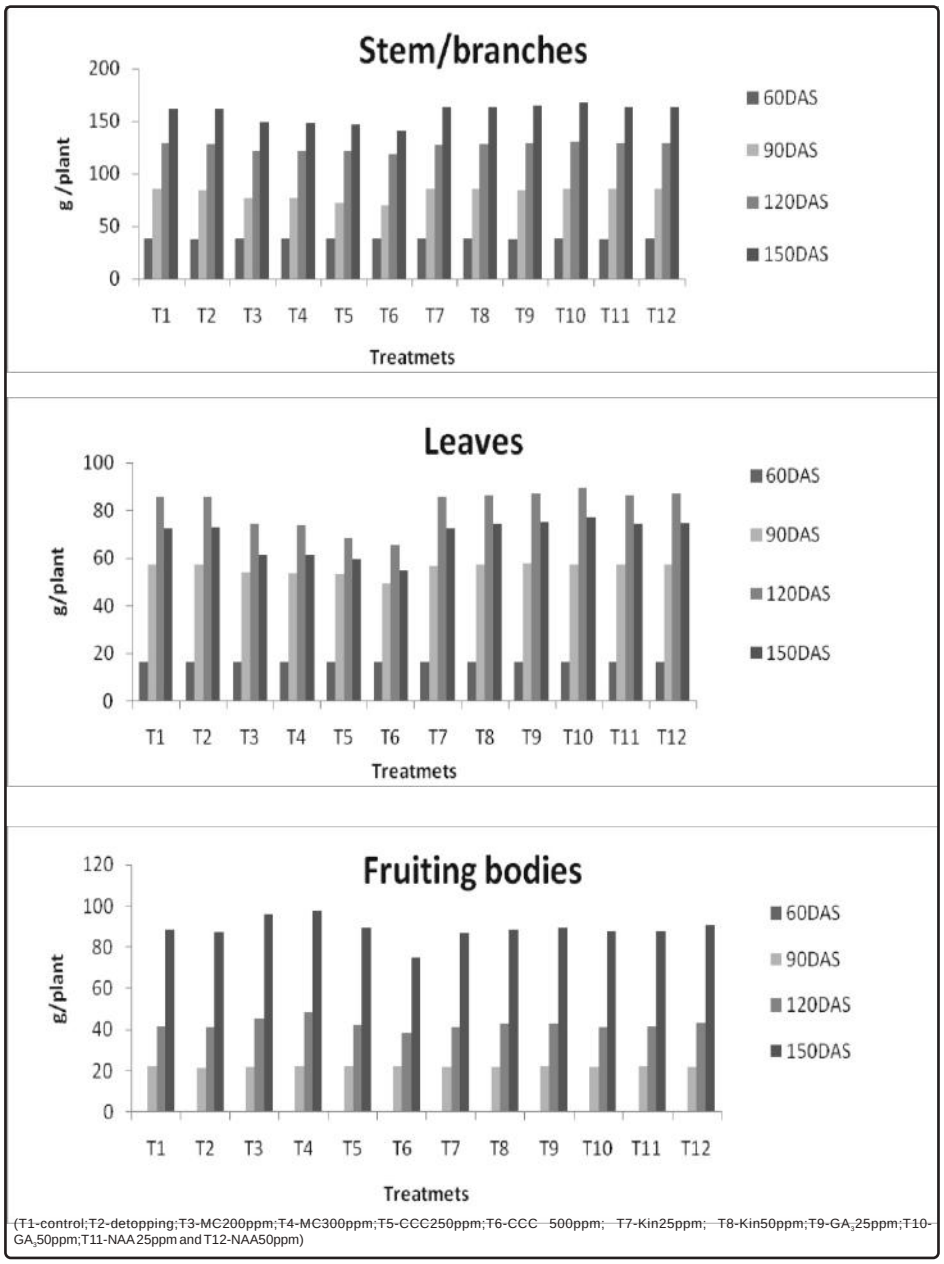

Fig. 1. Effect of plant growth regulators on periodic dry matter accumulation and its partitioning in *Bt* cotton during 2008 and 2009 (Pooled Data)

Table 1. Effect of plant growth regulation treatments on fruiting bodies and seed cotton yield of *Bt* cotton (Pooled data)

Treatment (ppm)	Flowers / plant	Total boll s per plant	Boll setting (%)	Boll weight (g)	Seed cotton yield (q ha^{-1})
Control	126.20	49.00	38.83	2.93	21.18
Detopping	125.50	48.05	37.62	2.89	20.44
MC 200	126.45	55.25	44.30	3.30	27.49
MC 300	126.35	56.60	45.19	3.35	28.64
CCC 250	125.65	49.70	39.51	2.98	21.73
CCC 500	119.55	44.15	36.35	2.69	16.34
Kinetin 25	125.90	48.40	38.43	2.95	20.75
Kinetin 50	126.90	50.25	39.65	3.06	22.47
GA3 25	126.90	50.70	39.99	3.07	22.89
GA3 50	127.25	48.20	37.89	2.96	20.43
NAA 25	127.55	49.80	39.04	3.00	22.02
NAA 50	129. 65	52.15	40.25	3.11	23.96
LSD (p=0.05)	NS	4.70	4.23	0.24	4.41

MC 200 ppm (3.30 g) but significantly better than control and other the treatments. All the other plant growth regulation treatments failed to exhibit any significant influence on boll weight. Similarly, increase in boll weight with the application of MC was also reported by Siddique *et al.* (2002).

Seed Cotton Yield: Different plant growth regulation treatments significantly affected the total seed cotton yield (Table 1). Application of MC 300 ppm resulted in higher seed cotton yield (28.64 q ha^{-1}) which was 35.22 per cent higher than control and was statistically at par with MC 200 ppm. Application of CCC 500 ppm produced the minimum total seed cotton yield which was significantly lesser than control. Spray of MC increased the total seed cotton yield because it restricts the excessive vegetative growth of the plant and enhanced the partitioning of the assimilates towards the fruiting bodies thereby exerting a favorable effect on various yield contributing components hence increased the total seed cotton yield. Similarly, Prasad (2004) also reported that increase in seed cotton yield with MC application. The significant reduction in seed cotton yield with higher concentration of CCC was observed by Wankhade et al (2002). The other growth regulator treatments failed to influence the seed cotton yield significantly.

