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# Studies on Effect of Cd and Hg on Biochemical Characteristics of *Populus deltoides* (W. Bartram ex Marshall) and its Uptake

**K.R. Phimu, Meena Thakur[1], Anchal Rana[*] and Shreya Handa**

*Department of Environmental Science, [1]Department of Entomology,*
*Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan-173 230, India.*
**E-mail: anchal.rana89@gmail.com*

***Abstract***: A study was carried to evaluate the performance of *Populus deltoides* seedlings grown under stressed condition with different doses of Cd and Hg in pot experiment. Cadmium had significant effect on all the biochemical parameters and mercury had significant effect on chlorophyll and total soluble sugar content. Cd had significant effect on the phenol content of *P. deltoides*, highest phenol content was observed at 20 ppm of Cd (4.72 mg $g^{-1}$), whereas, Hg and the combination of the metals had non-significant effect. The observed ability of *P. deltoides* to continue growth even at higher doses of Cd and Hg and the ability to accumulate metals in its tissues demonstrated its resistance to moderate to high levels of metals. The present study widens the scope for recording the effect of higher concentration of heavy metals beyond 20 ppm in future to confirm the phyto-remediation ability of this species.

***Keywords***: Cadmium, Heavy metals, Mercury, *Populus deltoides*, Phyto-remediation

Environment pollution is one of the severe problem the world is facing today. Our planet is becoming increasingly polluted with organic and inorganic compounds, primarily as a result of human activities. There is growing concern on presence of heavy metals in the environment. Toxic heavy metals in air, soil and water are global threats to the environment. Anthropogenic activities viz., mining, fossil fuel combustion, smelting and agricultural processes have locally increased the concentration of heavy metals such as cadmium, copper, chromium, lead, arsenic, nickel, mercury etc. in the soil up to levels that are dangerous for plants, animals and human beings (Sharma and Agarwal, 2005; Florea and Busselberg, 2006; Srinidhi *et al.,* 2007). Heavy metals when present in the soil, they are translocated to different parts of the plant thereby affecting various plant biochemical parameters (Pandey and Tripathi, 2011). Heavy metals have great environmental concern, as they are non-degradable and built-up to high concentrations in contaminated land and water, which affect harmfully all types of living organisms including the human being (Gupta *et al.,* 2000). At low concentrations, Cd is not toxic to plants but retards root growth and cell division, whereas, at higher concentration it inhibits chlorophyll biosynthesis and decreases total chlorophyll content and chlorophyll a/b ratios. It is frequently accumulated by agriculturally important crops and enters the food chain with a significant potential to impair animal and human health (Di Toppi and Gabrielli, 1999).

Mercury (Hg) enters into the environment from industrial emissions, use of mercuric chloride, fungicides such as mancozeb (16% Mn and 2% Hg), Zineb and Ziram (1-18% Hg) in agriculture is another source of mercury in the environment. High concentration of $HgCl_2$ causes significant decline in chlorophyll content which in turn lead to depletion in primary and total production. If Hg enters into aquatic systems, it undergoes chemical conversion from one form to the other in a cyclic manner. Mercury is a unique pollutant and oscillates between all the phases of the environment (Brosset, 1981) with high tendency for bio-magnification in trophic levels. It affects photosynthesis and oxidative metabolism of plants by interfering with electron transport in chloroplasts and mitochondria. Toxic level of $Hg^{2+}$ can induce visible injuries and physiological disorders in plants. High concentration of these metals in the environment act as stress factors causing physiological changes in the plant resulting in reduced vigour or in extreme case death of the plant. In the present study, *P.deltoides* seedlings were grown at graded doses of Cd + Hg and its impact was studied on various biochemical parameters of the seedlings.

## MATERIAL AND METHODS

The present investigation was carried out in experimental pots of Department of Environmental Science, College of Forestry, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh during the year 2014-2015. The farm is located at an altitude of 1273 m amsl and at an latitude of 35.5°N, longitude of 77.8°E, which falls in the mid hill zone of Himachal Pradesh having sub-temperate and semi-humid type of climate. The annual maximum and minimum temperature of the region ranges from 17.3°C to 32.6°C and 2.4°C to 18.6°C, respectively,

whereas, the annual rainfall is between 1000-1300 mm (average 1150 mm). About 70 per cent of rainfall is received in the monsoon season i.e. during June to September. Mean temperature during the crop season varied from 11.77–25.22°C, while the relative humidity was in the range of 41-60 per cent.

Young cuttings of uniform size from one year old cut back stems and branches of *P. deltoides* were planted in pots. The growing media was prepared by using sand, soil and FYM in the ratio 1:1:1. The cuttings sprouted completely after 30-40 days of planting and the selected treatment combinations were applied after complete establishment of the seedlings. In order to study the effect of cadmium and mercury toxicity on seedlings of *P. deltoides,* field experiment was conducted by applying four levels of heavy metals viz. 0, 5, 10 and 20 ppm each of Cd and Hg. Cd was applied through $CdCl_2.H_2O$(M.W. 201.324 g/mol) and Hg through $HgCl_2$ (M.W. 271.524 g/mol). In the field experiment, *P. deltoides* seedlings were exposed to a total of 16 treatment combinations of Cd and Hg as per the detail given below: $T_1(Cd_0Hg_0)$, $T_2(Cd_0Hg_5)$, $T_3(Cd_0Hg_{10})$, $T_4(Cd_0Hg_{20})$, $T_5(Cd_5Hg_0)$, $T_6(Cd_5Hg_5)$, $T_7(Cd_5Hg_{10})$, $T_8(Cd_5Hg_{20})$, $T_9(Cd_{10}Hg_0)$, $T_{10}(Cd_{10}Hg_5)$, $T_{11}(Cd_{10}Hg_{10})$, $T_{12}(Cd_{10}Hg_{20})$, $T_{13}(Cd_{20}Hg_0)$, $T_{14}(Cd_{20}Hg_5)$, $T_{15}(Cd_{20}Hg_{10})$ and $T_{16}(Cd_{20}Hg_{20})$.

**Chlorophyll content:** The leaf chlorophyll content was estimated by the method of Hiscox and Israeistam (1979).

**Phenol content:** The phenol content in plant samples was estimated by Bray and Thorpe method (1954). The optical density (O.D) values of the above extract were recorded on Spectrophotometer (Model-Spectronic-20D) at 650 nm wavelength against standard catechol blank.

**Total soluble sugar content:** Total sugar content in leaves of *P. deltoids* was estimated by colorimetric method, which is based on the principle of dehydration of carbohydrate present in the leaves with concentrated $H_2SO_4$ to produce furfural derivatives and phenol, which develops colour indicative of TSS content (Dubois *et al.*, 1956). The results were expressed in mg $g^{-1}$.

**Uptake of Cd and Hg in plant:** The dried leaf, stem and root samples were digested in di-acid ($HNO_3$ + $HClO_4$) mixture by taking 1 gm of sample as per standard procedure given by Singh *et al.* (2005). Heavy metals *viz*; Cd and Hg were estimated by using Inductively Coupled Plasma Emission Spectrometer (Model-ICAP 6300 Duo) and concentration was expressed as mg $kg^{-1}$.

Cd and Hg uptake was estimated by using the following formula:

$$\text{Uptake} = \frac{\text{(Leaf Nutrient, \% x Leaf dry weight) + (Shoot nutrient, \%, x Shoot dry weight) + Root nutrient, \% x Root dry weight x 1000}}{100}$$

## RESULTS AND DISCUSSION

The observation of chlorophyll content, total soluble sugar content and phenol content are presented in Table 1. The application of heavy metals caused the chlorophyll content of *P. deltoides* leaves to decrease with increasing metal concentrations though there was no statistical interaction effect (Table 1). The chlorophyll content in leaves ranged from 1.66 mg $g^{-1}$ at the highest applied dose ($Cd_{20}Hg_{20}$) to 2.19 mg $g^{-1}$ at control ($Cd_0Hg_0$). For Cd, the highest chlorophyll content (2.02 mg $g^{-1}$) was recorded at 0 ppm, whereas, lowest was recorded at 20 ppm (1.68 mg $g^{-1}$). Nikolic *et al.* (2008) reported that chlorophyll content of hybrid poplar (*Populus nigra* × *P. maximowitzii*) at two cadmium concentrations ($10^{-5}$ M and $10^{-4}$ M) decreased with increase in concentration of Cd. Pollaco (1997) reported that loss in chlorophyll content may be due to interference of metals with chlorophyll synthesis inhibiting photosynthesis and nutrient uptake. Cd is known to substitute $Mg^{2+}$ in chlorophyll and thus cause reduction in photosynthesis of plants.

Hg application also influenced the chlorophyll content of *P. deltoides* significantly. Highest chlorophyll content (1.92 mg $g^{-1}$) was recorded at Hg0 ppm, which decreased to 1.78 mg $g^{-1}$ at Hg 20 ppm. Higher concentration of Hg i.e. 10 and 20 ppm were statistically superior and at par with each other with respect to control. The results obtained from the study can be supported from the findings of Das *et al.* (2013) who reported 39.13 per cent decrease over control in chlorophyll content of *Hydrilla* plant grown in experimental ponds contaminated with 25 mg Hg. 36.02 per cent reduction in chlorophyll content in pigeon pea was recorded when the seeds were treated with 20 mg $l^{-1}$ of $HgCl_2$ over control (Aruna and Mohanty, 2014). The impaired chlorophyll development by heavy metals may be due to their interference with synthesis of proteins, the structural components of chloroplast (Nag and Mukherji, 1981). Decrease in chlorophyll is reported as a primary bio-indicator of Hg and Cd phytotoxicity (Aruna and Mohanty, 2014).

Total soluble sugar is an important constituent manufactured during photosynthesis and breakdown during respiration by the plants. In the present study, different Cd and Hg doses resulted in significant decrease in total soluble sugar content in leaves of *P. deltoides* seedling (Table 1). Significantly, highest soluble sugar content of 0.46 mg $g^{-1}$ was recorded at Cd 0 ppm i.e. where no Cd was applied and maximum sugar content of 0.20 mg $g^{-1}$ was recorded at 20 ppm of Cd concentrations. Increasing Cd doses resulted in significant decrease in total soluble sugar content in leaves of seedlings. Plucinska and Stobrawa (2004) also reported less carbohydrate parameters viz., sucrose, glucose and galactose content in *P. deltoides* plants grown in heavy metal

**Table 1.** Effect of graded doses of Cd and Hg on chlorophyll content, total soluble sugar content and phenol content (mg $g^{-1}$) in leaves of *P. deltoides*

| Hg Level / Cd Level | Chlorophyll Content | | | | | Total Soluble Sugar Content | | | | | Phenol Content | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Hg (0ppm) | Hg (5ppm) | Hg (10ppm) | Hg (20ppm) | Mean | Hg (0ppm) | Hg (5ppm) | Hg (10ppm) | Hg (20ppm) | Mean | Hg (0ppm) | Hg (5ppm) | Hg (10ppm) | Hg (20ppm) | Mean |
| Cd (0 ppm) | 2.19 | 2.05 | 1.96 | 1.89 | 2.02 | 0.53 | 0.48 | 0.41 | 0.41 | 0.46 | 1.96 | 1.49 | 1.89 | 2.46 | 1.94 |
| Cd (5 ppm) | 1.94 | 1.89 | 1.78 | 1.85 | 1.86 | 0.44 | 0.4 | 0.31 | 0.31 | 0.36 | 2.66 | 2.58 | 2.91 | 2.79 | 2.74 |
| Cd(10 ppm) | 1.84 | 1.76 | 1.81 | 1.7 | 1.78 | 0.33 | 0.24 | 0.23 | 0.23 | 0.25 | 3.5 | 4.67 | 4.01 | 4.53 | 4.18 |
| Cd(20 ppm) | 1.7 | 1.69 | 1.68 | 1.66 | 1.68 | 0.26 | 0.18 | 0.19 | 0.19 | 0.2 | 4.42 | 5.05 | 4.88 | 4.54 | 4.72 |
| Mean | 1.92 | 1.85 | 1.81 | 1.78 | | 0.39 | 0.32 | 0.28 | 0.28 | | 3.14 | 3.45 | 3.41 | 3.58 | |
| CD (p=0.05) | | | | | | CD (p=0.05) | | | | | CD (p=0.05) | | | | |
| Cd : 0.100 | | | | | | Cd: 0.07 | | | | | Cd : 0.62 | | | | |
| Hg : 0.100 | | | | | | Hg : 0.07 | | | | | Hg : NS | | | | |
| Cd × Hg: NS | | | | | | Cd × Hg : NS | | | | | Cd × Hg : NS | | | | |

polluted sites as compared to unpolluted sites.

Pandey and Tripathi (2011) reported that soluble sugar content of *Albizia procera* decreased with increasing concentration of heavy metals viz., Pb, As and Cd. Soluble sugar an important constituent is manufactured during photysynthesis and breakdown occurs during respiration by plants. The low sugar levels may be due to lowered synthesis or diversion of the metabolites to other synthesis processes (Hemalatha *et al.,* 1997). The decreasing trend in total sugar content with increase in the concentration of heavy metals in the soil of *P. deltoides* seedlings find support from the study of Aruna and Mohanty (2014) who also reported decreasing trend in sugar content of pigeon pea (*Cajanus cajan*) with increase in concentration of $HgCl_2$ and $CdCl_2$ (1, 5, 10, 20 $mgl^{-1}$). Das *et al.* (2013) reported that the protein and sugar content of *Hydrilla* plant grown in ponds contaminated with Cd and Hg was worst effected among all the biochemical parameters studied. A decrease of 68.13 and 72 per cent was recorded with Hg and Cd, respectively.

An increase in the phenol content with increasing doses of Cd and Hg was observed. The range of phenol content in leaves was 1.49 to 5.05 mg $g^{-1}$ at various levels of heavy metals though there was no significant interaction effect (Table 1). Application of graded doses of cadmium has significant effect on the phenol content of *P. deltoides*. Irrespective of Hg, highest phenol content was observed at 20 ppm of Cd (4.72 mg $g^{-1}$) followed by 10 ppm Cd (4.18 mg $g^{-1}$). Different doses of Hg resulted in non-significant influence on phenol content of *P. deltoides.* In general, there was increase in phenol content with increase in heavy metal concentrations indicating the protective role of phenols to plants. The present findings are in conformity with the findings of Gasecka *et al.* (2012) who reported rapid increase in total phenol content of *Salix viminalis* L**.** at increased copper level. Serving as chelators and antioxidants, the phenol content plays a protective role for plants and controls the oxidative stress under abiotic and biotic stress conditions (Michalak, 2006).

In the present study, high level of polyphenols may be due to foliar injuries like chlorosis and necrosis caused by metal toxicity on plants as observed. Increased level of polyphenols may be considered a signal of stress due to pollution or some other injury. Pandey and Tripathi (2011) also reported increase in polyphenol per cent content in *Albizia procera*, 4.2 per cent phenol content was recorded at Cd 10 ppm as compared to 2.92 in control. In their study, the increase in polyphenol content was more under arsenic and lead stress conditions. Polyphenols are found in all parts of the plant and offer resistance against diseases and pests. The concentrations of phenols can alter with the altered natural environmental conditions and increase in the tissues

surrounding a wound (Stafford, 1987).

The heavy metal concentration in leaves ranged from 0.060-0.496 mg $kg^{-1}$ and 0.073-0.247 mg $kg^{-1}$ for Cd and Hg, respectively (Table 2). Statistically, lowest content of Cd (0.060 mg $kg^{-1}$) was recorded at $T_3$ where no Cd treatment was applied, whereas, the highest concentration (0.496 mg $kg^{-1}$) was recorded at $T_{13}$ where 20 ppm of Cd was added to soils of *P. deltoides* seedlings. Accumulation of Hg in leaves of P. *deltoides* showed increasing trend i.e. with increase in Hg doses, there was a considerable increase in concentration of Hg in the leaves. Significantly, highest Hg concentration of 0.247 mg $kg^{-1}$ was found in $T_{16}$ (20 ppm of Hg) and lowest concentration of 0.073 mg $kg^{-1}$ was observed in control. The analysis of metal content in plant tissues revealed that the metals taken up by the plant go to the aerial tissues. The Hg content of aerial tissues was relatively lower than that of cadmium. Cadmium appears to be more mobile within the plant, so that the highest accumulation was in roots, followed by stem and leaves. There may be an antagonistic effect between Cd and Hg, which may influence the transport and bioaccumulation of Hg in aerial parts of seedlings. Antagonistic effect of Cd and Zn has been reported by Pichtel *et al.* (2008) that suppresses bioaccumulation and reduces uptake of heavy metals. The findings are supported by the results of Borghi*et al.* (2007, 2008) who reported that poplar clone grown with copper has higher copper concentration in leaves than in control plants and highest copper content was in root parts followed by stem and leaves of *P. alba* and *P. canadensis*.

The data presented in Table 2, shows the concentration of Cd and Hg accumulated in soils of *P. deltoides* when exposed to Cd and Hg doses for long period. In respect to Cd, in treatments $T_1$, $T_2$, $T_3$ and $T_4$ no Cd application was applied but its content ranged from 0.07-0.86 mg $kg^{-1}$, these treatments were statistically at par with each other with respect to Cd content. In treatments $T_5$, $T_6$, $T_7$ and $T_8$ where Cd 5ppm alone and Cd 5ppm and different levels of Hg (5,10 and 20 ppm) were applied, the Cd concentration ranged from 2.75-2.87 ppm and the values were statistically at par with each other indicating no interaction effect of Hg. Similarly at Cd 10 ppm alone and in interaction with different levels of Hg (5, 10 and 20 ppm) the Cd concentration in soil ranged from 4.04-5.13 mg $kg^{-1}$. With increase in Cd concentration to 20 ppm the accumulation of Cd in *P. deltoides* also increased, which varied from 6.83-7.78 mg $kg^{-1}$. In treatment $T_1$ and $T_3$ no Cd was applied and its concentration was below permissible level for soil ( 0.01-0.70 mg $kg^{-1}$). Similarly in treatments $T_1$, $T_6$, $T_9$ and $T_{13}$ where Hg was not applied, its concentration in soil varied from 1.35-1.47 mg $kg^{-1}$ which was below permissible level of 2 mg $kg^{-1}$ of Hg for soil. There was increase in accumulation of Hg with increase in the doses of Hg.