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It can be concluded that application of plant growth regulators on the cotton led to enhance the economic yield. The application of MP 300 ppm followed by MC 200 ppm yielded the best result in terms of improved dry matter accumulation and its partitioning to fruiting bodies, setting percentage, boll weight and finally seed cotton yield per plant.

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Influence of Spray Technology on Control of *Phalaris minor* and its Effect on Economics of Wheat (*Triticum aestivum* L.) at Farmers' Fields

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Abstract: This study was planned in *Rabi* 2010-11 & 2011-12 to demonstrate the spray technology for the control of *Phalaris minor* and its effect on economic output of wheat. The treatments *viz*., recommended spraying practice comprising application of clodinafop @ 60 g a.i./ha in 250 litres water at 30-35 days after sowing with flat fan nozzle and overlapping 1/3rd of the spray boom and keeping the spray lance straight (RP); farmer practice comprising application of clodinafop @ 60 g a.i./ha) in 188 litres of water at 40-48 days after sowing with cone type or flat fan nozzle, without any overlapping of the spray boom with to and fro movement of spray lance (FP), unweeded control (UW) and 2 hand weedings (2HW). Both recommended practice and 2 hand weedings produced significantly lesser number of *P. minor* than farmer practice and unweeded control but both were at par with each other in first year, while during second year in 2 hand weedings weed population was significantly lesser than recommended practice, which might be due to increase in resistant population. Similar trend was observed in dry matter also. In year 2010-11, grain yield under 2HW (49.52 q/ha) and RP (49.07 q/ha) was significantly more than FP (48.08 q/ha) but was at par with each other. But during 2011-12, the grain yield under RP was significantly lesser than 2HW and better than FP. Recommended practice produced highest net return and B: C ratio than all other treatments in both the years.

Key Words: Wheat, *Phalaris minor*, spraying techniques, economics, clodinafop

Wheat is the major food crop of India. One of the major agronomic operations in raising the wheat crop is the weed control especially *Phalaris minor*. But the main emerging issue in this context is the development of resistance in *P. minor* towards herbicides. Already *P. minor* developed resistance to isoproturon in Punjab (Walia *et al*., 1997) and Haryana (Malik and Singh, 1995). After this new herbicides were recommended for management of herbicide-resistant populations of *P. minor* in 1997-98. From these herbicides clodinafop –propargyl was used extensively by farmers due to its high efficacy and safety to wheat crop, but resistance to clodinafop was also reported in India (Chhokar and Sharma, 2008). This has created a continuous demand for newer herbicides to control *P. minor*. To bring out a new herbicide is not an easy process and requires a long time. Agronomic manipulations can be helpful to control the weeds more effectively and it may also increase the life span of herbicides. Farmers usually do not apply optimum quantity of water to spray the herbicide, use cone type of nozzle and do not keep the spraying lance stable and move it to and fro. Hence weeds get sub lethal dose at some area and more than recommended dose at other area. This leaves weed patches and strips, where optimum amount of spray fluid does not fall on the weeds. These weed patches and strips are a common site in wheat fields. The weeds left uncontrolled in the field not only reduce the yield of present crop but also increase the seed bank. Therefore, the study was planned on farmer fields to educate the farmers about proper herbicide spraying technology and to know the extent of weed infestation and economic loss due to the faulty spray techniques.

This study was planned in *Rabi* 2010-11 & 2011-12 on farmer fields of districts Ropar and Ajitgarh of Punjab state, characterized by sub-tropical climate with hot and dry summer from April to June and hot and humid from July to September and cold winters from December to January. The average annual rainfall is about 775 mm, around 75% of which is received during monsoon period from July to September. Same fifteen sites were selected each year from two districts (Ropar and Ajitgarh), representing alluvial soil type. The demonstrations were conducted using PBW550, DBW17, PBW621 and HD2967 cultivars and the sowings were completed between 1st to 21st November each year. The soils of the demonstration sites were low to medium in organic carbon and Nitrogen, while variable P and K were found to be medium to high. The soil was sandy loam to loam in texture. The crop was harvested during first fortnight of April. Nitrogen @ 125 kg/ha was applied in the form of urea in 2 equal splits, one at sowing and second at the time of 1st irrigation. Phosphorus was applied to the wheat crop @ 62.5

kg/ha in the form of DAP at the time of sowing with seed-cum-fertilizer drill.

Four treatments of weed control were exhibited i.e. recommended spraying practice comprising application of clodinafop @ 60 g a.i./ha (Topik 400 g/ha) in 250 litres water at 30-35 days after sowing with flat fan nozzle and overlapping 1/3rd of the spray boom and keeping the spray lance straight (RP); farmer practice (commonly followed by local farmers) comprising application of clodinafop @ 60 g a.i./ha (Topik 400 g/ha) in 188 litres of water at 40-48 days after sowing with cone type or flat fan nozzle, without any overlapping of the spray boom with to and fro movement of spray lance (FP), unweeded control (UW) and weed free through 2 hand weedings (2HW).The numbers of farmer fields were taken as replications and data was analyzed in RCBD.

Weed population consisted mainly of *Phalaris minor* and in some cases broadleaf weeds as well, but the data presented is only for *P. minor*. The population data was taken from randomly selected five places from each plot and presented as number of plants per meter square at 20 days after spray, while number of panicles per meter square were presented at harvest stage. For dry matter weeds were taken from randomly selected five places (each of one square meter) from each plot, then oven dried and weight converted to per hectare basis. Metsulfuron 20 WP @ 25 g/ha was applied in all the fields for controlling broadleaf weeds.

Weed control efficiency (WCE) was calculated using the formula (Singh *et al*., 2000):

$$WCE\ \% = \frac{WDWC - WDWT}{WDWC} \times 100$$

Where WDWC = Weed dry weight in weedy check, WDWT = Weed dry weight in treatment.

Effect on Weeds

(a) Weed Population: In both the seasons the *P. minor* infestation was drastically reduced by all 3 weed control treatments (recommended practice (RP), farmer practice (FP) and 2 hand weedings (2HW)). In 2010-11, the number of weeds at 20 days after spray in 2 hand weedings (2HW) and recommended practice(RP) were at par with each other but significantly lesser than the Farmer practice (FP) and Unweeded Control (Table 1). At the time of harvest also both 2 hand weeding and recommended practice (RP) produced significantly lesser weeds than farmer practice (FP) and unweeded control.

During 2011-12, some change in the above trend was noted. At 20 days after spray and at harvest, the numbers of weeds in 2 hand weedings (2HW) were significantly lesser than both recommended and farmer practice (FP). But the recommended practice (RP) was statistically superior to the famer practice. However the farmer practice (FP) showed significantly better control of weeds than unweeded control.

It was noted that during the year 2011-12 the weed count was more in comparison to the previous year 2010-11 both in recommended and farmer practice (FP) but not in handweeded treatment. This may be due to increasing resistant population among the *P. minor* population.

The numbers of weeds in recommended practice (RP) were numerically 3.76 times and 1.94 times lesser than farmer practice (FP) in 2010-11 and 2011-12 respectively.

(b) Weed dry matter: In year 2010-11, 2 hand weedings (2HW) and recommended practice (RP) were at par with each other but produced significantly lesser dry matter of *P. minor* (at harvest) than farmer practice(FP) and unweeded control, whereas farmer practice (FP) was significantly better than unweeded control (Table 1). In year 2011-12, 2 hand weedings (2HW) produced significantly lesser dry matter of *P. minor* than recommended practice (RP) and other treatments, but in recommended practice (RP) dry matter of *P. minor* was significantly lesser than farmer practice (FP). In

Table 1. *Phalaris minor* population (No. /m^2), dry matter and weed control efficiency under different weed control treatments in wheat

Treatment	Weed population (No./m^2)				Weed dry matter at harvest (q/ha)		Weed Control Efficiency (%)	
	Number of plants							
	20 DAS*		At harvest*		2010-11*	2011-12*	2010-11	2011-12
	2010-11	2011-12	2010-11	2011-12				
2 HW	1.16(0.39)	1.79 (2.47)	1.93 (3.00)	1.84(2.73)	1.12(0.26)	1.09(0.18)	91.1	94.8
RP	1.20(0.45)	2.26 (4.40)	2.28 (5.07)	3.36(10.67)	1.23(0.51)	1.42(1.06)	82.3	69.7
FP	1.77(2.20)	3.75 (13.27)	4.41 (19.07)	4.61(20.67)	1.57(1.69)	1.66(1.83)	41.1	47.8
UW	3.98(15.13)	5.45 (29.07)	5.57 (30.33)	5.97(35.07)	1.86(2.87)	1.96(3.51)	0.0	0.0
CD (p=0.05)	0.24	0.39	0.51	0.49	0.13	0.14	-	-

*Data subjected to square root transformation ($\sqrt{x+1}$) and values within parentheses are the original values

Table 2. Effect of different weed control methods on effective tillers, grain yield and economics of wheat.

Treatment	Effective tillers (No./m2)		Grain yield (q/ha)		Gross Returns (Rs/ha)		Variable Cost (Rs/ha)		Net Returns (Rs/ha)		B:C	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
2 HW	401.2	406.7	49.52	51.93	66853	73690	32228	33985	34625	39704	1.07	1.17
RP	400.1	406.0	49.07	51.40	66233	72951	24268	25026	41965	47925	1.73	1.92
FP	390.5	396.8	48.08	49.52	64883	70319	24268	25026	40615	45294	1.67	1.81
UW	387.6	392.0	44.62	46.50	60213	66030	23061	23569	37151	42461	1.61	1.80

second season recommended practice (RP) produced significantly more dry matter than 2 HW whereas it was at par in first season which might be due to increased resistant population of *P. minor* to clodinafop.

Weed control efficiency (WCE) was highest during both the years in 2 hand weedings (2HW) followed by recommended practice (RP) followed by farmer practice (FP). In recommended practice (RP), weed control efficiency WCE was 2 times more than farmer practice (FP) during year 2010-11 and 1.5 times during year 2011-12. Difference of WCE between 2 hand weedings (2HW) and recommended practice (RP) was more (25.1%) in year 2010-11 than 2011-12 (8.8%) which is supported by above weed count and dry matter data.

Effect on Crop: The number of effective tillers/m^2 during 2010-11 were at par under 2 hand weeding and the recommended practice (RP) but significantly higher than the farmer practice (FP) and unweeded control, both of which (farmer practice and unweeded control) were at par with each other (Table 2). The same trend followed in 2011-12 also.

Due to lesser competition by weeds the crop growth was better under 2 hand weeding, which was depicted very well by the grain yield data (Table 2). Grain yield under 2 hand weeding (49.52 q/ha) during 2010-11 was significantly more than farmer practice (48.08 q/ha) but was at par with recommended practice (49.07 q/ha). The recommended practice (RP) also gave significantly higher grain yield than the farmer practice (FP), even though the farmer practice (FP) was significantly better than the unweeded control. But during 2011-12 the grain yield under recommended practice (RP) was significantly higher than the farmer practice (FP) and unweeded control, but it was significantly lower than the 2 hand weeding(2HW) treatment which is supported by weed count and weed dry matter data.

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Economics: Recommended practice (RP) produced highest net return and B:C than all other treatments in both the years(Table 4). Farmer practice (FP) produced higher net returns and B:C than unweeded control and 2 hand weedings (2HW) during both the years. 2 hand weedings (2HW) produced more gross return but due to higher labour cost for hand weeding it produced lowest net return and B: C ratio than unweeded control. Recommended practice (RP) gave Rs. 7000/ha and Rs. 1350/ha more income than 2 hand weedings (2HW) and farmer practice (FP) respectively in year 2010-11 while during 2011-12 recommended practice (RP) gave Rs. 8221/ha and Rs. 2613/ha more income than 2 hand weedings (2HW) and farmer practice (FP), respectively.

Recommended practice (RP) of weed control provided better weed control and yield than farmer practice (FP). Recommended practice (RP) was economically more viable than farmer practice (FP) and 2 hand weedings (2HW). Although 2 hand weedings (2HW) provided significantly better weed control than recommended practice (RP) in second year but it was not economically viable because of more labour expenses for hand weedings.

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Influence of Different Storage Methods on Storage Quality of Onion

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Abstract: The investigation was carried out to study the effect of different storage methods on the storage quality and per cent marketable bulbs. Among various storage structures studied bamboo battens storage structure with AC sheet roofing with bottom and side ventilation showed the minimum physiological loss in weight, rotting and black mould incidence and highest percent of marketable bulbs were observed followed by wooden battens storage structure with galmenium sheet roofing and with bottom and side ventilation and the lowest was observed in bamboo battens thatched roof structure (sugarcane thrash) without bottom ventilation.