It is evident from the data that uptake of Cd and Hg

**Table 2.** Concentration and uptake of Cd and Hg in *P. deltoides*

| Treatments | Concentration of Cd and Hg in Leaves (mg $kg^{-1}$) | | Concentration of Cd and Hg in Soil (mg $kg^{-1}$) | | Uptake in plants(mg $plant^{-1}$) | |
|---|---|---|---|---|---|---|
| | Cd | Hg | Cd | Hg | Cd | Hg |
| T1 (Cd0Hg0)- control | 0.060 | 0.073 | 0.07 | 1.35 | 0.020 | 0.016 |
| T2 (Cd0Hg5) | 0.208 | 0.085 | 0.86 | 5.2 | 0.035 | 0.038 |
| T3 (Cd0Hg10) | 0.153 | 0.115 | 0.76 | 8.71 | 0.033 | 0.058 |
| T4 (Cd0Hg20) | 0.205 | 0.182 | 0.84 | 11.91 | 0.028 | 0.056 |
| T5 (Cd5Hg0) | 0.240 | 0.079 | 2.75 | 1.45 | 0.035 | 0.016 |
| T6 (Cd5Hg5) | 0.222 | 0.138 | 2.74 | 5.59 | 0.035 | 0.020 |
| T7 (Cd5Hg10) | 0.228 | 0.098 | 2.87 | 10.59 | 0.044 | 0.040 |
| T8 (Cd5Hg20) | 0.186 | 0.195 | 2.81 | 10.91 | 0.037 | 0.120 |
| T9 (Cd10Hg0) | 0.271 | 0.122 | 4.04 | 1.47 | 0.031 | 0.020 |
| T10 (Cd10Hg5) | 0.236 | 0.119 | 4.31 | 6.91 | 0.039 | 0.034 |
| T11 (Cd10Hg10) | 0.266 | 0.179 | 4.46 | 11.73 | 0.035 | 0.036 |
| T12 (Cd10Hg20) | 0.438 | 0.226 | 5.13 | 12.72 | 0.038 | 0.046 |
| T13 (Cd20Hg0) | 0.496 | 0.129 | 7.43 | 1.4 | 0.055 | 0.039 |
| T14 (Cd20Hg5) | 0.481 | 0.209 | 7.74 | 7.71 | 0.048 | 0.041 |
| T15 (Cd20Hg10) | 0.484 | 0.233 | 6.83 | 10.39 | 0.043 | 0.070 |
| T16 (Cd20Hg20) | 0.441 | 0.247 | 7.78 | 13.19 | 0.044 | 0.084 |
| CD (p=0.05) | 0.042 | 0.040 | 1.18 | 1.37 | 0.010 | 0.013 |

ranged significantly from 0.020-0.055 and 0.016-0.120 mg plant$^{-1}$, respectively (Table 2). Significantly, highest uptake of Cd (0.055 mg/plant) was observed in $T_{13}$ treatment ($Cd_{20}Hg_0$) whereas, lowest (0.020 mg plant$^{-1}$) was observed in control where no heavy metal treatment was applied. The seedlings grown in soils with no added Hg resulted in lowest uptake in plants i.e.0.016 mg/plant, whereas, significantly highest Hg uptake was found in $T_8$ ($Cd_5Hg_{20}$ ppm), where the uptake value was recorded as 0.120 mg plant$^{-1}$. The present trend is in line with Kuzovkina *et al.* (2004) who also observed similar trends while studying the uptake of Cd and Cu in different species of willow. In present investigation, there was significant increase in the concentration of Cd and Hg in plant tissues of *P. deltoides* upon exposure to high concentration in soil and the concentration varied among plant tissues. Similar findings were obtained by Sebastiani *et al.* (2004) who reported that maximum heavy metal uptake was found in treated plants of poplar clone than control plants. They also reported that copper uptake in leaves of treated plants was higher than in control plants. The observation of Moffat *et al.* (2001) on 3-year-old poplar clones (*P. trichocarpa* × *P. deltoides*) and *P. trichocarpa* proved that the uptake ratio for heavy metals in plants grown in soils treated with industrial waste increased as compared to control.

## CONCLUSION

Contamination of agricultural soils by spraying of pesticides, use of livestock manure, fertigation and other organic waste has been reported by various workers. Cd and Hg are ubiquitous in sewage, sludges, biosolids and wastewater from industrial (e.g. tanneries), agricultural (liquid manures from industrial farming) and domestic sources that are utilized as low price fertilizers for bioenergy plantations. According to the present studies on *P. deltoides,* there was decrease in all the morphological parameters, chlorophyll content and total soluble sugar content with increase in the graded doses of Cd and Hg, except for phenol content, which increased with increase in concentration.

The observed ability of *P. deltoides* to continue growth even at higher doses of Cd and Hg and the ability to accumulate metals in its tissues demonstrated its resistance to moderate to high levels of metals. The present study widens the scope for studying the effect of higher concentration of heavy metals beyond 20 ppm in future to confirm the phytoremediation ability of this species.

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# Effective Eco-Friendly Micro-Flora for Early Degradation of Herbicide and Enhancing Chickpea Productivity

**Uma, Tapas Chowdhury, Ravindra Soni and G.L. Sharma**

*Indira Gandhi Krishi Vishwavidyalaya, Raipur-492 012, India*
*E-mail:tapas_mb@radiffmail.com*

***Abstract:*** The investigation was carried out to evaluate the effective eco-friendly microflora for early degradation of herbicide and enhancing chickpea productivity. Fifteen soil samples were collected from different plots of a long term herbicidal trail where different herbicides were applied in *kharif* and *rabi* season continuously for last five years in a rice-chickpea cropping system. Three rhizobial, four phosphobacterial, two *Azotobactor* and two *Azospirillum* isolates were isolated and 11 crop beneficial herbicide tolerant microbial isolates were identified. Among different treatments dual inoculation of rhizobial isolate *Rhizobium*-3 and phospho-bacterial isolate PSB-4 was found best for rapid degradation of herbicide pendimethalin, followed by single inoculation of phosphor-bacterial isolate PSB-4. These native isolates had highest basal soil respiration, alkaline phosphatase activity and microbial population over control at 50 days after sowing. The combined application of *Rhizobium*-3 and PSB-4 also found supreme to increase the chickpea yield at highest level followed by isolate PSB-4 by mobilizing more nitrogen and phosphorus in crop rhizosphere.

***Keywords****:* Chickpea, Isolation, Microbes, Biochemicals, Degradability, Plant growth parameter, Yield

Chemical herbicides are more probably the most important component of weed management system for most of the major crops. The ultimate destination of herbicidal chemicals is the soil where they come in contact with different microflora, which are responsible for different biochemical transformations related to mineral nutrition to plants. Different reports envisaged that herbicidal application has adverse effects on bacterial, fungal (Shukla, 1997) and actinomycetes population (Rajendran and Lourduraj, 1999). Herbicides are often applied to crops to provide season-long weed control. However, herbicidal activity is beneficial only for the time it is needed. Longer herbicide activity can cause injury to subsequent crops. Several herbicides commonly persist in the soil long enough to injure subsequent crops. In addition, misapplication, crop failures, late applications, and adverse weather conditions can result in carryover (residual) of herbicides that normally decompose slowly. Microbial decomposition is one of the most important methods by which herbicides are decomposed in soil. Microorganisms consume the herbicide molecules and utilize them as a source of energy and nutrients for their growth and reproduction. In agriculture, many crop beneficial microorganisms are used as bio-fertilizer to increase the nutrients availability and enhance crop productivity. Many of them may degrade the herbicides at a faster rate. So by exploiting them as a microbial agent we can sustain the crop productivity and conserve environment simultaneously from the toxicity of herbicides.

## MATERIAL AND METHODS

The experiment was conducted during *Kharif* 2014 at green house conditions, Indira Gandhi Krishi Vishwavidyalaya, Raipur in an Alfisol with *Rabi* season chickpea to identify suitable crop beneficial microbe(s) for rapid degradation of applied herbicides. Fifteen soil samples were collected from different plots of a long term herbicide trial where different herbicides were applied in *kharif* and *rabi* season continuously for last five years in a rice-chickpea cropping system. From these soil samples three rhizobial, four phosphobacterial, two *Azotobactor* and two *Azospirillum* isolates were collected. The experiment included 20 treatments (Table 1). The experiment was conducted on *Rabi* chickpea (*Cicer aeiritinum*) with test variety JG-130. The pendimethalin herbicide was applied at pre emergence stage of crop i.e. a day after sowing of the crop. The soil was inceptisol (pH: 11, EC: 0.35 $dSm^{-1}$, available N: 223.57 kg $ha^{-1}$, available P: 8.96 kg $ha^{-1}$, and available K: 388.86 kg $ha^{-1}$, available Zn: 1.91 ppm, available Cu: 0.66 ppm, available Fe: 2.32 ppm, available Mn: 6.22 ppm). The treatments were replicated thrice under completely randomized design. Rhizosphere soil was collected at a depth of 4.5-7.0 cm at different stages of crop growth (10, 20, 30, 40, and 50 days after sowing) of crop for the purpose of analysis. The soil samples were subjected to analysis for degradation potential of herbicide and dehydrogenase activity as per the standard procedure.

## RESULTS AND DISCUSSION

In this experiment different microbial isolates were tested

as individual or in combination to evaluate the effective eco-friendly microflora for early degradation of herbicide and enhancing chickpea productivity.

**Alkaline phosphatase activity (APA):** The application of pendimethalin significantly reduced the APA at highest level soon after its application. The reduction of APA was observed up to 20 days after sowing (DAS) of chickpea crop and there was an increment in APA from 30 DAS, which indicated the initiation of degradation of applied herbicide. At 50 DAS, all the applied rhizobial and phosphor-bacterial inoculants alone were found effective and in combination to increase the APA value significantly over control excluding dual inoculation of *Rhizobium* -1 and PSB -3, which were applied in treatment $T_{10.}$ At this stage of crop growth, the top three good performing treatments were *Rhizobium*-3+PSB-4, PSB-4 and *Rhizobium*-2+PSB-1. Wyszkowska and Kucharski (2004) also expressed similar views and mentioned that phosphatases are among those soil enzymes that usually respond negatively to herbicides. Triflurotox caused some inactivation of acid phosphatase and alkaline phosphatase (Table 1).

**Basal soil respiration:** The observed value of BSR of soil showed the reduction of rate of respiration continuously from application of pendimethalin to 20 days after sowing of crop. The above observations are in close agreement with De Lonezo *et al.* (2001), who stated that herbicides affect non target microorganism by interfering with vital process such as respiration, photosynthesis and biosynthesis reaction as well as cell growth. At 50 DAS, highest value of BSR was recorded in all the treatments compared to the observation taken earlier. This showed the highest microbial activity in the crop rhizosphere. In this experiment, all the tested isolates were found effective as individual and in combination to dissipate the applied herbicide in soil except single treatment (*Rhizobium*-3+ PSB-4), which was found at par with control in this stage of growth. Highest BSR was recorded in treatment *Rhizobium*-3+PSB-4 (0.265 mg$CO_2$) followed by single inoculation of PSB-4 (0.263 mg). The lowest performer was

**Table 1.** Effect of pendimethalin (herbicide) on alkaline phosphatase activity (µg *p*-NP/h/g) and basal soil respiration rate (mg $CO_2$/h/100g) in rhizosphere soil at different growth stages of chickpea

| Treatment | | Days after sowing | | | | | |
|---|---|---|---|---|---|---|---|
| | | 10 | | 30 | | 50 | |
| | | APA | BSR | APA | BSR | APA | BSR |
| T1 | *Rhizobium*-1 | 142.4 | 0.136 | 151.5 | 0.151 | 249.3 | 0.239 |
| T2 | *Rhizobium*-2 | 139.2 | 0.115 | 145.0 | 0.135 | 232.7 | 0.201 |
| T3 | *Rhizobium*-3 | 139.4 | 0.116 | 148.5 | 0.123 | 236.9 | 0.202 |
| T4 | PSB-1 | 142.7 | 0.139 | 151.6 | 0.118 | 250.2 | 0.241 |
| T5 | PSB-2 | 142.9 | 0.138 | 151.9 | 0.143 | 251.2 | 0.244 |
| T6 | PSB-3 | 138.9 | 0.112 | 145.0 | 0.122 | 230.8 | 0.197 |
| T7 | PSB-4 | 145.3 | 0.147 | 153.7 | 0.120 | 256.9 | 0.263 |
| T8 | *Rhizobium*-1+ PSB-1 | 140.6 | 0.126 | 150.2 | 0.137 | 245.0 | 0.220 |
| T9 | *Rhizobium*-1+ PSB-2 | 140.3 | 0.123 | 150.0 | 0.147 | 244.1 | 0.217 |
| T10 | *Rhizobium*-1+ PSB-3 | 138.2 | 0.112 | 144.7 | 0.149 | 226.7 | 0.194 |
| T11 | *Rhizobium*-1+ PSB-4 | 142.3 | 0.133 | 151.2 | 0.129 | 248.3 | 0.234 |
| T12 | *Rhizobium*-2+ PSB-1 | 142.1 | 0.143 | 152.2 | 0.120 | 253.0 | 0.257 |
| T13 | *Rhizobium*-2+ PSB-2 | 142.7 | 0.145 | 152.3 | 0.142 | 253.6 | 0.255 |
| T14 | *Rhizobium*-2+ PSB-3 | 140.8 | 0.127 | 150.3 | 0.118 | 245.6 | 0.226 |
| T15 | *Rhizobium*-2+ PSB-4 | 140.0 | 0.120 | 149.7 | 0.148 | 243.2 | 0.211 |
| T16 | *Rhizobium*-3+ PSB-1 | 140.0 | 0.120 | 149.4 | 0.131 | 241.0 | 0.210 |
| T17 | *Rhizobium*-3+ PSB-2 | 141.5 | 0.131 | 150.8 | 0.127 | 249.7 | 0.231 |
| T18 | *Rhizobium*-3+ PSB-3 | 139.6 | 0.117 | 149.1 | 0.124 | 239.2 | 0.208 |
| T19 | *Rhizobium*-3+ PSB-4 | 143.6 | 0.145 | 152.9 | 0.140 | 257.6 | 0.265 |
| T20 | Control | 138.2 | 0.110 | 144.5 | 0.117 | 220.4 | 0.192 |
| CD (p=0.05) | | NS | NS | 4.65 | 0.01 | 1.74 | 0.01 |

Initial APA value : 158.3 µg p-NP/h/g; Initial BSR value : 0.159 mg $CO_2$/h/100g

*Rhizobium*-1+PSB-3 (0.194 mg). Our results are in agreement with previous finding reported by Vidali (2001) who mentioned that soil microorganisms, which are repeatedly exposed to pesticides may develop new capabilities to degrade such chemicals (Table 1).

**Rhizobial population:** The population of *Rhizobium,* which was recorded at different growth stages of crop revealed that rhizobial population in soil was seriously affected by application of pendimethalin soon after its application. The rhizobial population in crop rhizosphere reduced at 10 DAS. At 50 DAS, maximum growth of rhizobial flora was observed in crop rhizosphere in comparison to other growth stages. In this stage, all the *Rhizobium* inoculants alone and in combination increased the rhizobial population in crop rhizosphere significantly over control. However, in case of PSB only two isolates (PSB-2 and PSB-4) were found capable to degrade the pendimethalin herbicide at a faster rate than the native micro flora existing in the soil of control. This is in agreement with works of Tu *et al*. (2001) where they mentioned that depending on concentration and microbial species, herbicides have varying effect on soil microbial populations. They observed a significant decrease in population of above microflora on the first few days after the application, but after a period of six weeks recovery to the level of control was almost reached (Table 2). Baboo *et al.* (2013) also mentioned that unintended consequence of herbicide applications may be the reduction of sensitive populations and/or stimulation of certain microbial groups with or without detriment to co-existing microbial populations that may compete for available resources. Microorganisms are a highly heterogeneous group, including aerobes and anaerobes, heterotrophs and autotrophs or saprophytes, symbionts and parasites. The fate of the herbicide residues in soil is a matter of great concern since they persist on top soil (Ayansina *et al.,* 2003).

**Phosphobacterial population:** The population data showed that the phosphobacterial population reduced in soil soon after application of the herbicide and the decrease in the population was visualized up to 20 DAS. At this stage, the reduction in PSB population was reached to a maximum. At 50 DAS, the PSB population in soil reached to a maximum in the whole crop growth period under study. At this stage, the recorded data of PSB population had shown the similar trend to that of 40 DAS. Rhizobial isolates, *Rhizobium*-2 and 3 showed at par performance to that of control in this stage. In this stage of study, highest PSB population was recorded in treatment $T_{19}$ where PSB isolates 4 was in combination with *Rhizobium* 3 boost up the PSB population in soil to the maximum (6.89 X $10^3$), followed by effective PSB isolate- 4 (6.87 X $10^5$). However, rhizobial isolate 2 as an individual had shown the minimum promotion of PSB population (6.29 X $10^5$) in soil (Table 2).