***Key Words*:** Onion, Curing, TSS and Ascorbic acid

Onion (*Allium cepa* L.) is an important commercial crop grown almost all over the country. India ranks second in area (10.64 lakh ha) and production (151.18 lakhT) after China and third in export (11.63 lakh MT) after Netherlands and Spain .The major onion growing states are Maharashtra, Bihar, Karnataka, Gujarat, Andhra Pradesh, Uttar Pradesh, Orissa and Madhya Pradesh (Anon., 2011) . The onion produce is available in market during October-November (20%) as *kharif* crop, January-February (20%) as late *kharif* crop and April-May (60%) as *rabi* crop. The *rabi* crop has more storability and used for domestic, export and seed bulb purposes from June to November. This is the critical period in whole country, where there is no supply of fresh onions to the market resulting in price fluctuation. As such storage becomes a paramount importance for steady supply.

Storage methods have their own impact on post-harvest life and keeping quality of onion. There is a problem of sprouting and rotting of bulbs when stored in an environment of high humidity and temperature. High humidity coupled with high temperature favours sprouting and rotting of bulbs, which ultimately leads to loss of keeping quality, thereby reducing their storage life.

The present investigation was carried out in Department of Post-harvest Technology, Kittur Rani Channamma College of Horticulture, Arabhavi during *rabi* season of 2010-11. This experiment was carried out in completely randomized design with ten treatments replicated thrice (Table 1). Initial observations were recorded before imposing the treatments. The physiological loss in weight, sprouting, rotting and per cent marketable bulbs were recorded at 15-30 days interval upto 90 days of storage/ these parameters were calculated by using the formula given below.

Physiological loss in weight (%)

$$PLW\ (\%) \quad \frac{P_0 - P_1 \text{ or } P_2 \text{ or } P_3 \text{ or } P_4 \text{ or } P_5 \text{ or } P_6}{P_0} \times 100$$

Where, P_0 = initial weight P_1 = weight after 15 days
P_2 = weight after 30 days P_3 = weight after 45 days
P_4 = weight after 60 days P_5 = weight after 75 days
P_6 = weight after 90 days

$$\text{Rotting percentage} = \frac{\text{Weight of the rotted bulbs}}{\text{Initial weight of the bulbs}} \times 100$$

$$\text{Marketable bulbs (\%)} = \frac{\text{Weight of the healthy bulbs obtained}}{\text{Initial weight of bulbs stored}} \times 100$$

Physiological loss in weight: The physiological loss in weight of the bulbs irrespective of storage condition increased from 3.00 per cent at 15 DAS to 17.00 per cent at 90 DAS. Significant differences were observed in the physiological loss in weight of the bulbs among the storage methods throughout the storage period (Table.1). Minimum physiological loss in weight was recorded in the bulbs stored in bamboo battens storage structure with AC sheet roofing with bottom and side ventilation followed by bulbs stored under wooden battens storage structure with mangalore tiles roofing and with bottom and side ventilation. However, the maximum physiological loss in weight was recorded in the bulbs stored in bamboo battens thatched roof structure (sugarcane thrash) without bottom ventilation.

It may be due to proper ventilation in the structure, resulting in optimum temperature in the centre of the structure which results in less respiration and transpiration (Maini *et al*., 1997). These findings were in accordance with Warade *et al*. (1995) and Tripathi and Lawande (2003). The maximum physiological loss in weight was observed in onion bulbs stored in bamboo battens thatched roof structure (sugarcane thrash) without bottom ventilation may be due to

Table 1. Influence of different storage conditions on physiological loss in weight and rotting during storage of onion.

Treatment	Days after storage						
	Physiological loss in weight (%)				Rotting (%)		
	15	30	60	90	30	60	90
T_1	3.92	6.45	12.36	17.00	2.52	7.82	11.00
T_2	3.86	5.92	12.28	16.26	2.40	6.72	10.08
T_3	2.46	4.82	7.42	9.86	2.00	3.00	4.20
T_4	3.12	6.00	9.64	12.28	2.26	6.48	7.60
T_5	3.00	5.04	9.24	11.80	2.32	6.72	8.00
T_6	3.34	6.24	9.48	11.58	2.45	6.84	8.26
T_7	3.08	5.86	9.58	12.58	2.28	6.41	9.84
T_8	3.62	6.04	12.36	16.58	2.62	7.39	10.50
T_9	2.92	5.12	9.00	12.14	2.58	6.40	9.14
T_{10}	3.06	5.24	11.24	15.00	2.60	6.34	10.26
C.D. (p=0.05)	0.272	0.269	0.269	0.276	0.060	0.018	0.046

T_1-Bamboo battens thatched roof structure (sugarcane thrash) without bottom ventilation
T_2-Bamboo battens low cost storage structure with typha roofing with bottom and side ventilation
T_3-Bamboo battens storage structure with AC sheet roofing with bottom and side ventilation
T_4-Wooden battens storage structure with AC Sheet roofing and with bottom and side ventilation
T_5-Wooden battens storage structure with galmenium sheet roofing with bottom and side ventilation
T_6-Wooden battens storage structure with Mangalore tiles roofing and with bottom and side ventilation
T_7-Welded mesh cage with bottom and side ventilation
T_8- Plastic crate storage
T_9- Nylon net bags storage
T_{10}- Control (Farmers method in gunny bags)

the improper ventilation resulting in higher temperature in the centre of the structure due to higher rate of respiration in bamboo battens thatched roof structure (sugarcane thrash) without bottom ventilation (Subbaramu *et al*., 1990).

Rotting: There was no loss of bulbs due to rotting in all storage methods upto 15 days.The per cent rotting of bulbs irrespective of storage methods increased from 2.00 at 30 DAS to 11.00 at 90 DAS. Among the storage conditions evaluated, maximum loss due to rotting was recorded in bulbs stored in plastic crates (2.62%) at 30 DAS. However, at later stage of storage, the maximum loss due to rotting was recorded in bamboo battens thatched roof structure (sugarcane thrash) without bottom ventilation, whereas minimum rotting was observed in bamboo battens storage structure with AC sheet roofing with bottom and side ventilation. There was no black mould rot upto 45 days in bamboo battens storage structure with AC sheet roofing and with bottom and side ventilation and nylon net bag storage where as upto 30 days in all other storage conditions. After 45 DAS, minimum per cent black mould was noticed in bulbs stored in bamboo storage structure with AC sheet roofing and with bottom and side ventilation whereas maximum black mould per cent was found in bulbs stored in wooden battens storage structure with AC sheet roofing and with bottom and side ventilation (Table 2).

Onion bulbs affected by various post-harvest diseases like black mould, neck rot, white rot and soft rot. Among these, the only major post-harvest disease that was responsible for rotting of bulbs in storage was identified as black mould rot caused by *Aspergillus niger*. The black mould was not observed upto 45 days in bamboo battens storage structure with AC sheet roofing and with bottom and side ventilation (T_3) and nylon net bag storage (T_9) where as upto 30 days in all other methods of storage and no rotting was observed upto 15 days of storage. The rotting and black mould per cent of bulbs was significantly influenced by different storage conditions during all the stages of observations. Among the different storage conditions, the minimum rotting and black mould per cent was observed in bulbs stored in bamboo battens storage structure with AC sheet roofing and with bottom and side ventilation. This may be due to proper ventilation as well as minimum fluctuation in storage temperature 26^{0}C to 36^{0}C inside the structure (Maini *et al*. 1997), while the maximum rotting (11.00%) and black mould incidence (10.00%) were noticed in bamboo battens thatched roof structure without bottom ventilation due to major fluctuation in temperatures ranged from 24^{0}C to 40^{0}C. The higher rotting and black mould per cent may be due to the buildup of respiratory heat and humidity within the onion pile creating favourable condition for the proliferation of the spoilage pathogens. These findings were in accordance with Bongiwar and Shirsat (2000) and Surviliene (2006).

Marketable bulbs: There was highly significant differences among the different storage conditions regarding per cent marketable bulbs. Maximum per cent of marketable bulbs was recorded in bulbs stored in bamboo battens storage

Table 2. Influence of different storage conditions on black mould incidence and marketable bulbs of onion during storage

Treatment	Days after storage					
	Black mould incidence (%)			Marketable bulbs (%)		
	45	60	90	30	60	90
T_1	2.00	4.00	8.00	91.03	79.82	72.00
T_2	1.00	2.00	6.20	91.68	81.00	73.70
T_3	0.00	1.00	3.50	93.18	89.58	85.94
T_4	2.00	4.00	10.00	91.80	83.88	80.12
T_5	1.00	2.00	7.40	92.64	84.54	80.20
T_6	1.00	2.66	5.20	91.31	83.68	80.16
T_7	1.00	2.40	5.40	92.26	84.01	77.14
T_8	1.50	3.66	5.73	91.34	80.26	73.16
T_9	0.00	1.00	4.66	92.30	84.60	78.72
T_{10}	1.00	2.00	5.00	92.16	82.42	74.74
C.D. (p=0.05)	0.71	0.75	0.53	2.69	2.70	2.71

***** Initial total sugar was 9.52 per cent
See foot note at Table 1 for treatment detail

structure with AC sheet roofing and with bottom and side ventilation followed by bulbs stored in wooden battens storage structure with galmenium sheet roofing and with bottom and side ventilation which was on par with the wooden battens storage structure with mangalore tiles roofing and with bottom and side ventilation) and bulbs stored in wooden battens storage structure with AC sheet roofing and with bottom and side ventilation (Table.2)

The minimum per cent of marketable bulbs was in bamboo battens thatched roof structure without bottom ventilation and maximum marketable bulbs at the end of storage period (90 DAS) was found in onion bulbs stored in T_3 (85.94%) at 90 DAS followed by bulbs stored in wooden battens storage structure with galmenium sheet roofing and with bottom and side ventilation (80.20%) which was on par with the storage structure with mangalore tiles roofing and with bottom and side ventilation (80.16%) and bulbs stored in wooden battens storage structure with AC sheet roofing and with bottom and side ventilation (80.12%) .This may be due to lowest physiological loss in weight and rotting per cent in bamboo battens storage structure with AC sheet roofing and with bottom and side ventilation. The present findings were also in confirmation with the result of Srivastava *et al*. (1997) and Sharma and Kamalesh (2000) in onion. This clearly indicates the role of ventilation for maintaining higher marketable bulbs, while the least per cent marketable bulbs obtained in T_1 (72.00%) may be due to higher weight loss and rotting. Due to lack of proper ventilation in thatched roof structure without bottom ventilation the per cent rotting was more and hence per cent of marketable bulbs were less. (Kukanoor *et al*. 2006).

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Seasonal Variation in Physico-Chemical and Microbiological Analysis of Sewage Water in Gwalior City, India

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***Abstract*:** The present studies were undertaken to assess the pollution level in sewage water in different season such as summer (April), monsoon (July) and winter (December). Sewage water samples were analyzed for various physico-chemical parameters like colour, temperature, taste, pH, turbidity, acidity, hardness, TDS, TSS, TS, chloride, alkalinity, free CO_2, carbonate, bicarbonate, sulphate, DO, BOD, COD. The bacteriological study of these samples included bacteriological parameters like Total plate count (TPC), Most Probable Number (MPN), Total Faecal Coliform (TFC) and Total Streptococcal Count (TSC) has given the information regarding the bacterial load and contamination limit. The present findings reveal that sewage water was highly polluted in summer as a result of contamination with industrial, agricultural and domestic wastes.

***Key Words*:** Dissolved oxygen, Physicochemical parameters, Seasonal variation, Waste water

Globally it has been estimated that more than 250 million cases of waterborne diseases reported each year, which results about 10 million deaths. (Javed *et al*. 2014). The most possible sources of soil and water pollutions are sewage, residues of industrial factories and intensive fertilization. The contamination and quality of irrigation water is one of the main concerns especially in the regions with limited water resources. In such region not only, the water resources should wisely be utilized at the same time should be prevented from contamination. It is especially common in developing countries, where water treatment cost is high. As there is a gradual decline in availability of fresh water for irrigation in India, the use of sewage and other industrial effluents for irrigating agricultural lands is on the rise. Therefore a continuous periodical monitoring of water quality is necessary, particularly in the area of industrial settlements, so that appropriate steps may be taken for water resource management practices.