**Table 2.** Effect of pendimethalin (Herbicide) on soil rhizobial population (x$10^5$ $gm^{-1}$ soil) and phosphate solubilizing bacterial population (x$10^3$$gm^{-1}$ soil) in rhizosphere soil at different growth stages of chickpea

| Treatments | Days after sowing | | | | | |
|---|---|---|---|---|---|---|
| | 10 | | 30 | | 50 | |
| | RHIZO | PSB | RHIZO | PSB | RHIZ | PSB |
| T1 | 2.41 | 3.22 | *4.52* | 3.62 | *7.32* | 6.36 |
| T2 | 2.13 | 3.19 | 4.23 | 3.57 | 6.98 | 6.29 |
| T3 | 2.16 | 3.20 | 4.26 | 3.60 | 7.02 | 6.33 |
| T4 | 2.10 | 3.56 | 4.14 | 3.94 | 6.87 | 6.75 |
| T5 | 2.11 | 3.60 | 4.16 | 3.99 | 6.91 | 6.78 |
| T6 | 2.06 | 3.26 | 4.13 | 3.68 | 6.86 | 6.46 |
| T7 | 2.14 | 3.65 | 4.20 | 4.08 | 6.95 | 6.87 |
| T8 | 2.29 | 3.45 | 4.45 | 3.83 | 7.19 | 6.61 |
| T9 | 2.28 | 3.41 | 4.41 | 3.80 | 7.15 | 6.58 |
| T10 | 2.09 | 3.25 | 4.20 | 3.66 | 6.96 | 6.42 |
| T11 | 2.38 | 3.53 | 4.50 | 3.92 | 7.30 | 6.72 |
| T12 | 2.53 | 3.63 | 4.72 | 4.04 | 7.46 | 6.83 |
| T13 | 2.48 | 3.62 | 4.58 | 4.01 | 7.42 | 6.80 |
| T14 | 2.31 | 3.48 | 4.46 | 3.86 | 7.22 | 6.64 |
| T15 | 2.24 | 3.36 | 4.37 | 3.77 | 7.12 | 6.54 |
| T16 | 2.22 | 3.34 | 4.34 | 3.74 | 7.11 | 6.51 |
| T17 | 2.36 | 3.52 | 4.50 | 3.89 | 7.28 | 6.69 |
| T18 | 2.18 | 3.31 | 4.30 | 3.70 | 7.07 | 6.48 |
| T19 | 2.54 | 3.66 | 4.74 | 4.12 | 7.49 | 6.89 |
| T20 | 2.01 | 3.18 | 4.11 | 3.54 | 6.84 | 6.23 |
| CD (p=0.05) | NS | NS | 0.08 | 0.08 | 0.04 | 0.12 |

Initial rhizobial population: 2.98x$10^5$, Initial PSB population: 5.26x$10^3$
See table 1 for treatment detail

**Plant height:** Pendimethalin inhibited microbial inoculums used in different treatments, which are reflected in the early stage of plant growth. At 30 DAS, some of the microbial isolates alone and in combination were found significant to enhance the plant growth. However, rest of the microbial isolates alone and in combination were found significantly affected by applied herbicide at 30 DAS. Performance of treatments $T_1$, $T_2$, $T_3$, $T_5$, $T_9$, $T_{12}$, $T_{13}$, $T_{16}$, and $T_{17}$ were found significantly better over control. With the advancement of plant growth, the toxic effect of herbicide become normalize and at 60 DAS all the treatments were found significant better to promote plant growth over control, resulting that at this stage of crop growth effect of pendimethalin was completely dissipated. At this stage, highest plant growth was recorded due to dual inoculation of *Rhizobium* isolate-3 and PSB isolate 4 (45.25), followed by *Rhizobium* isolate 2 and PSB

isolate 3 (43.14). The poorest performance was recorded in *Rhizobium*-1+PSB-3 (36.83). In this growth study, it was observed that dual microbial inoculation of N fixing and P solubilizing microbes was found superior over single inoculation of aforesaid microbes. Dual inoculation increased the N-fixation as well as P-solubilization in the crop rhizosphere in comparison to single inoculation where either of the activities occurred (Table 3).

**Dry matter:** The dry matter of chickpea plants significantly increased due to single inoculation of *Rhizobium*-2, *Rhizobium*-3, PSB-3 and inoculation of *Rhizobium*-1 + PSB-3 and *Rhizobium*-3 + PSB-3. Highest dry matter (2.74g) was recorded due to combined application of *Rhizobium*-3 and PSB-4 in treatment T19, followed by single inoculation of PSB isolate 4 (Table 3). Lowest dry matter was recorded in treatment where rhizobial isolate-1 and applied with PSB isolate-3 (2.17g).

**Yield:** The number of pods in chickpea plants significantly increased due to single inoculation of *Rhizobium* -2, PSB-3 and dual inoculation of *Rhizobium*-1 and PSB-3. Highest pod number (31.7) was recorded due to inoculation of *Rhizobium*-3 + PSB-4 combined with treatment no. $T_{19,}$ followed by single inoculation of PSB isolates. Lowest pod no. was attributed to treatment $T_{10}$ where rhizobial isolate 1 was applied with PSB isolate 3. This observation was in close agreement in Raj *et al.* (2012) that mixed inoculation of *Rhizobium* and PSB presented significant rise in all the yield attributes over other treatments. The grain yield of chickpea plant was significantly affected by crop beneficial microbial inoculation under xenobiotic organo-chemical environment. Toxic effect of pendimethalin did not affect the applied microbial inoculants in most of treatments except few (*Rhizobium*-1, PSB-3 and *Rhizobium*-1 + PSB-3). Highest grain yield (7.54 g plant$^{-1}$) was recorded in treatment $T_{19}$, which received rhizobial isolate 3 and PSB isolate 4. PSB isolate 4 was second in order, which produced 7.12 g yield plant$^{-1}$. Minimum yield (50.3 g plant$^{-1}$) was associated with treatment $T_{10}$ where rhizobial isolate 1 was used with PSB isolate 3. The dual inoculation of effective N fixer and P-solubilizer enhanced the crop yield by fixing more nitrogen of solubilizing phosphate. The soluble phosphorous facilitated the rhizobial movement in soil to increase the nodulation in chickpea plant and ultimately facilitated nitrogen nutrition to concerned crop (Table 3).

**Table 3.** Effect of pendimethalin (herbicide) on pod number, dry matter, yield and plant height of chick pea at different stage

| Treatments | Pods | Dry | Grain | Plant | |
|---|---|---|---|---|---|
| | | At harvest | | Days after sowing | |
| | | | | 30 | 60 |
| T1 | 27.7 | 2.53 | 6.45 | 28.00 | 38.00 |
| T2 | 22.7 | 2.18 | 5.38 | 30.95 | 40.00 |
| T3 | 23.3 | 2.18 | 5.50 | 31.33 | 38.12 |
| T4 | 28.0 | 2.57 | 6.52 | 26.80 | 39.66 |
| T5 | 28.3 | 2.61 | 6.74 | 31.61 | 41.00 |
| T6 | 22.0 | 2.18 | 5.24 | 24.00 | 41.33 |
| T7 | 30.3 | 2.73 | 7.12 | 24.30 | 42.16 |
| T8 | 26.0 | 2.21 | 6.19 | 24.80 | 39.50 |
| T9 | 25.3 | 2.20 | 5.95 | 30.01 | 40.41 |
| T10 | 21.3 | 2.17 | 5.03 | 23.56 | 36.83 |
| T11 | 27.3 | 2.46 | 6.42 | 22.85 | 41.44 |
| T12 | 29.3 | 2.72 | 6.94 | 29.35 | 44.00 |
| T13 | 29.0 | 2.63 | 6.84 | 31.16 | 38.42 |
| T14 | 26.7 | 2.21 | 6.33 | 26.78 | 43.14 |
| T15 | 25.0 | 2.20 | 5.90 | 24.28 | 36.14 |
| T16 | 24.7 | 2.20 | 5.85 | 28.64 | 37.06 |
| T17 | 27.0 | 2.43 | 6.37 | 32.50 | 39.11 |
| T18 | 24.3 | 2.18 | 5.78 | 25.87 | 39.14 |
| T19 | 31.7 | 2.74 | 7.54 | 24.35 | 44.25 |
| T20 | 21.3 | 2.17 | 5.02 | 21.33 | 35.00 |
| CD (p=0.05) | 1.98 | 0.02 | 0.38 | 1.93 | 0.67 |

See table 1 for treatment details

## CONCLUSION

Dual inoculation increased the N-fixation as well as P-solubilization in the crop rhizosphere in comparison to single inoculation where either of the activities occurred. The grain yield of chickpea plant was significantly affected by crop beneficial microbial inoculation under xenobiotic organo-chemical environment. Highest grain yield (7.54 g plant$^{-1}$) was recorded in rhizobial isolate 3 and PSB isolate 4. Dual inoculation of rhizobial isolate *Rhizobium*-3 and phosphobacterial isolate PSB-4 was found best for rapid degradation of herbicide pendimethalin, followed by single inoculation of phospho-bacterial isolate PSB-4.

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# Meta Analysis for Impact Assessment of Chenani Watershed Development Programme of J&K (India)

**N.D. Singh and Rakesh Kumar**

*Faculty of Agriculture, Khalsa College, Amritsar-143 002, India*
*E-mail: ndsingh74@gmail.com*

***Abstract:*** The present study was undertaken for estimating the impact of Chenani watershed development programme (WDP) in terms of improvement in resource condition and availability in the project area. A multilateral approach using combination of both the quantitative and qualitative parameters was adopted for overall impact assessment of WDP. Although the economic analysis using benefit cost approach showed positive impact of WDP as the B: C ratio was greater than 1 and net present value was positive at 10 and 15 per cent discount rates, but the other indicators like change in land use/cover pattern, soil erosion level and carrying capacity of the natural resources showed no significant improvement in the year 2009 from the base year (i.e. 1991) and non project area respectively. Similarly, poor people's participation was observed in all activities of WDP, resulting in severely restricting the benefits of this approach. Thus, it was proved from the study that economic viability of WDP cannot ensure its ecological viability.

***Keywords*:** Watershed, Carrying capacity, Quantitative approach, Qualitative approach, Discount rate

India has invested, since early 1950's more than Rs. 170 billions (US $ 4 billions) on watershed development programmes (WDP's) covering more than 45 million ha, and in the recent years the annual expenditure on these programmes have exceeded Rs. 10 billion which reflects the priority and faith of Indian Government on WDP's for improvement of natural resources (Reddy *et al.,* 2007). Although these WDP's have resulted in increasing cropping intensity, changing cropping patterns, increasing productivity of crops, augmenting underground recharge of water and increasing family incomes and employment opportunities in some areas but these improvements were short lived and WDP's failed to generate sustainability of these improvements. Further more, despite the long history of WDP's, there are no systematic and large scale impact assessment studies on their performance as there is lack of proper indicators and evaluation methods to assess the overall impact of these programmes (Government of India, 2001).

However, the National Wasteland Development Board (NWDB) in collaboration with National Remote Sensing Agency, Hyderabad (NRSA) identified 147 different districts spread over different agro-climatic zones of the country, having more than 17 per cent area under wastelands. Such wastelands possess great potential of mitigating the biomass requirement of the people living in these areas, if put to optimal and judicious use. The Udhampur district of J&K was one of such district and therefore a WDP for Chenani watershed was formulated by Forest Department, Government of Jammu and Kashmir during the year 1990 and was started as a centrally sponsored scheme with the help of NWDB, in 1992. The Chenani WDP was executed in 3300 ha, with financial implication of Rs. 22.95 millions from the year 1992 to 1997 and was claimed to be quite successful by the project implementing agency, as it had helped in improving the condition and availability of natural resources considerably in the study area (Forest Department, 1997)

The present study was undertaken for assessing the impact of this particular WDP in terms of resource conditions and availability. As some other WDP's are ongoing in Udhampur district, therefore lessons learnt from previous (WDP) experiences could be very helpful in making future WDP's more effective, efficient, economical and sustainable.

## MATERIAL AND METHODS

In the present study multilateral approach using both quantitative and qualitative parameters were used for estimating the impact of WDP on the project area. In quantitative analysis of WDP, land use pattern and benefit cost analysis were undertaken whereas for qualitative analysis of WDP indicators like carrying capacity of the natural resources, soil erosion level, people's participation in WDP were used for overall impact assessment of WDP in the present study. The 'with and without' approach was used to estimate the change/difference in terms of these indicators, so as to compare the extent of difference WDP has made in the area regarding resources condition and availability in Project Area (PA) where WDP was implemented as compared to area where no WDP was implemented i.e. Non Project Areas (NPA).

In the beginning, information about the study area was collected from Revenue, Forest, District Statistical, Water Resources, Animal Husbandry departments and Directorate of Soil Conservation, Government of Jammu and Kashmir. The secondary data includes information regarding area, number of villages, land use pattern, land holdings, number of households, human and animal population, availability of fuel wood, fodder and other by products of natural resources in the study area (PA and NPA separately), pasture development and wastelands in the area. Information regarding WDP's activities undertaken like details of plantations, formation of enclosures, fencing erected, grasses and legumes sown, soil and water conservation methods adopted, assets created and costs incurred on these activities were also collected from forest department. Primary data was collected by using conventional method i.e. personal questionnaire method, where information was collected from 300 households i.e. 150 from PA and NPA respectively, regarding their participation in project activities and benefits derived due to WDP. Information regarding economic variables like education level, employment pattern, income level, production and consumption patterns of fuelwood, fodder and foodgrains were also collected from respondents. Along with these conventional data, advanced data using the satellite images of 1:50,000 scale of the study area for the year 1991 (before implementation of WDP) and year 2007 (after the implementation of WDP) were procured from National Remote Sensing Agency (NRSA) Hyderabad. Geographical Information System (GIS) was used for extracting information from images like land use/cover pattern, types and conditions of natural resources, categorization of land resources on the basis of their condition and level of soil erosion were also estimated. These images were also used for verification of the data, which was collected from various other sources.

**Analytical tools used:** In the initial stages of analysis, simple averages, frequencies and percentages were used and in the advanced stages of analysis benefit-cost technique was used with benefit cost ratio (B:C ratio), net present value (NPV) so as to work out economic viability of WDP. In the present study only tangible benefits due to WDP were taken into consideration as non tangible benefits like amount of ground water recharge, air purified etc. were beyond the scope of the study. The cost incurred and benefits derived from the WDP were aggregated and net benefits were discounted at 10, 15, 20 per cent rate. The NPV analysis was done using following formula:

$$PV = B_0\text{-}C_0 + \frac{B_1 - C_1}{(1+v)} + \frac{B_2 - C_2}{(1+v)^2} - - - \frac{B_n - C_n}{(1+v)^m}$$

Where

PV = Present value of net benefits occurring from the project for 10 years

B = Indicates benefits

C = Indicates costs

n = The projects life in years

v = The rate of time preference or discount rate

**Land Use Pattern:** In the land use pattern, the land resources were categorised into forest lands agricultural lands, scrublands and drainage areas. Each category was further subdivided into various groups i.e. :-

*i) Forest lands* – These lands were categorised on the basis of Crown Density (CD) of trees into Dense forests (with CD>40 per cent), Moderate forests (CD between 10 to 40 per cent) and open/degraded forests (CD<10 per cent)

*ii) Agricultural lands*- These lands were categorised into cultivable and uncultivable lands.

*iii) Scrub lands*- Areas under wasteland, pasture lands, open lands etc. come under scrub lands. It was categorised into three sub classes on the basis of Green Biomass Density (GBD) i.e. dense scrub (with GBD>40 per cent), thin scrub (with GBD between 10 to 40 per cent) and degraded scrub (GBD<10 per cent)

**Carrying Capacity**: Carrying Capacity estimation was done in terms of fuelwood, fodder and foodgrains, in two phases. In the first phase production level of various categories of forest land, agricultural lands and scrub lands were estimated by using sampling techniques. Sample plots measuring 20 mtrs x 20 mtrs were laid on different categories of forest and scrub lands so as to estimate the annual production/productivity of fuelwood and fodder from these land resources. Similarly, the amount of foodgrains produced from the agricultural lands was estimated by multiplying the productivity of crops (evaluated from sample households) with the cropping pattern in the study area. In the second step number of persons/animals/households that can be supported with the production capacity were estimated by dividing the total production capacity with per household per year requirement in case of fuelwood, per cow head per year requirement for fodder and per person per year requirement in case of foodgrains. Human carrying capacity (HCC) in terms of energy was computed on the basis of areas under cereals and pulses, yield per hectare and population during that period. Total production of cereals and pulses were converted into their calorific values (in K cal/M t) by multiplying the total production of cereals and pulses with their respective calorie contents. Then per capita availability of calories were estimated by using the formula :-

$$\text{Human Carrying Capacity} = \frac{\text{Total production in calorie}}{\text{Per capita calorie requirement (in Kcal/yr)}}$$

**Level of Soil Erosion**:

In the present study extent and magnitude of soil erosion was estimated according to the methodology adopted by the directorate of soil conservation, Govt of J and K, based on parameters like:- a) Loss of top soil, b) Slope of the area, c) Gully Erosion, d) Land slides and landslips, e) Stream bank Erosion, f) Land use etc. On these parameters soil erosion was measured in terms of six erosion intensity classes (E.I), from E.I class I to E.I – VI indicating intensity of erosion problem in ascending order

**People's Participation Level in WDP's:** In the present study people's participation in the WDP activities were estimated on the basis of information collected from respondents in the project area. The people's participation level was estimated by using following formula:

$$PPL = \sum_{i=1}^{N} \frac{Ei}{Pi} x100$$

Where

PPL = People's Participation level

$\Sigma$ = Summation of N respondents

1 = One is $i^{th}$ respondent

Ei = Extent of people participation

Pi = Potential of people's participation

People's participation in various WDP activities was estimated for different stages right from planning stage to implementation stage and subsequently during maintenance stage. Participation in all forms was recorded i.e. labour, cash and time etc, during the WDP. Each stage was further categorized in to different sub stages on the basis of activities performed under them (As per records of the implementing agency). The participation in the respective stages were evaluated by averaging the total number of persons, who have participated with number of sub stages in the respective stages. Overall participation (in per cent) was evaluated by considering participation at each stage of WDP by the respective section of society.

## RESULTS AND DISCUSSION

### Change in Land Use Pattern due to WDP

The land use/land cover pattern in the study area as analyzed from satellite images (Fig. 1) showed significant change in 2007 than the base year (1991). This 'before and after' approach showed decrease in total forest area by 135 ha i.e., 4.3 per cent from the base year especially dense and moderate forests by 65 ha and 133 ha. Whereas, area under degraded forests increased by 63 ha from the base year indicating conversion of area under dense and moderate forests into degraded forests. The significant increase in area under degraded forests from the base year highlights limited or no impact of WDP on land use pattern.