Sewage water sample was collected in sterile plastic container near MLD Sewage treatment plant located at Morar Cant, Gwalior, (MP) March 2012 to February 2013. Water samples were collected during morning hours between 8.00 to 10.00 a.m. during summer (March to June 2012), monsoon (July to October 2012) and winter (November to February 2013).Different physico-chemical parameters (colour, turbidity, pH, acidity, alkalinity, hardness, Total Solids, Total Suspended Solids, Total Dissolved Solids, Dissolved Oxygen, Biological Oxygen Demand & Chemical Oxygen Demand) (Patil *et al*., 2012) of collected sewage water were analyzed by standard procedures (APHA, 1995, Usharani *et al*., 2010).

The alkaline pH was also recorded throughout the year. The transparency of the water (turbidity) shows that water is more turbid in monsoon and least turbid in winter. In monsoon months the flushing of water from the catchment area were increases the turbulence and suspension of particles, whereas in winter the settlement of silt, clay and heavy suspended particles result in least turbidity in winter. The alkalinity & acidity both were observed lowest during summer which followed by monsoon and highest during winter due to the decomposition of organic matter in water body whereas lowest alkalinity during summer followed by monsoon. The sewage water was alkaline which consisted of soap water, feces, urine and garbage from domestic source. The increase level of carbonate and bicarbonate in the sewage water might be due to flushing of amount of carbonate and bicarbonate through the sewage water and biological activity, procuring CO_2 which dissolved in sewage water to form carbonate and then bicarbonate.

The highest hardness was measured in winter and lowest in summer. Kaur and Sharma (2001) reported maximum hardness in summer. The increase in hardness can be attributed to the decrease in water volume and increase in the rate of evaporation at high temperature.

The lowest amount of free carbon dioxide was recorded in monsoon and highest in summer due to the decomposition of organic matter. The free CO_2 was fast during summer whereas it is low during monsoon. The pollution has a direct relationship with the total solids going in full agreement with the present investigation, but the maximum value of these solids has been noticed during rainy season while in present study, the maximum value was recorded in summer as has also been noticed.

The lowest concentration of chloride was observed in winter and highest in summer. The low concentration of chloride was observed in winter by Venkatesharaju *et al*.,

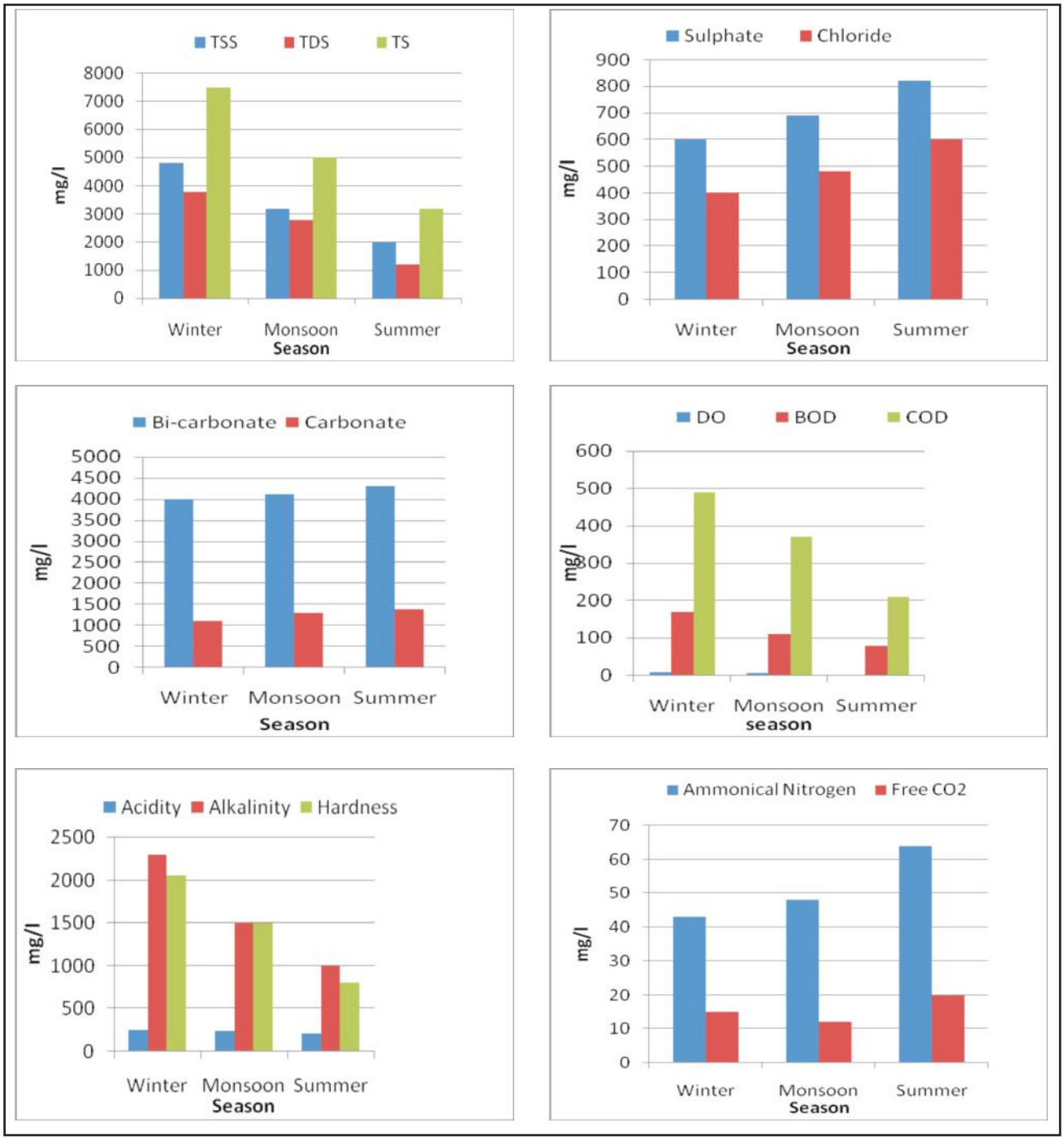

Fig. 1. Seasonal variation in physico-chemical parameters of sewage water sample

Table 1. Seasonal variation in microbiological parameters (TPC, MPN, TFC and TSC) of sewage water

S.N.	Microbiological parameters	Summer	Monsoon	Winter
1	Total plate count (TPC)	$12X10^{11}$	$10X10^{8}$	$5X10^{7}$
2	Most probable number (MPN)	1600	540	110
3	Total faecal count (TFC)	$11X10^{5}$	$8X10^{4}$	$5X10^{3}$
4	Total streptoccal count (TSC)	$7X10^{3}$	$5X10^{3}$	$3X10^{2}$

(2010). The highest content of sulphate was recorded during summer; the high value might be due to low water level during summer supported by Shinde *et al*. (2011).