**Table 1.** Change in Land Use/ Land Cover in the Project Area

| Particulars | 1991 | 2007 | Change |
|---|---|---|---|
| 1) Forest Area | 3155 | 3020 | -135 (4.3) |
| a) Dense forests | 1027 | 962 | -65 (6.3) |
| b) Moderate/open forests | 1412 | 1279 | -133 (9.4) |
| c) Degraded forests | 716 | 779 | 63 (8.8) |
| 2) Agricultural Area | 2658 | 2824 | 166 (6.2) |
| a) Cultivated area | 2189 | 2454 | 265 (12.1) |
| b) Uncultivated area | 69 | 370 | - 99 (21.1) |
| 3) Scrub Area | 2460 | 2508 | - 48 (2.0) |
| a) Dense scrub | 1385 | 1223 | - 162 (11.7) |
| b) Moderate scrub | 948 | 853 | - 95 (10.0) |
| c) Thin scrub | 357 | 432 | 75 (21.0) |
| 4) Drainage System | 489 | 390 | - 99 (20.2) |
| 5)Residential/commercial areas / | 136 | 155 | 19 (13.9) |
| G. Total (1+2+3+4+5) | 8898 | 8898 | - |

Source: Satellite Images NRSA ; Figures in parentheses () show percentage change from the base year

### Economic Analysis of WDP

As benefits/returns from certain components of WDP like trees planted, mechanical structures etc, start coming after a time gap and continue for number of years, therefore B - C analysis was done for a period of ten years i.e. from 1992 to 2002 using discount rates of 10, 15 and 20 per cent for each component of WDP (Table 2). The overall B: C ratio for WDP was estimated greater than 1 with significant NPV at 10 and 15 per cent discount rates which signifies economic viability of the WDP as any project with B:C ratio greater than one is

**Table 2.** Benefits Cost Analysis of Components of WDP at Different Discount Rates

| Particulars | Benefits | Cost | NPV | B/C |
|---|---|---|---|---|
| Afforestation | | | | |
| a) 10 % | 349.13 | 199.26 | 149.96 | 1.75 |
| b) 15% | 390.63 | 284.78 | 105.84 | 1.37 |
| Horticultural plantations | | | | |
| a) 10% | 10.43 | 28.12 | 17.69 | 0.37 |
| b) 15% | 12.57 | 40.62 | 28.05 | 0.31 |
| Soil & moisture conservation | | | | |
| a) 10% | 18.51 | 35.40 | 16.89 | 0.52 |
| b) 15% | 23.32 | 51.86 | 28.54 | 0.45 |
| Pasture land development | | | | |
| a) 10% | 56.33 | 113.13 | 56.79 | 0.50 |
| b) 15% | 72.79 | 162.30 | 89.50 | 0.45 |
| Fuel saving devices | | | | |
| a) 10% | 92.45 | 4.32 | 88.13 | 21.4 |
| b) 15% | 119.65 | 6.28 | 113.38 | 19.05 |
| Overall | | | | |
| a) 10% | 526.85 | 380.23 | 146.62 | 1.39 |
| b) 15% | 618.96 | 545.84 | 73.12 | 1.13 |

considered to be economically viable. But at 20 per cent discount rate NPV was negative and B: C ratio less than 1, signifies non viability of WDP at this discount rate.

Only two components i.e. afforestation and fuel saving devices were economically viable with B: C ratio greater than 1 and positive NPV at all the discount rates. Whereas, the other three components i.e. horticultural plantations, soil and moisture conservation measures and pasture land development were economically non viable. The promotion of fuel saving devices component was the only component having highest benefit cost ratio of 21.4, 19.05 and 17.2 at 10, 15 and 20 per cent discount rate respectively and significantly high NPV. It could be interpreted that even a small component of WDP (with only 1 per cent expenditure of total fund) could provide more benefits than other large components (which used up major portion of total funds) which failed to generate sufficient economic viability. The IRR which signifies discount rate at which benefits and costs are equal and if subtracted becomes zero, was not estimated as already three components of WDP were having NPV less than zero even at 10 per cent discount rate (Table 2)..

Moreover, the authenticity of official records of implementing agency was doubtful, as they were not in accordance with the situation on ground. On critically analyzing the official records of the project implementing agency for details regarding activities undertaken during WDP, serious discrepancies were observed in the records :-

Except one component of WDP (horticultural plantations) rest all components fell short of the approved targets. The afforestation in forest area fell short by 160 ha and pasture land development by 32 ha. Moreover, as against the sanctioned amount of Rs. 22.95 millions for WDP, a sum of Rs. 20.63 millions could be procured by the implementing agency from the state government, which reflects inefficiency on their part. This has resulted in non fulfilment of many approved targets of the WDP by implementing agency.

The number of trees (i.e. 12, 42, 188) claimed to be planted under aforestation by the implementing agencies during the project, would have required nearly 1100 ha of area at 3m x 3m spacing (and not 1840 ha of area as shown in records) resulting in significant change in land use pattern of the area. But in reality no such drastic change were observed in the land use pattern of the forest area as analysed from satellite images procured from NRSA, Hyderabad. Moreover conversion of dense and moderate forests into degraded forests areas was observed in this study.

Furthermore as against target of 3000 $m^3$ area for treatment under soil and moisture conservation, 16,521 $m^3$ areas was treated at much lower cost (i.e. Rs. 1.57 millions) than approved target of Rs 1.95 millions. Therefore, significantly more area (i.e. 13,521 $m^3$) was treated at low cost which is quite surprising.

Some of the major objectives like to encourage scientific agriculture, horticulture, pesiculture etc. for bringing area under intensive productivity campaign, were completely ignored as none of the works carried out during the project were aimed for fulfilment of these objective.

The overhead expenses incurred were Rs 2.91 millions i.e. 14.1 per cent of the total sanctioned amount which is quite significant. It includes expenses incurred on purchase of vehicles (one jeep and two pickup vans), construction of residential quarters for forest officials, construction of stores, purchase of implements etc. (Table 3).

**Carrying Capacity**

The overall comparison of carrying capacities in terms of fuelwood, fodder and foodgrains between PA and NPA, revealed overall better situation in terms of availability of resources (fuelwood, fodder and foodgrains) in the NPA than PA. The difference in production capacities, carrying capacities and burden on carrying capacities of PA and NPA respectively. In case of fuelwood the production capacity of PA was 279.7 M t/yr, less than NPA's production capacity. The carrying capacity of PA in terms of fuelwood was less than NPA by 554 families per year and the burden on natural

**Table 3.** Comparison of Physical and Financial (in Rs. million) Approved and Achieved Targets of WDP

| Components of work | Approved Targets of WDP | | Achievements of WDP | | Difference | |
|---|---|---|---|---|---|---|
| | Phy. | Fin. | Phy. | Fin. | Phy. | Fin. |
| Afforestation in forest area | 2000 ha | 10.20 | 1840 ha | 9.35 | 160ha | 0.85 |
| Horticultural plantations. | 200 | 1.45 | 200 ha | 1.29 | 0 | 0.16 |
| Pasture land development | 1100 | 5.70 | 1068 ha | 5.29 | 32 ha | 0.41 |
| Soil and moisture conservation | 3000 $m^3$ | 1.95 | 16521$m^3$ | 1.58 | 13521$m^3$ | 0.37 |
| Promoting fuel saving devices | 1000 | 0.25 | 800 | 0.20 | 200 unit | 0.05 |
| Overhead expenses | 0 | 3.40 | - | 2.91 | - | 0.49 |
| G. Total | 3300 ha + 3000 $m^3$ + 1000 | 22.95 | 3108 ha+ 16521 + 800 units | 20.63 | 192ha+ 13521+ 200 units | 2.32 |

resources for fuelwood was exerted by 639 more families in PA than NPA every year. In case of fodder the production capacity of PA fell short by 1780.1 M t/yr from that of NPA thereby resulting into low carrying capacity of 446 cowheads per year in PA than NPA respectively (Table 4).

**Table 4.** Comparison of Production and Carrying Capacities of PA and NPA

| Particulars | PA | NPA | Differenc |
|---|---|---|---|
| A) Fuelwood | | | |
| 1) Production capacity (M t/yr) | 6198.55 | 6478.25 | -279.7 |
| 2) Carrying capacity (households/yr) | 1878 | 1963 | -85 |
| 3) Total no. of households | 3798 | 3244 | 554 |
| 4) Burden (families/yr) | 1920 | 1281 | 639 |
| B) Fodder | | | |
| 1) Production capacity (M t/yr) | 33279.65 | 35059.75 | -1780.1 |
| 2) Carrying capacity (cowheads/yr) | 8319 | 8765 | -446 |
| 3) Total cowheads | 16396 | 16529 | -133 |
| 4) Burden (cowheads/yr) | 8077 | 7764 | 313 |
| C) Foodgrains | | | |
| 1) Production capacity (M t/yr) | 3752.3 | 3782.1 | -29.8 |
| 2) Carrying capacity quantitatively | 25701 | 25905 | -204 |
| 3) Total no. of persons (excluding minors) | 29870 | 24361 | 5509 |
| 4) Burden (persons/yr) | 4169 | 1544 | 2625 |
| 1a) Production capacity ($Kcalx10^5$/yr) | 122907.76 | 123203.28 | -295.52 |
| 1b) Carrying capacity qualitatively (person/yr) | 18707 | 18752 | -45 |
| 1c) Burden | 11163 | 5609 | 5554 |

Nearly 75 per cent of the total energy requirements of the people were fulfilled from cereals and pulses. The recommended value of calories was 6.57 x $10^5$ K cal/per person/year which was obtained by multiplying per person per day energy requirement with number of days in an year as 2400 x 365 x 0.75, where 2400 Kcal is recommended energy requirement for a person per day (Desai and Subramanian, 1996). The total energy produced (in K cal/yr) was estimated to be 122907.76 x $10^5$ K cal per year in PA and 1,23,203.28 x $10^5$ K cal per year for NPA. The human carrying capacity (persons/yr) was estimated to be 18,707 persons per year in PA and 18,752 persons per year in NPA, which is quite less than total population of 29,870 and 24,361 persons in the respective areas. The carrying capacity in terms of calories falls short by 11,163 persons in PA and 5609 in NPA every year. Therefore it was clearly established that even in terms of TFP, the area falls short of the requirement of foodgrains both quantitatively as well as qualitatively. One of the reason for this situation was low productivity of agricultural lands in the area due to poor resource condition (quality) and lack of irrigation facilities which leads to foodgrains deficit in the area.

**Soil Erosion**

The land under E.I class VI was considered to be beyond conservation and regeneration, whereas soils under III, IV, V required immediate attention for redemption of soil, so that it could be saved from future deterioration and ultimate loss. The soil under E.I classes I and II were having erosion at minimum levels. Nearly 3.8 per cent of the total area in PA and 2.5 per cent in NPA were under E.I category VI. The maximum area in both PA as well as NPA were under E.I category III, IV and V, with 36.2, 25.3 and 14 per cent area in PA and 39, 28.2 and 11.4 per cent in NPA respectively (Table 5). From comparison of areas of PA and NPA facing various levels of soil erosion problem small difference was observed within the same E.I level of the respective areas. This signifies limited or no significant improvement in soil erosion status of PA due to WDP, as due to high level of siltation in river tawi (because of soil erosion), the Chenani hydel project still faces many problems resulting in reduction in its production capacity. Moreover regular landslides and landslips were reported during monsoon seasons especially in Samroli area of PA, resulting in closure of NH-1A, which highlights the ineffectiveness of measures undertaken during WDP for controlling erosion problem in the area.

**Table 5.** Soil Erosion Level

| E.I class | PA | NPA |
|---|---|---|
| I | 658 (7.4) | 761 (9.3)* |
| II | 975 (11) | 630 (7.7) |
| III | 3222 (36.2) | 3192 (39) |
| IV | 2252 (25.3) | 2309 (28.2) |
| V | 1246 (14) | 933 (11.4) |
| VI | 338 (3.8) | 204 (2.5) |
| Nallahs | 207 (2.3) | 158 (1.9) |
| Total | 8898 (100) | 8187 (100) |

* figures in parentheses ( ) represents in per cent

**People's Participation Level in WDP**

The overall people's participation in the planning stage was maximum from local leaders i.e. 16 per cent, followed by farmers whereas the women's participation was only 2.8 per cent. In the implementation stage maximum participation was from labourers (14 per cent), as they were engaged for WDP activities like construction of structures, plantations, grass cultivation and entry point activities etc. Local leaders and farmers followed by landless labourers with 11.5 and 9 per cent participation respectively during implementation stage.

**Table 6.** People's Participation in WDP (in per cent)

| Stages of Participation | | Land Less Labourer | Farmers | Non-Farming Community | Women | Local Leaders |
|---|---|---|---|---|---|---|
| A | Planning stage | | | | | |
| | 1. Mapping of the area | 00 | 00 | 00 | 00 | 10 |
| | 2. Need assessment | 12 | 08 | 08 | 02 | 20 |
| | 3. Group discussion | 08 | 13 | 07 | 04 | 17 |
| | 4. Meetings | 00 | 12 | 07 | 05 | 15 |
| | 5. Training/lectures | 00 | 15 | 03 | 05 | 18 |
| | Total | 4.0 | 9.6 | 5.0 | 2.8 | 16 |
| B | Implementation stage | | | | | |
| | 1. Construction of structures | 23 | 09 | 07 | 02 | 13 |
| | 2. Closure formation | 16 | 00 | 00 | 00 | 00 |
| | 3. Plantation of trees | 20 | 00 | 00 | 00 | 00 |
| | 4. Patches grown | 18 | 00 | 00 | 00 | 00 |
| | 5. Entry point activities | 13 | 15 | 08 | 00 | 23 |
| | 6. Sharamdan (volunteer service) | 04 | 12 | 00 | 00 | 20 |
| | 7. Kulhad bandi (ban on tree felling) | 08 | 16 | 08 | 06 | 19 |
| | 8. Charai bandi (ban on grazing) | 10 | 20 | 05 | 08 | 17 |
| | Total | 14 | 09 | 3.5 | 2.0 | 11.5 |
| C | Maintenance stage | | | | | |
| | Mean People's Participation in WDP | | | 6.6 | | |

Mean Participation < 33 per cent Low people's participation
Mean Participation between 33-66 per cent Medium people's participation Mean Participation > 66 per cent High people's participation

In the maintenance stage maximum participation was from local leaders followed by farmers and non farmers. The overall low people's participation in WDP activities especially during maintenance stage was mainly responsible for poor condition of assets created i.e. closures, soil and moisture conservation structures etc. as observed during field visits in the area. Moreover most of the closures were used for grazing cattle's and collecting fuelwood, and mechanical structures need immediate repairs. The overall extent of people's participation in per cent was analysed for different sections of the society in the PA, the local leaders participation level was highest followed by farmers and landless labourer. The overall mean people's participation was estimated to be 6.6 per cent which is quite low (Table 6)

## CONCLUSION AND POLICY IMPLICATIONS

On the basis of meta analysis it was established that WDP implemented in Chenani area of Udhampur district, had limited/no significant impact on natural resource condition and their availability in PA. Similarly no comparative improvement in production capacity and subsequently the carrying capacity of resources was observed in terms of fuelwood, fodder and food grains in the PA than NPA. The study also highlighted decrease in area and tree density in forests, conversion of dense forests into degraded forests, increase in agricultural area and aggravated soil erosion problem in the area. Moreover the soil erosion problem which was quite serious in the PA has not improved. Although, the economic analysis showed positive impact of WDP, but still WDP failed to have any impact on natural resource condition and availability, carrying capacity, erosion problem and vegetative cover of PA. Thus, it was proved from the study that economic viability of WDP cannot ensure its ecological viability.

On the basis of above conclusions policy implications for future WDP's in the hill areas are a) Launching need based watershed development programmes in in areas where tribals and other weaker sections of the society live; b) People's participation should be generated by involving them in WDP activities right from planning to implementation stage and subsequently maintenance stage; c) Training of WDP implementing officials, right from top to bottom for implementing project activities for fulfilling the project objectives; d) Improving efficiency and accountability of WDP by regular monitoring & evaluation; f) Strict legislative measures for restricting people's greed to save natural resources from exploitations & subsequent losses; g) Popularizing alternative sources of energy like gobar–gas plants, solar lights, solar cookers, etc

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# Isolation and Screening of Lipase Producing Microorganisms from Natural Sources

**M.G. Singh[1], Chandraveer[2] and Abhishek M. Tripathi[3]**

[1]*Division of Agriculture Education, ICAR, New Delhi-110112, India*
[2]*Department of Dairy and Food Microbiology, CDFST*
*Maharana Pratap University of Agriculture and Technology, Udaipur-313 001, India*
[3]*Global Change Research Institute AS CR, v.v.i., Brno-603 00, Czech Republic*
*E-mail: mkb_jaipur@yahoo.com*

***Abstract:*** Lipases are the enzymes that bring about a wide range of bioconversion reactions. Lipases occur widely in nature, but microbial lipases are commercially most significant. Lipase catalyzedtrans-esterification, hydrolysis and esterification are the important class of reactions for technological applications in fats and oil industry, dairy industry, pharmaceuticals and bakery industry. The main reason for the steadily growing interest in lipases is also because of their enantio-selective, regioselective and chemo-selective nature. Enzyme-mediated reactions are attractive alternatives to tedious and expensive chemical methods. Present investigation aimed at bio-prospection of lipase producing microbial isolates from various natural sources. The better enzyme producing microbial isolate for its ability to produce the enzyme was investigated under diverged nutrient conditions of lipase assay. A total of twenty two microbial isolates were isolated from different sources, out of which nine fungal isolates and thirteen bacterial isolates were found to show appreciable lipase producing ability. These cultures were further used to find out their quantitative production of lipase in liquid media with time. It was observed that in majority of the cases, the lipase production increased with time, reaching the maximum on fifthday and decreasing thereafter.