The high level of ammonical nitrogen was recorded in summer which may be due to heavy rainfall & flushing of agricultural water into sewage water.

Dissolved oxygen was recorded maximum in winter and lowest in summer may be due to the low solubility at high temperature and high degradation of organic substances. They reported the maximum value of dissolved oxygen in winter in sewage waste water. The BOD & COD are the parameters of pollution, the higher load of them produced obnoxious conditions in the environment and they are directly concerned with the productivity. The carbon and nitrogen is also associated with the pollution and they hold a key position in bio-fertility.

Microbiological parameters: Total bacterial load were found to be higher in summer season than the respective level found in monsoon and winter. Higher bacterial population during summer due to higher faecal inputs into sewage water from various sources (Kolarevic *et al*. 2012).

Escherichia coli & *Klebsiella pneumoneae* are included in the faecal coliforms. All the water samples were contaminated with more number of faecal coliforms. The more number of faecal coliform indicated the presence of faecal material from warm blooded animals. The faecal streptococci group comprises of *Streptococcus faecalis, S. bovis, S. equinus and S. avium* since they commonly inhabit the intestinal tract of human and warm blooded animals. The faecal streptococci group ($11X10^5$ in summer) was found in summer in the sewage water samples. The reason for the high number of faecal streptococci might be due to addition of human and warm blooded animal excreta. The bacterial parameters such as TPC ($12X10^{11}$), MPN (1600), TFC ($11X10^5$) and TSC ($7X10^3$) exceeded the standard limit. Therefore sewage water must be pretreated and then disposed of into the environment for avoiding health hazards.

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Effect of Mineral Supplementation on Production Status of Buffaloes Fed on Forage Based Diet

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***Abstract*:** Mineral mixture supplementation to animals was given and its effect on problems of anoestrous, repeat breeding and vaginal prolapse was studied for three years under field conditions. Selected animals were subsequently given three treatments viz. Control, T1 and T2. Control group was fed for 2 months as per the farmers practice i.e green fodder and rice bran/ mustard seed cake/ cereal grains. The animals that did not respond to control treatment were treated with T1 for another 2 months in which animals were fed with green fodder and concentrate mixture but without mineral mixture (T1). The animals that did not respond to T1 were treated with T2, in which T1 was supplemented with mineral mixture and iodized salt, again for two months (T2). Mean of 3 years data indicated that in T1, 7.6% animals responded positively to anoestrous and 17% to repeat breeding. But under T2 treatment, 2 out of 9 animals responded positively to prolapse while 74% and 61% animals recovered from problems of anoestrous and repeat breeding. In case of milk yield and milk fat also, T2 was significantly better than T1 and control while T1 and control were statistically at par. Under T2 the profit earned by selling the milk was significantly greater than T1 and control.

Key Words: Anoestrous, Milk fat, Milk yield, Mineral mixture, Prolapse, Repeat breeding

Nutritional level of the diet of animals has a direct effect on their breeding, gestation and parturition (calving). While both overfeeding and underfeeding of the animals is detrimental to their normal reproductive function, so is the unbalanced supply of nutrients. Protein and energy are the nutrient components needed in the largest quantities and directly affect condition scores and normal reproductive performance of dairy animals (Blezinger 2005). Some minerals act directly on reproductive organs and some through hypophyseal-pituitary activity. Their deficiency impairs enzymatic and hormonal activity, thereby the effect is observed in the form of low producing, anoestrous and repeater animals. In the field, mineral deficiencies are a very common problem in dairy animals. Animals are mostly reared on forage and the mineral supplementation is not a regular feature. Dairy farmers especially the small farmers and those who have dairy as subsidiary occupation usually feed the minerals and even the concentrate feed only during late pregnancy and early lactation. Keeping in view the above cited problems, this study was planned to assess the effect of mineral supplementation in animals on anoestrous, repeat breeding and vaginal prolapse under field conditions.

A three year study from 2010-11 to 2012-13 was planned at local dairy farms of Ropar district of Punjab in buffaloes' reproductive problems, which are common under field conditions due to unbalanced diet of animals. A total of 144 buffaloes were selected from 25 villages of Ropar district of Punjab during three years of study. The buffaloes selected were those showing either Anoestrous since six months from parturition or Repeat breeding consecutively for three times or prolapse. In case of animals showing prolapse study was conducted for three months with one month each for each group. Animals were physically examined and ensured that no persistent corpus leuteum or follicle was there. It was also ensured that the above cited problems are not due to some infective disorder. Twenty five villages selected followed similar management practices. Animals were being given forage based diet without any mineral supplementation. Even the practice of feeding concentrate mixture was quite irregular; rather sole feeding of either oilseed cake or rice bran or rice polish was being done. Animals were fed green fodder, some dry fodder/straw, mustard oil cake or rice bran. No mineral mixture was given.

The selected problematic buffaloes were exposed to 3 treatments subsequently viz. control, T1 (Green fodder and concentrate mixture without mineral mixture and T2 (Green fodder and concentrate mixture with mineral mixture and iodized salt) for a period of 2 months under each treatment. Under control, the group of animals was fed for 2 months as per the farmers practice i.e. green fodder and rice bran/ mustard seed cake/ cereal grains, and the response was observed. The animals that did not respond positively to control treatment were treated with T1 for another 2 months in which animals were fed with green fodder and concentrate mixture but without mineral mixture. The data of animals that recovered with T1 treatment was recorded and the animals which did not show improvement in any condition were treated with T2, in which, in addition to T1, 2 kg mineral mixture and 1 kg iodized salt per quintal of feed was added. T2 also continued for two months. Results were compiled to see the effect of feeding concentrate mixture instead of individual ingredients and subsequent effect of feeding mineral mixture along with concentrate mixture on the above cited problems of anoestrous, repeat breeding and prolapse.

Statistical analysis was done as per Chi square test (X^2) and equality of proportions was estimated for anoestrous, repeat breeding, prolapse, milk yield and milk fat percentage. The profit per day was calculated by subtracting the amount incurred on daily dose of mineral mixture (other costs being constant) from the sale of extra milk yield obtained due to feeding of mineral mixture. The mineral mixture fed to the animals had following composition:

Name of the salt	%age
Dicalcium Phosphate (IG)	55.0
Limestone powder (IG)	32.0
Magnesium Sulphate (IG)	10.0
Ferrous Sulphate (IG)	2.00
Copper Sulphate (IG)	0.5
Mangenese dioxide (LR)	0.55
Zinc Sulphate (IG)	0.25
Cobalt Chloride (LR)	0.08
Potassium Iodide (LR)	0.1

The mean data of 3 years indicates that out of average of 17 animals that were showing the symptoms of anoestrous, none of them recovered in control group, but 7.6 % animals out of 17 recovered when they were fed with T1 group where only concentrate mixture was supplemented which meant that animals were suffering from nutritional deficiency other than that of minerals (Table 1). Rest 15 animals when shifted to T2 group and were given concentrate mixture and mineral mixture, and 74.5 % animals recovered from the problem of anoestrous. It can be concluded that as none of the animals recovered in control group and there was a minimal animal's recovery in the T1 feeding group while a big chunk (74.5%) of animals recovered in T2 feeding group, most of the selected animals were having mineral deficiency due to which they were behaving infertile this condition was corrected by use of mineral mixture. In the case of animals with the problem of repeat breeding also, none of the animals recovered in control group, 17.1 % recovered in concentrate mixture group (T1) but 61.1% recovered after feeding mineral mixture supplemented concentrate mixture (T2). *Selvaraju et al.* (2009) concluded that after receiving mineral mixture, among the postpartum anoestrus animals, 84.21 and 85.71% exhibited estrus and conceived, respectively, within 2 months of ASMM (Area specific Mineral mixture) supplementation. Among the repeat breeders, 78.6% conceived within 2 inseminations. Similar results were recorded by Gupta *et al*. (2012) for anoestrous and repeat breeding. Results were not that satisfying in case of prolapse, where only 21.5 % animals showed signs of recovery under T2 group while none of the animals recovered in control and T1 group. These animals did not show complete recovery from the problem rather the severity was reduced The response could be low due to possibly inherited nature of prolapse and secondly that reason of prolapse is muscular weakness (Powell, 2005).

In case of anoestrous the Chi Square (X^2) test value was found to be highly significant establishing that proportion of cured animals in all the three treatments were not equal, further paired comparisons were made and found that there was no significant difference between Control and T1 whereas T2 differed highly significantly from Control as well as T1. While for the repeat breeders, the test value differed significantly among all the three treatments (Table 2). Further paired comparisons revealed that there was significant difference between Control and T1, T1 and T2 and also Control and T2. This indicates that while T2 had larger impact on curing repeat breeders, T1 also showed some impact but not as much as T2. This result is in accordance with study conducted by Devasena *et al*. (2010) and Mohapatra *et al*. (2012) who also indicated improvement in anoestrous and repeat breeding status after feeding mineral mixture.

In case of prolapse neither of the two treatments (Control or T1) showed any effect on curing prolapse, while

Table 1. Effect of feeding mineral mixture on reproductive problems of animals

Year		Response to A noestrous (No. of animals)		Response to R epeat breeding (No. of animals)		Response to P rolapse (No. of animals)	
		Initial no. of animals	Positive response	Initial no. of animals	Positive response	Initial no. of animals	Positive response
2012 -13	Control	16	0	19	0	7	0
	T1	16	1	19	2	7	0
	T2	15	12	17	11	7	2
2011 -12	Control	20	0	28	0	8	0
	T1	20	2	28	5	8	0
	T2	18	13	23	14	8	2
2010 -11	Control	15	0	18	0	13	0
	T1	15	1	18	4	13	0
	T2	14	10	14	8	13	2
Mean	Control	17.0	0.0	21.7	0.0	9.3	0.0
	T1	17.0	1.3	21.7	3.7	9.3	0.0
	T2	15.7	11.7	18.0	11.0	9.3	2.0

Table 2. Percentage of animals that recovered from their respective problems in Control*, T1** & T2 group

Year	% of animals recovered in T1group		% of animals recovered in T2 group		
	Anoestrous	Repeat breeder	Anoestrous	Repeat breeder	Prolapse
2012 -13	6.3	10.5	80.0	64.7	28.6
2011 -12	10.0	17.9	72.2	19.6	25.0
2010 -11	6.7	22.2	71.4	57.1	15.4
Mean	7.6	17.1	74.5	61.1	21.5
Proportion of cured animals	0.078	0.17	0.74	0.62	0.21

*None of the animals recovered from any of the condition in control group
**None of the animals recovered from prolapse in T1 group

Table 3. Proportions of milk productivity and its economics as affected by different treatments

Treatments	2012-13	2011-12	2010 -11	Totals	Treatment Means
Daily Increase in Milk Yield(ltr)					
C	0.06	0.04	0.04	0.14	0.05
T1	0.21	0.09	0.15	0.45	0.15
T2	0.41	0.49	0.54	1.44	0.48
				C.D.	0.13
Increase in Milk Fat %					
C	0.03	0.01	0.01	0.05	0.02
T1	0.03	0.15	0.17	0.35	0.12
T2	0.17	0.19	0.255	0.61	0.20
				C.D.	0.11
Additional Profit Rs/day					
C	2.1	1.4	1.4	4.9	1.64
T1	7.35	3.15	5.25	15.75	5.25
T2	8.68	11.67	13.4	33.75	11.25
				C.D.	4.83

T3 gave a comparatively better impact, though the proportion of animals which improved was not big enough but it was statistically significantly better than T1 and Control (Table 2). This recovery was possibly due to the fact that level of micro and macro minerals is lowered down in animals suffering from prolapse (Ahmad *et al*., 2005 and Bhatti *et al*., 2006). The T2 was significantly better than T1 and control but statistically there was no difference observed between T1 and Control with respect to milk yield (Table 3) while it was not so in the case of milk fat percentage, where T2 was significantly better than Control but not from T1, whereas, T1 was at par with Control. Tiwari *et al*. (2012) also observed that mineral mixture supplementation not only increased the milk yield but also made it persistent in lactating (pregnant) and lactating (non-pregnant) animals.

Blood serum calcium and phosphorus concentrations were also increased significantly and reached above their critical levels (8.00 mg/dl and 4.00 mg/dl respectively) in all categories of animals. The serum zinc, manganese and copper concentration also increased but not significantly due to dietary supplementation of these minerals. The additional profit per day was significantly greater in T2 than T1 and control. T1 and control were statistically at par (Table 3).

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