***Keywords*****:** Lipase assay, Natural sources, Screening, Submerged fermentation

Lipids play a significant role in almost all aspects of human lives, from nutrition to cosmetics and flavours to stains. Hence the enzyme associated with them cannot be under estimated. Lipases (triacylglycerol acylhydrolases EC 3.1.1.3) are a class of hydrolases which are very unique as they hydrolyse fats into fatty acids and glycerol at the water-lipid interface and can reverse the reaction in non-aqueous media (Abada*,* 2008). Lipases have emerged as one of the leading biocatalysts with proven potential for contributing to the multibillion dollar lipid based industry and have been used in *in situ* lipid metabolism and *ex situ* multifaceted industrial applications (Joseph *et al.,* 2008; Salihu *et al.,* 2012).The number and variety of lipases available has increased enormously in the recent past. This is mainly the result of the huge achievements made in the cloning and expression of enzymes from microorganisms, and an ever increasing demand for these biocatalysts with novel and specific properties such as specificity, stability, pH and temperature (Vulfson *et al*., 1994; Sharma *et al.,* 2001).

Lipases find immense application in various areas such as dairy and food industry, oil industry, medicine, pharmaceutical, cosmetic perfumes detergents, agriculture etc. Hence, lipases are today the choice of catalysts for all biochemical processes due to high versatility in their catalytic behaviour (Bornscheuer *et al.,* 2002). Microbial lipases have gained special industrial attention due to their stability, selectivity, and broad substrate specificity (Sharma *et al.,* 2001; Dutra *et al.*, 2008). Many microorganisms are known to be potential producers of extracellular lipases, including bacteria, yeast and fungi (Griebeler *et al.,* 2011; Joseph *et al*., 2008). They are resistant to solvents and are exploited in a broad spectrum of biotechnological applications. Applications and role of lipases vary from hydrolysis of fats and oils, organic synthesis, modification of fats, flavour enhancement in food processing,resolution of racemic mixtures and chemical analysis (Saxena *et al.,* 1999; Franken *et al.,* 2010). Novel biotechnological applications, like biopolymer synthesis, biodiesel production, treatment of fat-containing waste effluents, enantiopure synthesis of pharmaceuticals and nutraceutical agents, have been established successfully (Joseph *et al.,* 2008; Salihu *et al.,* 2012).

Microorganisms have been reported as potential lipase producers exhibiting the capability to utilizing most agricultural residues (Salihu *et al.,* 2012) like olive-mill waste water (Brozzoli *et al.,* 2009) and oil cakes are the most widely utilized substrate of all (Singh *et al.,* 2010). Looking at the vast prospects and future applications, a study was planned for assessing bio-prospection of lipase producing microorganisms from various natural sources. Soil samples were collected from various natural sources. The better enzyme producing microbial isolate was screened for its

ability to produce the enzyme and then the enzyme activity and specific activity were investigated.

## MATERIAL AND METHODS

The study was conducted in department of Dairy & Food Microbiology, College of Dairy & Food Science Technology, MPUAT, Udaipur. All chemicals and glasswares used under investigation were of analytical grade and were procured from local commercial suppliers.

**Sample collection from natural sources:** Natural soil samples were collected in sterile glass bottles with sterilized spatula from various places such as petrol pumps, soil in vicinity of wash- places of utensils of hostel mess, kerosene oil shop, from processing area of oil mill,car and motor garage and near small vendors of deep fried snacks like samosa, jalebi, etc., and kerosene oil shop. Samples were also taken from rotten coconut, cheese and kidney beans slurry.

**Isolation of lipase producing microorganisms:** Samples from selected natural sources were serially diluted with sterile distilled water and were inoculated on Tributyrin Agar Plates (TBA) containing per litre of peptone, 5g; beef extract, 3g; tributyrin, 10ml and agar-agar, 20g followed by incubation for 24-48 hours at 37 ˚C to screen the microorganisms producing lipase.

Tributyrin was added into the medium after autoclaving when the medium reached a temperature of 40-45˚C. Media of four different pH (5,7,9 and10) were prepared for inoculating each sample using 1mM solution of hydrochloric acid and sodium hydroxide. Samples were inoculated on TBA plates of all the four different pH (5,7,9 and10) and were incubated at two different temperatures i.e. 37˚ C and 25˚ C for 24- 48 hours. The lipase producing isolates produced a zone of clearance around them, hence, zone of clearance producing colonies were identified as lipase producing microorganisms and isolated.

**TBA plate assay :** Lipase producing micro-organisms produced a zone of clearance (hydrolysis) when their appropriate dilutions were spread on the TBA medium. The zone size was measured after 24 and 48 hours of incubation at 37˚C (Dutra *et al*., 2008). Colonies producing largest zone of clearance were selected from each plate, and streaked on TBA plates to obtain pure isolated colonies.

The samples from selected natural sources were inoculated on Tributyrin Agar Plates (TBA) to screen the microorganisms producing lipase. Samples were inoculated on TBA plates of four different pH (5, 7, 9 and10). They were incubated at two different temperatures i.e. 37˚ C and 25˚ C for 24-48 hours. The lipase producing isolates produced a zone of clearance around them and colonies producing largest zone of clearance were selected, and streaked on TBA plates to obtain pure isolated colonies.

**Preservation of isolates:** Isolated colonies from streaked TBA plates were picked and streaked on TBA slants. Cultures were stored at 4˚C and sub cultured at regular intervals of time i.e.15 days.

**Lipase assay:** Lipase activity in the present investigation was determined spectrophotometrically by measuring the amount of fatty acids released from the substrate as described by Lowry and Tinsley (1976). Medium used for carrying fermentation with bacterial cultures was composed of - 8% (w/v) corn steep liquor, 0.1% (w/v) $NaH_2PO_4$, 0.05% (w/v) $FeSO_4.7H_2O$ 0.1% (w/v) $Cacl_2$, 3% (v/v) olive oil Medium was adjusted to desired pH (7.0 and 10.0). Fermentation medium for fungal isolates composed of Tryptone 5g, yeast extract 5g, dextrose 1g, $K_2HPO_4$ 1g, unsalted butter 5g (per litre) pH 5.0 at 28˚C (Jensen, 1983). Substrate emulsion was prepared by mixing 92 ml Buffer, 100 mg bile salts, 2g gum arabic and 10 gm olive oil. Isolates were grown aerobically at 30˚C in the fermentation medium. The submerged fermentation was carried out in 100 ml erlynmeyer flasks, each containing 25 ml medium. The flasks were incubated on rotary shaker at 30˚C at 200 rpm. Lipase assay was carried out by taking out samples from fermentation flasks at regular intervals of time (24 hours) for a period of six days and assayed for lipase activity. The supernatant obtained after centrifugation at 5000 rpm was used as a source of lipase. A mixture of 5 ml culture supernatant was incubated at 37˚C on rotary shaker at 150 rpm for 20 minutes. The reaction was terminated after taking one ml aliquote from the above system and keeping it in boiling water for 10 minutes. Centrifugation was done at 2000 rpm for 2-3 min. The upper layer (2ml) was taken for further estimation. It was evaporated in boiling water bath and 5 ml benzene was added. It was vortexed and 1ml cupric acetate reagent was added. After vortexing, it was centrifuged at 3000 rpm for five minutes. A control was run simultaneously, in which the enzyme was deactivated by an initial heat treatment (by keeping in boiling in water bath for 10 minutes). Absorbance of the upper phase was measured spectrophotometrically at 715 nm wavelength. Lipase activity was defined as the amount of enzyme catalyzing the release of 1 µmol of free fatty acids released per min per ml under the standard assay conditions.

**Protein determination:** The supernatant was assayed for protein content according to method given by Lowry *et al*. (1951) using a Bovine Serum Albumin as standard for calibrated curve.

**Preparation of standard graph:** Standard protein graph was plotted by taking different aliquots of a standard solution

made of Bovine serum albumin (10mg/50 ml). It was used for protein estimation for assessing lipase activity. Standard oleic acid graph was plotted by taking different aliquots from standard Oleic acid solution(400mg/100 ml) and was used to find concentration of free fatty acid in unknown sample.

## RESULTS AND DISCUSSION

A total of nine fungal and thirteen bacterial isolates were found from various natural sources. In the fungal category, three isolates (MFC-3, MFC- 4, and MFC-5) were obtained at pH7,five isolates (MFC- 1, MFC- 2, MB 3, MFC- 4, and MFC-5) were obtained at pH 5 and one isolate (MFC- 3) was obtained at pH 10.Under bacterial category, six isolates were obtained at pH 7 (MBC-1, MBC-2, MBC-5, MBC-7, MBC-8 and MBC-9), 6 isolates at pH 10 (MBC-1, MBC-2, MBC-3, MBC-5, and MBC-7) and 1 isolate at pH 5 (MBC-6).

They were further tested by TBA plate assay to have a comparative account of their lipase producing ability. The lipase assay showed, maximum relative zone of clearance by two fungal cultures(MFC- 2 and MFC-3) at pH 5; one fugal and one bacterial (MFC-5 and MBC-2) at pH 7 and two bacterial cultures (MBC-1 and MBC-3) at pH 10.A comparative account of lipase activity, and specific activity of the different microbial isolates have been given in Table 1. It was observed that all the isolates showed significant difference ($p \leq 0.001$) among lipase activity of all the microbial isolates. The lipase producing microorganisms were found in all the pH range taken for the study i.e. acidic, basic and neutral pH, which is in accordance with other studies (Grbavcic *et al.,* 2007; Gupta *et al.,* 2007; Abada, 2008; Menoncin *et al.,* 2010). These isolates were further analysed for their quantitative production in liquid of lipase by them in liquid media with time. As clearly seen in the Table 1, bacterial isolate MBC-3 (at pH 10) was found to have significantly higher lipase activity (0.725 µmol/ml/min) and bacterial isolate MBC-2 (at pH 7) was found to have significantly lower lipase activity (0.039 ±0.03µmol/ml/min) as compared to all the microbial isolates isolated in the study. Also, the study resulted in sufficiently higher average lipase activity from all the isolates screened (0.304 µmol/ml/min). These results are in congruence with those reported earlier by Grbavcic *et al.* (2007); Lee *et al.* (2008) and Marques *et al.* (2014).

**Lipase assay:** The lipase activity of the culture supernatant was measured as the amount of free fatty acids released per ml enzyme solution per min at 37˚C at a regular interval of 24 hours. The comparative profile of lipase production with respect to time for microbial isolates MBC 2, MFC 5, MFC 2, MFC 3, MBC1 and MBC 3 has been graphically presented in figures 1, 2,3,4,5 and 6, respectively.

It is clearly seen that both lipase activity and specific activity in microbial isolates MBC-2, MFC-3 and MBC-1 is shown to be maximum on fifth day (Fig. 1, 3 and 5, respectively), whereas, bacterial isolate MBC-3 was found to have maximum lipase and specific activity on second day (Fig. 6). Fungal isolate MFC-5 is observed to show maximum lipase and specific activity on first day and a gradual

**Table 1.** Lipase activity of screened microbial isolates

| Screened microbial isolates | Average lipase activity (µmol/ml/min) | Average specific activity (µmol/mg/min) |
|---|---|---|
| MBC-2 (pH 7) | 0.039 | 0.003 |
| MFC-5 (pH 7) | 0.219 | 0.016 |
| MFC-2 (pH 5) | 0.351 | 0.072 |
| MFC-3 (pH 5) | 0.055 | 0.038 |
| MBC-1 (pH 10) | 0.440 | 0.034 |
| MBC-3 (pH 10) | 0.725 | 0.077 |
| Mean | 0.304 | 0.046 |
| CD (p=0.05) | 0.0081 | 0.0011 |
| SE ± | 0.0026 | 0.0004 |
| CV % | 3.68 | 3.80 |

$p \leq 0.0001$

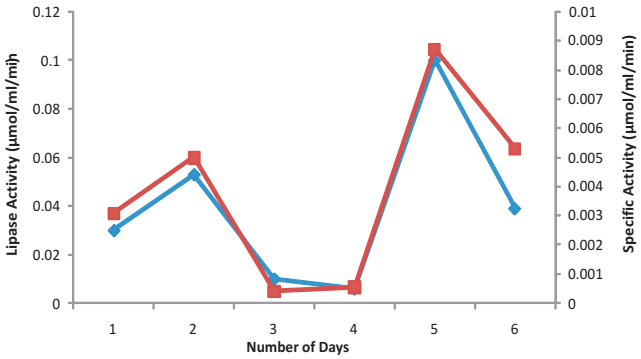


**Fig. 1.** Time course of lipase production by bacterial isolate MBC-2 (pH 7.0)

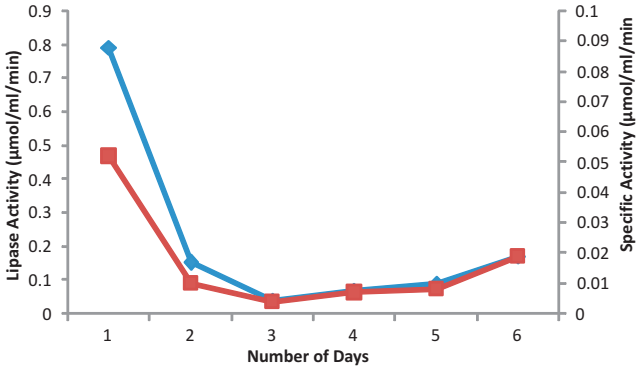


**Fig. 2.** Time course of lipase production by bacterial strain MFC-5 (pH 7.0)

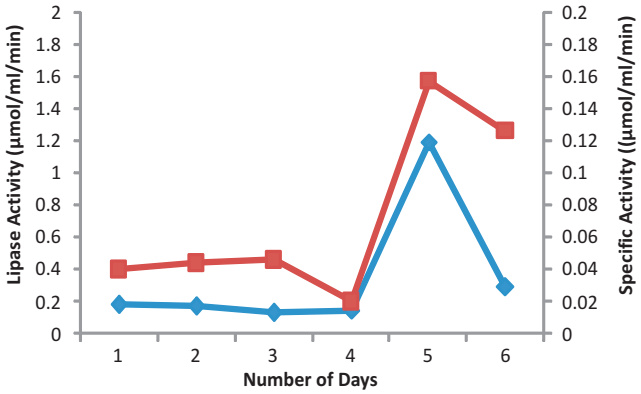


**Fig. 3.** Time course of lipase production by bacterial strain MFC-2 (pH 5.0)

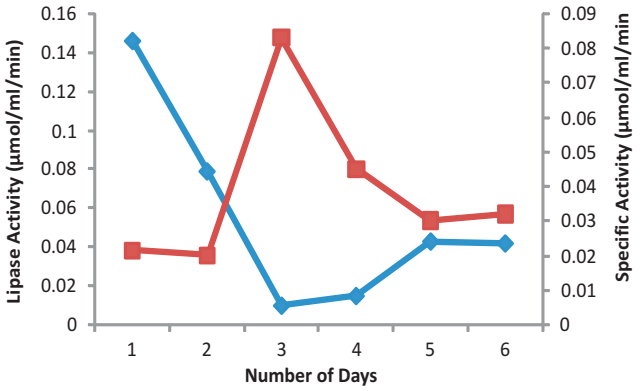


**Fig. 4.** Time course of lipase production by bacterial strain MFC-3 (pH 5.0)

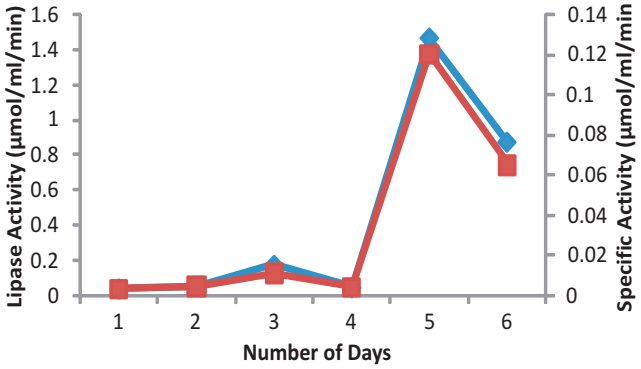


**Fig. 5.** Time course of lipase production by bacterial strain MBC-1 (pH 10.0)

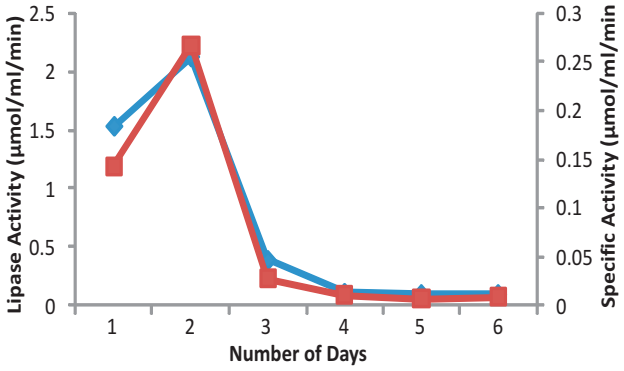


**Fig. 6.** Time course of lipase production by bacterial strain MBC-3 (pH 10.0)

decrease thereafter (Fig. 2). Figure 4 gives comparative account of lipase production of culture MFC-3 with time. In this case, unlike other cultures, it is observed that lipase and specific activity were maximum on different days. The lipase activity was found to be highest on fifth day whereas specific activity wasmaximum on third day.

In majority of the cases, the lipase production increased with time, reaching maximum on day fifth and decreasing thereafter.In a similar study Mahadik *et al.* (2002) found similar results after screening various fungal isolates. They too have reported lipase activity to be the maximum on the fifth day of fermentation when assayed for a period of 6 days, and a prolonged incubation time beyond this period decreased the activity, which is in agreement to the present piece of research.

## CONCLUSION

Twenty two microbial isolates showed appreciable lipase producing ability. Amongst them, six isolates were short-listed, which showed highest lipase production and their fermentation profile with respect to time was worked out by submerged fermentation. It can be concluded that microbes isolated produced reasonably good levels of extracellular lipase under all the pH conditions given. Lipase activity was found to increase in general with time and depreciate thereafter. Mechanisms regulating biosynthesis vary widely in different microorganisms. Also, these enzymes are stable over a broad pH and temperature range and salt concentrations. However, there is a further need to identify these microbes biochemically and also maximize their lipase producing capacity by optimizing process parameters, cultural conditions and genetic manipulations techniques.

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# Economic and Environmental Consequences of Bio-pesticide (*Pseudomonas fluorescens)* Use in Paddy Farms of Southern India

**M. Thilagavathi and M. Chandrasekaran**

*Tamil Nadu Agricultural University, Coimbatore-641 003, India*
*E-mail: tmuthukamatchi@yahoo.com*

***Abstract***: The present study analysed the economic and environmental benefits due to bio-pesticide (*Pseudomonas fluorescens)* application in paddy cultivation. The effect of bio pesticide: *Pseudomonas fluorescens* was the highest at 7.36% in paddy productivity.The hazardous level of pesticide use was minimized in biopesticide user's farms, which was indicated by the differences in EIQ field rating value per ha (-58.13)) between users (EIQ field rating 42.43) and non-users (EIQ field rating 100.56). It would imply that there is a substantial reduction in pesticide pollutants in soil and water of bio pesticide user's farms.The non availability of quality product (mean score value of 67.50) and availability of less virulent culture in the market (mean score value 66.20) were the major constraints realized by the farmers in its adoption. Hence the bio pesticide, *Pseudomonas fluorescens* has positive impact (both economically and environmentally) on paddy production.

***Keywords***: *Pseudomonas fluorescens,* Paddy farms, Decomposition analysis, EIQ value

Over the last few decades, intensive and extensive cultivation of high yielding varieties of crops were introduced in India with a motive to increase food grain production resulted that the five-fold increase in food grain production from 51million tonnes during 1960's to 252.23 million tonnes in 2015-16. This agricultural transformation, popularly known as “green revolution”, had its impact on natural resources, environment and biodiversity. Intensive cultivation, spread of high-yielding varieties, monoculture and overlapping of cropping seasons have resulted in high incidence of pests and diseases, which reduces crop output by 25% at globally (FICCI report, 2015) and it was 35-45% in India. To enhance the productivity, the pesticides were consumed at higher rate over a period of time and it was 3.6 billion kgs and 45390 tonnes during the period 2013 but the per hectare consumption of pesticides in India is the lowest one in the world i.e. 0.6 kg $ha^{-1}$ against 5-7 kg $ha^{-1}$ in the UK and 13 kg $ha^{-1}$ in China. In Tamil Nadu, the pesticide consumption level was decreased to 2269 metric tonnes during the year 2012-13 from 2466 metric tonnes in 2008-09. The negative effects of pesticides necessitated for the use of biopesticides, which is environmentally safe. The increased consumption of biopesticide from 1920 metric tonnes in 2006 to 3366 metric tonnes in the year 2010 with the share of 3% in total pesticide market (FICCI report, 2015) emphasizes the research study on its economic and environmental impact assessment.Paddy is the second major crop (5.6%) next to cotton in biopesticides consumption in India. Paddy occupies 29.3% share in total food crop area in Tamil Nadu. Hence, a study was conducted to assess the economic and environmental impact of *Pseudomonas fluorescens* on rice cultivation in Tamil Nadu with the following specific objectives, to assess the net gain of the use of the bio-pesticide: *Pseudomonas fluorescens* at farm level, to identify the differences in input use, yield and cost and returns of users and non-users of *Pseudomonas fluorescens* to analyze the environmental benefits due to bio pesticide (*Pseudomonas fluorescens)* application and to identify the constraints at farm level.

## MATERIAL AND METHODS

The wholesome information about the farm households, which include the agro-socio- economic details of households including cropping pattern, irrigation sources, cost and returns, major pest and diseases incidence, chemicals used, health and other related problems encountered (reduction in natural enemies population etc.) due to chemicals consumption, awareness and general opinion of *Pseudomonas fluorescens,* reasons for adoption of bio- pesticides, details on reduction in pest and disease incidence, improvements in crop yield, farmers opinion and their suggestions towards improvement in quality aspects of bio pesticide were collected during the year 2011–12 from 30 users and 30non-users of *Pseudomonas fluorescens* sample farm households in Thanjavur district of Tamil Nadu where the farmers have the practice of application of *Pseudomonas fluorescens* for more than five years. To fulfil the objectives of the study, the differences in crop productivity, net gain

received in paddy cultivation under the users and non-users of *Pseudomonas fluorescens* were worked out by using cost and return analysis and partial budgeting technique from the cross section data collected from the sample farms. Sources of the productivity differences between the users and non-users sample farms were identified by decomposing the productivity changes, following Bisaliah (1977) model of decomposition technique as discussed below.

$\ln Y_{usr} = \ln A_{usr} + a_{usr} \ln SD_{usr} + b_{usr} \ln HL_{usr} + c_{usr} \ln ML_{usr} + d_{usr} \ln IR_{usr} + e_{usr} \ln N_{usr} + f_{usr} \ln P_{usr} + g_{usr} \ln K_{usr} + h_{usr} \ln MU_{usr} + i_{usr} \ln PS_{usr} + j_{usr} \ln EDU_{usr} + e_{usr}$ .....(1)

$\ln Y_{nusr} = \ln A_{nusr} + a_{nusr} \ln SD_{nusr} + b_{nusr} \ln HL_{nusr} + c_{nusr} \ln ML_{nusr} + d_{nusr} \ln IR_{nusr} + e_{nusr} \ln N_{nusr} + f_{nusr} \ln P_{nusr} + g_{nusr} \ln K_{nusr} + h_{nusr} \ln MU_{nusr} + i_{nusr} \ln PS_{nusr} + j_{nusr} \ln EDU_{nusr} + e_{nusr}$.....(2)

Subscript usr - users of *Pseudomonas fluorescens;* Subscript nusr - non users of *Pseudomonas fluorescens*

Y - Yield per hectare of paddy from user farm ornon user farms of *Pseudomonasfluorescens*

A - Intercept; SD - Seeds used ($kgha^{-1}$) ; HL - Human labour (man days $ha^{-1}$); ML - Machine Labour (Rs. $ha^{-1}$); IR - Number of irrigation $ha^{-1}$; N - Nitrogen (kg $ha^{-1}$); P - Phosphorus (kg $ha^{-1}$); K - Potash (kg $ha^{-1}$); MU - Farm yard manure (tonnes $ha^{-1}$); PS - Value of pesticides (Rs. $ha^{-1}$); EDU-Education in no. of years ; e - Random error term

Taking differences between Equations (1) and (2) adding and subtracting some terms and on rearranging these terms, one gets Equation (3):

$\ln (Yd_{usr}/Yd_{nusr}) = \{\ln (A_{usr} / A_{nusr})\} + \{(a_{usr} - a_{nusr}) \ln SD_{nusr} + (b_{usr} - b_{nusr}) \ln HL_{nusr} + (c_{usr} - c_{nusr}) \ln ML_{nusr} + (d_{usr} - d_{nusr}) \ln IR_{nusr} + (e_{usr} - e_{nusr}) \ln N_{nusr} + (f_{usr} - f_{nusr}) \ln P_{nusr} + (g_{usr} - g_{nusr}) \ln K_{nusr} + (h_{usr} - h_{nusr}) \ln MU_{nusr} + (i_{usr} - i_{nusr}) \ln PS_{nusr} + (j_{usr} - j_{nusr}) \ln EDU_{nusr}\} + \{a_{usr} \ln (SD_{usr} / SD_{nusr}) + b_{usr} \ln(HL_{usr} / HL_{nusr}) + c_{usr} \ln(\ln ML_{usr} / \ln ML_{nusr}) + d_{usr} \ln(IR_{usr} / IR_{nusr}) + e_{usr} \ln (\ln N_{usr} / \ln N_{nusr}) + f_{usr} \ln (P_{usr} / P_{nusr}) + g_{usr} \ln (K_{usr} / K_{nusr}) + h_{usr} \ln (\ln MU_{usr} / \ln MU_{nusr}) + i_{usr} \ln (PS_{usr} / PS_{nusr}) + j_{usr} \ln (EDU_{usr} / EDU_{nusr})\} + [(U2 - U1)]$ .....(3)

The Equation (3) apportions the differences in yield per hectare between *Pseudomonas fluorescens* user farms and non user farms into three components The LHS of Equation (3) denotes the difference in per hectare productivity of paddy in *Pseudomonas fluorescens* users farms and non users farms while the RHS decomposes the difference in productivity into the changes due to Bio pesticide: *Pseudomonas fluorescens* technology as well as changes in input-use. The first term on right hand side indicates the per cent change in yield due to a shift in the scale parameter A. The next term measured the effect of change in slope parameters. These two terms summed up to the total productivity effect. The third term measured the contribution of changes in input levels to changes in output. To assess the environmental impact of the usage of biopesticide the "Environmental Impact Quotient" (EIQ) was designed by Kovach *et al.* (1992) was used. The EIQ considers eight environmental parameters like the effect of pesticides on pesticide applicators, harvesters, consumers, groundwater, fish, birds, bees and beneficial arthropods. A composite EIQ score was calculated for each pesticide active ingredient using an algebraic equation to combine the numerical ratings assigned each of these effects on farm workers, consumers and on non-human biota. The EIQ method gives the impact that result from the interaction of toxicity and exposure. Therefore most of the effects were calculated by multiplying the rating of exposure indicators and the rating of the toxicity indications. The formula for determining the EIQ value for individual pesticide is given below and it is the average of the EIQ of farm worker, consumer and non-human biota.

EIQ= [C × (DT × 5)+(DT×P)]+[C× [(S+P)/2] ×Sy+L]+[(F×R)+((S+P)/2 X3)+(Z×P X3)+(B ×P ×5)].....(4)

Where,

C-Chronic toxicity or long –term health effects; DT-Indicator of acute toxicity of people

P-Persistence of pesticide residue on plant surface; S-Pesticide half like in the soil

Sy-Systemicity or mode of action; L-Leaching potential; F=fish toxicity; R= Surface loss potential; D=Bird toxicity; Z=Bee toxicity

EIQ field use rating = EIQ× per cent of active ingredient × rate of application

In this study the minimum EIQ for a pesticide active ingredient (a.i.) is 11.33 and the maximum 49.36. It was opined that higher the toxic compounds have higher the EIQ values.Most of the EIQ values used in this study were taken from a database of over 450a.i. that are currently available on a Cornell University website(http://nysipm.cornell.edu/publications/eiq/). However some pesticide a.i. that was not available at that site, we used the EIQ of a chemically similar product, which belonged to the same hazard classification of the World Health Organization (WHO).To assess the constraints at farm level, the constraints in adoption of technology were identified and ranked by using Garrett's scoring technique as follows.

$$\text{Percent position} = \frac{100(R_{ij} - 0.50)}{N}$$

Where, $R_{ij}$- Rank assigned for the $i^{th}$ category by the $j^{th}$ respondent; N- Number of reasons assigned by the $j^{th}$ individual; Using the table developed by Garrett, mean of the score was arrived. Highest mean score was ranked first. Thus, according to the mean score, reasons were ranked.

## RESULTS AND DISCUSSION

The socio –economic profile of sample farm households is given in Table 1. Majority of farmers ranged in age group of 45-55 years. Literacy is average, majority population had education upto primary level and farming experience of 25-35 years.

**Input use pattern of sample farmers:** All the sample farmers are deviating at higher level from the recommended doses of input application. The farmers practiced with the higher seed rate application (85% higher than the recommended level) followed by the lower application of farmyard manure(25% of the recommended doses). Also the farmers are practising application of lower rate of N fertilizers (47% of the recommended doses of N fertilizers) might be the reason for lesser yield than the potential yield.

**Economics of cultivation of paddy in users and non-users:** The total variable/ working cost was Rs.37749 and 37591 per hectare of paddy farms in users and non-users of *Pseudomonas fluorescens* bio-pesticide (Table 3).

The users (farmers applying *Pseudomonas fluorescens* biopesticide) spending higher cost than the non-user farms in terms of seed cost and manures and fertilizer application. But there is a substantial reduction in chemicals and its application cost (on an average Rs.419 $ha^{-1}$) was observed.

**Table1.** Socio - economic profileof the sample farm households

| Particulars | Numbers | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Users | Non –users | Particulars | User | Non-user | Particulars | User | Non-user |
| Age of sample farmer(years) | | | Educational level | | | Experience in farming (years) | | |
| <45 | 4 | 7 | Illiterate | 3 | 5 | >25 | 11 | 12 |
| 45-55 | 16 | 17 | Primary | 11 | 17 | 25-35 | 10 | 12 |
| >55 | 10 | 6 | Secondary | 8 | 0 | >35 | 9 | 6 |
| | | | Collegiate | 8 | 8 | | | |
| Total | 30(100.0) | 30 | | 30 | 30 | | 30 | 30 |

**Table 2.** Input use pattern for users and non-users of *Pseudomonas fluorescens*

| Input | Users | | | Non–users | | |
|---|---|---|---|---|---|---|
| | Recommendation | Usage | % deviation | Recommendation | Usage | % deviation |
| Seed (k $sha^{-1}$) | 40 | 74 | +85 | 40 | 74.1 | + 85.25 |
| Farm yard manure (ton $ha^{-1}$) | 12.5 | 3.66 | -70.72 | 12.5 | 2.16 | - 82.72 |
| Chemical fertilizer(kg $ha^{-1}$) | | | | | | |
| N | 150 | 69.24 | -53.84 | 150 | 75.04 | - 49.97 |
| P | 50 | 51.13 | +2.26 | 50 | 54.32 | + 8.64 |
| K | 50 | 65.46 | +30.92 | 50 | 105.07 | +110.14 |
| Pesticides value (Rs. $ha^{-1}$ ) | - | 221.89 | - | - | 623 | - |
| Bio-pesticide (*pseudomonas fluorescens*) | | 265.53 | | | 0 | |

**Table 3.** Cost and returns of paddy farms (users and non users farm)

| Particulars | Users | Percentage | Non- users | Percentage | Difference |
|---|---|---|---|---|---|
| Seed (Rs.$ha^{-1}$) | 1618 | 4.3 | 1507 | 4.0 | (+) 111 |
| Manures and fertilizers (Rs. $ha^{-1}$) | 6628 | 17.6 | 6162 | 16.4 | (+) 466 |
| Chemicals (Rs.$ha^{-1}$) | 872 | 2.3 | 1033 | 2.7 | (-) 161 |
| Labour use both machine and human (Rs.$ha^{-1}$) | 28631 | 75.8 | 28889 | 76.9 | (-) 258 |
| Total variable cost (Rs.$ha^{-1}$) | 37749 | 100 | 37591 | | (+) 158 |
| Yield (Kg$ha^{-1}$) | 5541 | | 5340 | | (+) 201 |
| Gross return (Rs.) @ the sale price Rs.12 $kg^{-1}$ of paddy | 66492 | | 64080 | | (+) 2412 |
| Net return (Rs. $ha^{-1}$) | 28743 | | 26489 | | (+) 2254 |

As returns, the user farmers were obtained 5.54 tonnes of yield from one hectare, which was 201 kg higher than the non-user farms yield (5.34 tonnes of yield $ha^{-1}$) through which they earned 3.76 per cent (Rs.2412) higher income than the non-user farms.

**Impact of *Pseudomonas fluorescens* technology on paddy farms**

**Economic impact:** Partial budgeting analysis of *Pseudomonas fluorescens* technology revealed that the change in net gain per hectare was Rs. 3020.48 in user's farms than the non-user's farms of biopesticide *Pseudomonas fluorescens* (Table 4).

The contribution was primarily from reduced input cost with respect to reduction in chemical uses (pesticides, fungicides and herbicides) and due to reduction in labour use charges i.e Rs.1946 and increased income level due to additional yield. The results in turn revealed that the lesser chemical use lead to health safety for farmers and labours involving in chemical spraying operations, predators and also reduces pesticide residues in environment (air, soil and water).

**Technology impact:** The total estimated productivity difference between users and non-users of *Pseudomonas fluorescens* bio-pesticide for paddy was 4.10% (Table 5).

Among the various sources responsible for total productivity variation, the effect of bio pesticide, *Pseudomonas fluorescens* was the highest at 7.36 percent. The negative differences in input use level implying that the inefficiency or negative contribution of changes in input use or the indiscriminate uses of inputs by the paddy growers in the study area lowering the advantage by – 3.26 per cent. Thus, the net gain was only 4.10 per cent. Among the various inputs contributing to the productivity difference between users and non-users of paddy farms, human labour (0.17%), fertilizer (1.72%), pesticides (0.414%) contributed positively.

**Table 4.** Partial budgeting analysis for the users of *Pseudomonas fluorescens* with the Non-users of paddy farms

| Changes in values (Rs. $ha^{-1}$) | | Paddy | |
|---|---|---|---|
| Gain | Rs./ha | II. Loss | Rs./ha |
| A. Reduced cost | | C. Added cost | |
| i) Chemical | 920.00 | i) Seed | 111.00 |
| ii) Chemicals and labour use | 1026.00 | ii) FYM | 775.00 |
| | | iii) Seed treatment materials (Bio | 446.00 |
| Total (A) | 1946.00 | Total (C ) | 1332.00 |
| B. Added return | | D. Reduced return | Nil |
| Increased in income | 2406.48 | | |
| Total(B) | 2406.48 | | |
| Total gain (A+B) | 4352.48 | Total loss ( C+D) | 1332.00 |

Net gain = (Total gain – Total loss) = 4352.48 – 1332.00 = Rs.3020.48 $ha^{-1}$

**Table 5.** Decomposition of sources of differences in productivity in users and non- users paddy farms

| Sources of difference in productivity of paddy | Percentage |
|---|---|
| Total observed change in productivity | 3.76 |
| Total estimated difference in productivity | 4.10 |
| Due to *Pseudomonas fluorescens* biopesticide | 7.36 |
| Due to difference in input use level | -3.26 |
| a) Seeds | -0.29 |
| b) Human labour | 0.17 |
| c) Machine labour | -0.011 |
| d) Number of irrigation | -0.44 |
| d) Fertilizer | 1.72 |
| e) Manures | -4.67 |
| f) Pesticides | 0.414 |
| g) Education | -0.153 |

**Environmental impact:** The farmers are using different type of chemicals namely herbicides, pesticides, acaricides and fungicides to control the weeds, pests, mites and fungal pathogens in paddy cultivation mainly to control stem borer (5-6 % of yield loss), blast and false smut (4.2% of yield loss).

The sample farmers in the study area are using highly toxic (organo-phosphate group of chemicals) to moderate toxic and very slightly toxic chemicals, which was indicated by the EIQ values of the chemicals ranging from the minimum value of 11.33 to maximum value of 49.36 (Table 6). However, the EI assessment showed that on an average, hazard was twice as higher as in non users group of farmers since the non-user group of sample farmers are applying more quantity of hazards i.e., highly toxic chemicals (monocrotophos, carbendazim and carbofuran), which

**Table 6.** EIQ value for the users and non-users of *Pseudomonas fluorescence* in paddy farms $ha^{-1}$

| Pesticides | EIQ value | EIQ field rating $ha^{-1}$ | |
|---|---|---|---|
| | | Users | Non-users |
| Oxadiargyl | 11.33 | 5.6 | 4.70 |
| Quizalofopethyl | 22.14 | 0.63 | 0.66 |
| Monocrotophos | 35.34 | 8.47 | 9.11 |
| Carbandazim | 38.75 | 5.79 | 17.71 |
| Etoxazole | 13.42 | 0 | 6.30 |
| Carbofuran | 38.75 | 0 | 6.37 |
| Triazole | 26.1 | 0 | 7.74 |
| Prophonophos | 49.36 | 5.85 | 18.29 |
| Sulpur | 32.66 | 16.09 | 29.68 |
| Total EIQ field rating | | 42.43 | 100.56 |

causes ill effects to the environment (air, water and soil) and health of farm labourers, farmers and other living things at close proximity to chemical use. The results of the EIQ analysis revealed that there is a reduction in EIQ rating value $ha^{-1}$ i.e., -58.13 in users than the non-users of bio-pesticide (*Pseudomonas fluorescens)* in paddy farms indicating the reduction in pesticide pollutants in soil and water. The sample farmers also revealed that there was a substantial increase in natural enemies (spider, dragon flies and beetles) to the pests in their farms.

The constraints in adoption of this technology were identified through Garrett's scoring technique (Table7) that, most of the farmers ranked first (mean score value of 67.5) about the availability of low quality products in market with the shortest shelf life, which created a major problem like low viability. The second major constraint was identified as non-availability of high virulence and native specific cultures (mean score value of 66.2), which has reduced the vulnerability of pest and diseases in the crop. Also, it was identified that the farmers are not having the full knowledge to use and periodicity of its use (mean score value of 46.63) followed by their opinion on its timely availability. They felt that there won't be much problem in getting the product from the market because the product was sold by different firms including TNAU but getting a quality product is difficult because of missing information about the product nature and its quality.

## CONCLUSION

The net gain realized by the users due to technology adoption was Rs. 3020.48 $ha^{-1}$ through additional returns and cost savings in chemicals. The contribution of bio-pesticide *pseudomonas fluorescens* was higher in the yield difference in paddy i.e., 7.36 per cent but the yield potential was lowered by indiscriminate uses of several inputs at farm level, which implied the potential benefit of bio-pesticide in increasing the productivity at farm level. The sample farmers in the study area are using highly toxic (organo-phosphate group of chemicals) to moderate toxic and slightly toxic chemicals to protect their crop from weeds, mites, pest and is diseases. The hazardous level of pesticide use was twice as higher as in non-users group of farms. The non user group of farmers are applying more quantity of toxic chemicals (monocrotophos, carbendazim and carbofuran) than the users group resulting in ill effects to the environment (air, water and soil) and health of farm labourers, farmers and other living things at close proximity to chemical use, which was indicated by the differences in EIQ field rating value per ha i.e -58.13 between users (EIQ field rating 42.43) and non-users (EIQ field rating 100.56) group of paddy farmers. It would imply that there is a substantial reduction in pesticide pollutants in soil and water of bio-pesticide user farms than non-user farms, which was observed through the substantial increase in the natural enemies (spider, dragon flies and beetles) population in users sample farms. In spite of these positive qualities in its adoption, the sample farmers also indicated about some constraints like the availability of low quality product with short shelf life and availability of less virulent culture in the market with the mean score value of 67.5 and 66.2. Hence, it would be concluded that the bio-pesticide *Pseudomonas fluorescens* has positive impact (both economically and environmentally) on paddy production. This study also indicated that the availability of the better quality product in the market increased the benefits at macro level.

**Table 7.** Constraints in the adoption of bio-pesticide (*Pseudomonas Fluorescens)* technology

| Constraints suggestions | Score | Rank |
|---|---|---|
| Shortest shelf life product | 67.50 | 1 |
| Non-availability of high virulence and native specific cultures | 66.20 | 2 |
| Poor knowledge on bio pesticide product | 46.63 | 3 |
| Non-availability of the product in time | 45.19 | 4 |

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# Response of Broadbean (*Vicia faba*) to Irrigation and Phosphorus Levels in Alluvial Zone of West Bengal

**S. Sarkar and A. Sarkar**

*Department of Agronomy*
*Bidhan Chandra KrishiViswavidyalaya, Mohanpur, Nadia-741 252, India*
*E-mail: smritikanasarkar12@gmail.com*

***Abstract*:** The experiment was conducted in rabi seasons of 2009-2011 to study the effect of three irrigation regimes (rainfed, irrigation applied at Ψ = -0.03 MPa at 30 cm soil depth and Ψ = -0.03 MPa at 30 cm soil depth) as main plots and four phosphorus rates (0, 25, 50 and 75 kg $P_2O_5ha^{-1}$) as sub plots on the productivity and efficiency of broadbean. Highest seed yield and efficiencies were recorded when the crop was irrigated at $I_3$ – Ψ = -0.03 MPa at 30 cm soil depth. There was a significant increase in yield, production and economic efficiency with increasing levels of P application. Highest net returns and net return/rupee invested were obtained with the application of irrigation at $I_3$ – Ψ = -0.03 MPa at 30 cm soil depth along with 75 kg $P_2O_5ha^{-1}$. Different irrigation and phosphorus levels altered the soil moisture extraction pattern in all 4 layers (0-15, 15-30, 30-45, 45-60 cm) and extraction rate increased with increasing moisture level in the soil. Significantly highest water use efficiency (WUE) was recorded under rainfed condition when crop was fertilized with 75 kg $P_2O_5ha^{-1}$.

**Keywords**: Broadbean, Yield, Irrigation, Phosphorus, Water use efficiency

Pulses are an integral part of the cropping systems of the farmers because of the suitability of these crops to fit well in the crop rotation and crop mixtures. Mature broadbean grains are a good resource of protein, starch, cellulose and minerals. Therefore, it is of importance for human and animal food (Haciseferogullari *et al*., 2003). High yield, low anti-nutritional factors, high adaptation ability to modern agriculture will make this plant more attractive for farmers, feed and food manufacturers (Duc, 1997). Broad bean is reputed to be more sensitive to water deficits than some other grain legumes (McDonald and Paulsen, 1997; Amede and Schubert, 2003). Abiotic stresses, such as moisture and soil fertility, are largely responsible for low productivity of broadbean. Water is indispensable for every metabolic activity of the plant. Limited quantity of water available for irrigation calls for scheduling of irrigation to improve water productivity of the crop. Because of climate change and shrinking water availability, demand for irrigation might not be met fully. Therefore, irrigation scheduling both amount and timing, based on soil depletion can avoid excess water applied to the crop and maximize the crop productivity per drop of water. Fertilizer is the other major and scarce input, which influences the crop growth and yield tremendously. Phosphorus is recognized as the second major plant nutrient after nitrogen and also an integral part of balanced fertilization for pulse crops. Phosphorus (P) plays a vital role in production of broadbean as its availability not only improves the growth and yield but also enhances the symbiotic N-fixation. Improving nutrient-use efficiency is important to reduce costs of crop production (Bernal *et al.,* 2002). The positive response of phosphorus application to broadbean has been reported by EL-Abagy (2003.) It becomes imperative to determine the response of broadbean to phosphorus application under varying irrigation levels. In view of these points, the present experiment was under taken to determine the most efficient irrigation schedules and correct dose of phosphorus for broad bean in alluvial zone of West Bengal.

## MATERIAL AND METHODS

Field experiments were conducted during *rabi* seasons of 2009-10 and 2010-11at Bidhan Chandra Krishi Viswavidyalaya, Gayeshpur (22.1˚N, 89.2˚E and 9.75m above mean sea-level) in West Bengal. The soil of the experimental site was alluvial and sandy loam in texture with pH 7.62, organic carbon 0.64 %, available N 172.6 $kgha^{-1}$, available P and K of 14.6 and 162.4 $kgha^{-1}$, respectively. The moisture content at field capacity was 21.1% and at permanent wilting point 9.6%.

The experiment was laid out in split plot design with 4 replications. Main plot treatments consisted of three levels of irrigation, viz. $I_1$ – rainfed, $I_2$ – Ψ = -0.05 MPa at 30 cm soil depth, $I_3$ – Ψ = -0.03 MPa at 30 cm soil depth and sub-plots with four levels of phosphorus of each main plot, viz. $P_1$ (no phosphorus application), $P_2$ (25 kg $P_2O_5ha^{-1}$), $P_3$ (50 kg $P_2O_5ha^{-1}$), $P_4$ (75 kg $P_2O_5ha^{-1}$). N @ 15 $kgha^{-1}$, $P_2O_5$ @ 0 / 25 / 50 / 75 $kgha^{-1}$(as per treatment) and $k_2O$ @ 25 $kgha^{-1}$were applied as basal through urea, single superphosphate and muriate of potash, respectively during both the years of

experiment. Broad bean 'Local Red' was sown at a spacing of 20cm x 15cm with a seed rate of 60 kgha$^{-1}$during the 2$^{nd}$ week of November. Plot size was 5m x 3m. Inoculation of seeds with *Rhizobium* culture (1.5 kgha$^{-1}$) was done prior to sowing. A pre-sowing irrigation was given for proper germination and establishment. Remaining irrigations were applied as and when required depending on soil moisture tension. Two irrigations in plots under $I_2$ treatment and three irrigations in plots under $I_3$ treatment were applied. Irrigation water depth (IW) was maintained 50 mm for each irrigation with the help of parshall flume. Irrigation was withdrawn 15 days before harvesting of the crop. The crop was harvested at maturity i.e. in 3$^{rd}$ week of March and yield date was recorded. Total rainfall during the crop growth period was 57.8 and 79.3 mm in successive years of experiment, respectively. The mean minimum and maximum temperature of about 13.8-21.9˚C and 25.7-34.9˚C, respectively were recorded during the crop growth period. The total pan evaporation during the growth period was 452.6 and 468.3 mm in 2010 and 2011, respectively. Soil moisture studies were done during the entire crop period starting from sowing to final harvesting of the crop. Soil moisture record and soil samples were collected from middle of each plot and space between crop rows corresponding to all treatments from 0-15, 15-30, 30-45 and 45-60 cm soil depths with the help of an auger at sowing, immediately before and 48 hours after giving irrigation of each irrigation and at the same time from $I_1$ (rainfed) plots nearly about 15 days interval and finally at harvest to determine the total soil moisture used up by the crop. The soil samples were dried in the oven at 105˚C for 72 hours to calculate the moisture content on gravimetric basis. Volumetric moisture content was then calculated by multiplying the respective bulk density with the gravimetric moisture content.

The profile soil moisture depletion was calculated from the change in soil water content in successive sampling from the following relationship.

$$d = \Sigma u = \sum_{i=1}^{n} \frac{M_{1i} - M_{2i}}{100} \times B.D.i \times Di + ER + Gwc$$

Where, d = Moisture deficit in the root zone;

u = Consumptive use (mm) during a given irrigation interval; $M_{1i}$ = Soil moisture percent at the time of first sampling in the i$^{th}$ layer; $M_{2i}$ = Soil moisture percent at the time of second sampling in the i$^{th}$ layer; B.D.i = Bulk density of soil in the i$^{th}$ layer (g cc$^{-1}$); Di = Depth for i$^{th}$ layer of the soil (cm); ER = Effective rainfall during the period (cm); Gwc = Ground water contribution during the interval (cm). As the water table was below 2 m from soil surface, so ground water contribution was supposed to be nil. At harvest the NPK content in plant was estimated by standard methods. Soil moisture extraction rate was calculated by using following formula:

$$\text{Soil moisture extraction rate (cm day}^{-1}\text{)} = \frac{\text{Soil moisture extraction by the crop (cm)}}{\text{Duration of two successive soil sampling (day)}}$$

$$\text{PE (kg grain kg}^{-1}\text{ P uptake)} = \frac{\text{Grain yield in N-fertilized plots} - \text{Grain yield in zero-P plot}}{\text{(P uptake in P fertilized plot)} - \text{(P uptake in zero-plot)}}$$

$$\text{AE (kg grain kg}^{-1}\text{ P applied)} = \frac{\text{Grain yield in N-fertilized plots} - \text{Grain yield in zero-P plot}}{\text{Quantity of N fertilizer applied in P-fertilized plot}}$$

## RESULTS AND DISCUSSION

**Growth attributes**: The growth parameters viz. plant height, relative growth rate (RGR) were significantly influenced by both irrigation and phosphorus treatments (Table 1). Irrigation applied at Ψ = -0.03 MPa at 30 cm soil depth recorded maximum plant height and was followed by the treatment receiving irrigation at Ψ = -0.05 MPa at 30 cm soil depth. There was a positive response of phosphorus application at increased rate on plant height. The maximum plant was with the application of phosphorus @75 kgha$^{-1}$followed by 50 kg $P_2O_5$ ha$^{-1}$ and then 25 kg $P_2O_5$ ha$^{-1}$. The mean RGR showed variable response to irrigation levels and phosphorus management treatments at different stages of crop growth. At earlier stages the mean RGR was higher compared to later stages of crop growth. Decreasing water regime increased the RGR. At all growth stages, rainfed broad bean showed higher mean RGR, while, among phosphorus treatments, control treatment showed better result. The high RGR of bean at unfavourable conditions of water and nutrients was also reported by Boutraa and Sanders (2001). The N,P and K content in broad bean shoot was maximum with the application of irrigation at Ψ = -0.03 MPa at 30 cm soil depth. Different rates of phosphorus significantly influenced the N,P and K concentration in crop shoot. With the increasing levels of phosphorus, NPK concentration increased and the highest values were recorded with the application of 75 kg $P_2O_5$ ha$^{-1}$ treatment. 50 kg $P_2O_5$ ha$^{-1}$ recorded the next best performance. The results confirm the findings of Tufenkei *et al*. (2006).

**Yield, total phosphorus uptake:** The seed yield, biological

yield and total phosphorus uptake of broad bean were significantly higher with the application of irrigation applied at Ψ = -0.03 MPa at 30 cm soil depth, followed by at Ψ = -0.05 MPa at 30 cm soil depth and rainfed (Table 2). 75 kg $P_2O_5$ $ha^{-1}$ treatment was significantly superior with maximum yield over other levels of phosphorus. Treatment receiving 50 kg $P_2O_5$ $ha^{-1}$ recorded 17.68% higher seed yield over 25 kg $P_2O_5$ $ha^{-1}$. Increase in seed yield of broad bean with the increase in rates of phosphorus dose through the improvement of yield attributes was also observed by Luikham *et al.* (2009). Biological yield also showed the same pattern. Total P uptake by the crop was increased with the increase in phosphorus rates mainly due to the increase in yield components and yield of the crop..

**Economics:** The monetary returns by increased yield was more than the investment made for crop growth, irrigation and quantity of phosphorus applied, resulting in higher net return and net return/rupee invested (Table 2). Among the irrigation treatments, irrigation applied at Ψ = -0.03 MPa at 30 cm soil depth recorded highest net returns and net return/rupee invested followed by the treatment receiving irrigation at Ψ = -0.03 MPa at 30 cm soil depth and rainfed. Among phosphorus rates, 75 kg $P_2O_5$ $ha^{-1}$ maintained its superiority with maximum returns and was followed by the treatment receiving 50 kg $P_2O_5$ $ha^{-1}$ and 25 kg $P_2O_5$ $ha^{-1}$.

**Phosphorus use indices**: The increase in production and economic efficiencies were in irrigated crop when compared to rainfed one. However, broad bean irrigated at Ψ = -0.03

**Table 1.** Effect of irrigation schedules and phosphorus rates on plant height, relative growth rate and nutrient content in shoot of broadbean (Pooled data of 2 years)

| Treatments | Plant height (cm) | | | | Relative growth rate | | | Nitrogen content | Phosphorus content | Potassium content |
|---|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS | At harvest | 30 -60 DAS | 60-90 DAS | 90-120 DAS | | | |
| Irrigation levels | | | | | | | | | | |
| $I_1$:Rainfed | 15.17 | 25.23 | 47.60 | 57.72 | 0.0662 | 0.0209 | 0.0099 | 1.64 | 0.22 | 2.21 |
| $I_2$: = -0.05 MPa at 30 | 17.08 | 32.33 | 60.48 | 69.70 | 0.0608 | 0.0189 | 0.0098 | 1.70 | 0.22 | 2.19 |
| $I_3$: = -0.03 MPa at 30 | 18.89 | 33.24 | 63.48 | 71.13 | 0.0588 | 0.0204 | 0.0097 | 1.73 | 0.24 | 2.23 |
| CD (p=0.05) | NS | 0.248 | 0.154 | 0.265 | 0.0117 | 0.0038 | 0.0022 | 0.025 | NS | 0.047 |
| Phosphorus levels | | | | | | | | | | |
| $P_1$=0 kg $P_2O_5$$ha^{-1}$ | 15.69 | 27.22 | 51.56 | 61.54 | 0.0727 | 0.0217 | 0.0102 | 1.64 | 0.15 | 1.88 |
| $P_2$=25 kg $P_2O_5$$ha^{-1}$ | 16.53 | 29.33 | 55.69 | 64.42 | 0.0637 | 0.0205 | 0.0098 | 1.67 | 0.19 | 2.18 |
| $P_3$=50 kg $P_2O_5$$ha^{-1}$ | 17.55 | 31.26 | 59.24 | 67.77 | 0.0574 | 0.0189 | 0.0095 | 1.72 | 0.25 | 2.34 |
| $P_4$=75 kg $P_2O_5$$ha^{-1}$ | 18.42 | 33.26 | 62.25 | 70.99 | 0.0540 | 0.0193 | 0.0093 | 1.74 | 0.32 | 2.43 |
| CD (p=0.05) | 0.150 | 0.246 | 0.165 | 0.423 | 0.0076 | 0.0039 | 0.0027 | 0.014 | 0.025 | 0.054 |

**Table 2.** Effect of irrigation schedules and phosphorus rates on yield, total phosphorus uptake and economics of broadbean

| Treatments | Seed yield (t $ha^{-1}$) | | Biological yield (t $ha^{-1}$) | | Total phosphorus uptake (kg $ha^{-1}$) | | Net return (x$10^3$₹$ha^{-1}$) | | Net return rupee$^{-1}$ invested (₹) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2009-11 | 2010-11 | 2009-10 | 2010-11 | 2009-10 | 2010-11 | 2009-10 | 2010-11 | 2009-10 | 2010-11 |
| Irrigation levels | | | | | | | | | | |
| $I_1$:Rainfed | 3.55 | 3.74 | 7.70 | 8.02 | 17.25 | 19.32 | 18.9 | 20.2 | 1.22 | 1.28 |
| $I_2$: = -0.05 MPa | 4.52 | 4.83 | 9.58 | 10.04 | 22.32 | 22.80 | 28.7 | 31.9 | 1.31 | 1.37 |
| $I_3$: = -0.03 MPa | 4.79 | 5.05 | 10.15 | 10.54 | 24.78 | 26.96 | 31.4 | 33.8 | 1.44 | 1.49 |
| CD (p=0.05) | 0.21 | 0.21 | 0.49 | 0.91 | 1.05 | 0.56 | - | - | - | - |
| Phosphorus levels | | | | | | | | | | |
| $P_1$=0 kg $P_2O_5$$ha^{-1}$ | 3.21 | 3.49 | 6.97 | 7.52 | 10.32 | 11.82 | 15.2 | 17.3 | 1.25 | 1.28 |
| $P_2$=25 kg | 4.01 | 4.25 | 8.59 | 8.91 | 16.71 | 17.08 | 23.7 | 25.5 | 1.30 | 1.34 |
| $P_3$=50 kg | 4.72 | 5.01 | 10.09 | 10.46 | 24.41 | 27.15 | 31.3 | 33.8 | 1.42 | 1.47 |
| $P_4$=75 kg | 5.22 | 5.41 | 10.92 | 11.24 | 34.35 | 36.07 | 35.4 | 37.8 | 1.54 | 1.61 |
| CD (p=0.05) | 0.26 | 0.21 | 0.54 | 0.55 | 1.64 | 1.14 | - | - | - | - |

MPa at 30 cm soil depth recorded higher values over that irrigated at Ψ = -0.05 MPa at 30 cm soil depth (Table 3). The increment in production and economic efficiency due to irrigation may be due to increment in crop growth and grain yield as a result of sufficient moisture availability for crop growth. Effect of phosphorus fertilization was also statistically comparable on the production and economic efficiency. With successive increase in phosphorus levels perceptible increase in both cases was up to 75 kg $P_2O_5$ $ha^{-1}$. The different irrigation and phosphorus treatments had significant effect on agronomic efficiency (AE), physiological efficiency (PE) and partial factor productivity (PEP). Application of irrigation Ψ = -0.03 MPa at 30 cm soil depth recorded highest AE, PE and PEP followed by irrigation at Ψ = -0.05 MPa at 30 cm soil depth, whereas, the lowest values were in rainfed crop. However AE, PE and PEP declined with the increased application of phosphorus.

**Soil moisture extraction pattern, moisture extraction rate and water use efficiency:** Soil moisture extraction pattern of broadbean under different irrigation regimes was measured in all 4 layers (0-15, 15-30, 30-45, 45-60 cm) (Fig.1). Due to frequent irrigation there was maximum availability of soil moisture in the surface layer. Crop extracted maximum percentage of soil moisture from the top layer (0-15 cm) compared to 15-30 and then 30-45 cm. The minimum moisture uptake was from deeper layer (45-60 cm). The crop irrigated at Ψ = -0.03 MPa at 30 cm soil depth extracted maximum soil moisture (52.04%) from 0-15 cm layer followed by that irrigated at Ψ = -0.05 MPa at 30 cm soil depth (51.42%) and rainfed (48.51%). In deeper layers (30-45 and 45-60 cm), the rainfed crop extracted higher moisture than the irrigated one. This might be due to moisture stress in upper layers has compelled the root to go deeper layers to meet the water requirement (Kumar and Rana, 2007). Different doses of phosphorus showed a slight variation in the soil moisture extraction pattern. In 0-15 and 15-30 cm layer, the higher percentage of soil moisture was extracted when the crop was fertilized with 75 kg $P_2O_5$ $ha^{-1}$. It was closely followed by the treatment receiving 50 kg $P_2O_5$ $ha^{-1}$. However, in deeper layers (30-45 and 45-60 cm), the maximum moisture extraction was in the control 0 kg $P_2O_5$ $ha^{-1}$. The soil moisture extraction rate of broad bean was calculated under different irrigation and phosphorus levels on daily basis beginning from 8 DAS on wards in 2009-10 and from7 DAS on wards in 2010-11 (Table 4). The water

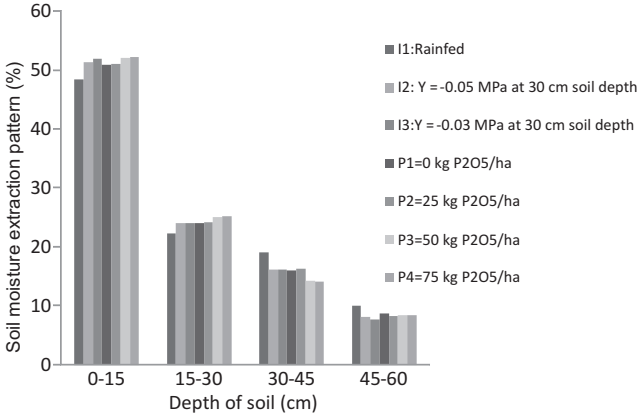



**Fig. 1.** Moisture extraction pattern of broadbean as influenced by different levels of irrigation and phosphorus

**Table 3.** Effect of irrigation Schedule and phosphorus rates on partial factor productivity and efficiencies in broadbean

| Treatments | Production efficiency (kgha$^{-1}$day$^{-1}$) | | Economic efficiency (`ha$^{-1}$day$^{-1}$) | | Physiological efficiency (kg$^{-1}$) | | Agronomic efficiency (kg grain increased kg$^{-1}$ nutrient applied) | | Partial factor productivity (kg seedkg$^{-1}$ P) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2009-10 | 2010-11 | 2009-10 | 2010-11 | 2009-10 | 2010-11 | 2009-10 | 2010-11 | 2009-10 | 2010-11 |
| $I_1$:Rainfed | 28.41 | 29.92 | 151.4 | 161.7 | 77.43 | 73.52 | 18.98 | 18.15 | 89.49 | 93.46 |
| $I_2$: = -0.05 MPa at 30 cm soil depth | 36.16 | 38.64 | 229.8 | 255.4 | 78.58 | 80.45 | 22.73 | 19.93 | 114.74 | 121.15 |
| $I_3$: = -0.03 MPa at 30 cm soil depth | 38.32 | 40.41 | 251.3 | 270.7 | 83.63 | 91.02 | 25.87 | 22.85 | 120.71 | 127.87 |
| CD (p=0.05) | 0.63 | 0.92 | 23.5 | 21.2 | 2.90 | 2.10 | 0.08 | 0.86 | 3.66 | 3.89 |
| $P_1$=0 kg $P_2O_5$$ha^{-1}$ | 25.68 | 27.92 | 121.9 | 138.6 | - | - | - | - | - | - |
| $P_2$=25 kg $P_2O_5$$ha^{-1}$ | 32.08 | 34.01 | 189.7 | 204.2 | 127.6 | 131.5 | 32.61 | 29.67 | 160.72 | 170.13 |
| $P_3$=50 kg $P_2O_5$$ha^{-1}$ | 37.76 | 40.08 | 250.5 | 270.8 | 107.9 | 94.46 | 30.39 | 28.93 | 94.59 | 100.21 |
| $P_4$=75 kg $P_2O_5$$ha^{-1}$ | 41.76 | 43.28 | 283.4 | 302.5 | 84.03 | 76.68 | 26.92 | 24.63 | 69.61 | 72.14 |
| CD (p=0.05) | 0.64 | 0.94 | 27.0 | 31.3 | 4.30 | 5.80 | 1.64 | 0.74 | 4.33 | 4.52 |

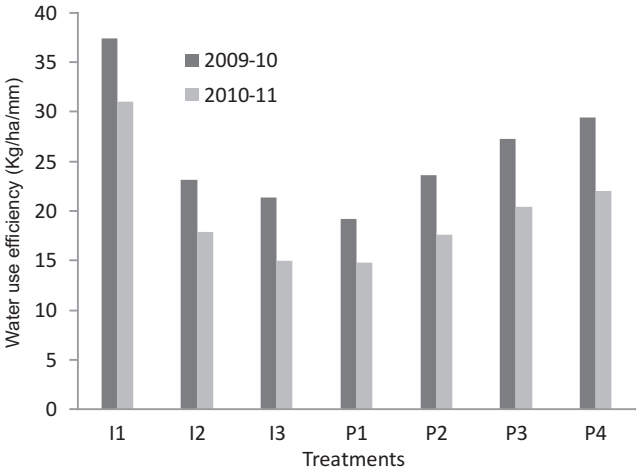
**Table 4.** Effect of irrigation and Phosphorus rates on soil moisture extraction rate (cm day$^{-1}$) during growth period of broad bean

| Soil moisture extraction rate (cm day$^{-1}$) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 2009-10 | | | | | 2010-11 | | | | |
| Days after sowing | $P_1$ (No phosphorus) | $P_2$ (Phosphorus @ 25 kg ha$^{-1}$) | $P_3$ (Phosphorus @ 50 kg ha$^{-1}$) | $P_4$ (Phosphorus @ 75 kg ha$^{-1}$) | Days after sowing | $P_1$ (No phosphorus) | $P_2$ (Phosphorus @ 25 kg ha$^{-1}$) | $P_3$ (Phosphorus @ 50 kg ha$^{-1}$) | $P_4$ (Phosphorus @ 75 kg ha$^{-1}$) |
| $I_1$ = Rainfed | | | | | | | | | |
| 8 | 0.077 | 0.078 | 0.084 | 0.081 | 7 | 0.069 | 0.078 | 0.092 | 0.082 |
| 23 | 0.084 | 0.104 | 0.093 | 0.093 | 22 | 0.109 | 0.097 | 0.098 | 0.107 |
| 38 | 0.091 | 0.117 | 0.113 | 0.107 | 36 | 0.124 | 0.114 | 0.136 | 0.124 |
| 53 | 0.163 | 0.191 | 0.167 | 0.147 | 51 | 0.145 | 0.135 | 0.138 | 0.173 |
| 68 | 0.08 | 0.049 | 0.07 | 0.097 | 61 | 0.272 | 0.318 | 0.247 | 0.178 |
| 83 | 0.057 | 0.042 | 0.045 | 0.05 | 76 | 0.075 | 0.068 | 0.073 | 0.072 |
| 98 | 0.037 | 0.03 | 0.036 | 0.042 | 95 | 0.059 | 0.064 | 0.061 | 0.066 |
| 114 | 0.022 | 0.015 | 0.03 | 0.026 | 114 | 0.050 | 0.060 | 0.055 | 0.057 |
| $I_2$ : Ψ = -0.05 MPa at 30 cm soil depth | | | | | | | | | |
| 8 | 0.07 | 0.071 | 0.09 | 0.079 | 7 | 0.075 | 0.079 | 0.074 | 0.081 |
| 23 | 0.093 | 0.11 | 0.105 | 0.111 | 22 | 0.078 | 0.088 | 0.087 | 0.091 |
| 38 | 0.13 | 0.125 | 0.127 | 0.123 | 37 | 0.107 | 0.114 | 0.119 | 0.095 |
| 51 | 0.175 | 0.166 | 0.164 | 0.17 | 48 | 0.233 | 0.218 | 0.234 | 0.23 |
| 67 | 0.202 | 0.212 | 0.169 | 0.215 | 60 | 0.912 | 0.895 | 0.921 | 0.918 |
| 83 | 0.208 | 0.216 | 0.248 | 0.242 | 73 | 0.24 | 0.223 | 0.253 | 0.258 |
| 102 | 0.219 | 0.197 | 0.231 | 0.223 | 85 | 0.204 | 0.216 | 0.242 | 0.196 |
| 116 | 0.175 | 0.173 | 0.176 | 0.189 | 98 | 0.369 | 0.39 | 0.321 | 0.369 |
| | | | | | 114 | 0.041 | 0.04 | 0.05 | 0.057 |
| $I_3$ : Ψ = -0.03 MPa at 30 cm soil depth | | | | | | | | | |
| 8 | 0.096 | 0.075 | 0.085 | 0.091 | 7 | 0.083 | 0.07 | 0.078 | 0.092 |
| 23 | 0.105 | 0.12 | 0.123 | 0.115 | 22 | 0.11 | 0.099 | 0.091 | 0.099 |
| 39 | 0.107 | 0.134 | 0.126 | 0.126 | 37 | 0.114 | 0.109 | 0.099 | 0.113 |
| 58 | 0.179 | 0.165 | 0.171 | 0.189 | 55 | 0.578 | 0.629 | 0.632 | 0.623 |
| 73 | 0.239 | 0.245 | 0.261 | 0.273 | 73 | 0.239 | 0.232 | 0.235 | 0.241 |
| 91 | 0.300 | 0.318 | 0.305 | 0.311 | 89 | 0.468 | 0.498 | 0.513 | 0.498 |
| 109 | 0.253 | 0.259 | 0.255 | 0.27 | 100 | 1.21 | 1.19 | 1.14 | 1.19 |
| 120 | 0.211 | 0.226 | 0.224 | 0.201 | 114 | 0.089 | 0.095 | 0.125 | 0.109 |

extraction rate of the crop depends on the amount of irrigation and increases with the increase in moisture status of the soil. In general, irrespective of irrigation and phosphorus levels, the moisture extraction rate increased up to a certain growth stage and there after the trend was in decreasing pattern till harvest. But when there was more availability of moisture either through irrigation or rainfall, then the same was increased. Broadbean irrigated at = -0.03 MPa at 30 cm soil depth recorded maximum moisture extraction of 0.318cmday$^{-1}$ at 91 days after sowing (DAS) and 1.21 cm day$^{-1}$ at 100 DAS during first and second year, respectively. In general, the root water uptake was maximum immediately after irrigation and gradually decreases till the next irrigation application as reported by Jana and Mallick (2003). The variation in soil moisture extraction rate due to changes in phosphorus levels was narrow throughout the growth period.

Water use efficiency of broadbean was found increased with the decrease in levels of irrigation and crop grown under rainfed condition i.e., without any irrigation application, which recorded the highest water use efficiency (37.45 and 31.09 kg ha$^{-1}$ mm$^{-1}$ in 2009-10 and 2010-11, respectively) followed irrigation at = -0.05 MPa at 30 cm soil depth (Fig.2). There was a steady increase in water use efficiency value with the increasing levels of phosphorus upto 75 kg $P_2O_5$ ha$^{-1}$. The highest value (29.51 and 22.05 kg ha$^{-1}$ mm$^{-1}$ in successive years, respectively) was obtained with 75 kg $P_2O_5$ ha$^{-1}$ and followed by the application of 50 kg $P_2O_5$ ha$^{-1}$ and 25 kg $P_2O_5$ ha$^{-1}$. The lowest water use efficiency was under the treatment where broad bean was not fertilized with phosphorus.

Thus, it can be concluded that both irrigation and phosphorus fertilization in proper rate and time are necessary for maintaining adequate moisture and fertility




$I_1$ = Rainfed; $I_2$ : Ψ = -0.05 MPa at 30 cm soil depth; $I_3$ : Ψ = -0.03 MPa at 30 cm soil depth;
$P_1$ = No phosphorus application; $P_2$ = Phosphorus @ 25 $kgha^{-1}$; $P_3$= Phosphorus @ 50 $kgha^{-1}$ and $P_4$ = Phosphorus @ 75 $kgha^{-1}$.

**Fig. 2.** Water use efficiency of broadbean as influenced by different levels of irrigation and phosphorus

status of soil to ensure increased growth, efficient and profitable cultivation of broad bean.

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# Effect of Silicon and Nitrogen Application on Yield and Micronutrient Contents in Rice (*Oryza sativa* L.)

**Jugal K. Malav and V. P. Ramani[1]**

*Deptartment of Agricultural Chemistry and Soil Science, S.D. Agricultural University, Sardarkrushinagar-385 506, India*
*[1]Micronutrient Research Project, Anand Agricultural University, Anand-388 110, India*
*E-mail: jugalmalav966@gmail.com*

***Abstract:*** Field trials were conducted to study the effect of silicon and nitrogen application on yield and micronutrient contents of rice. The experiment was carried out in factorial randomized block design with three replications, encompassing four levels of silicon *viz.,* 0, 200, 400 and 600 kg Si $ha^{-1}$ from calcium silicate and four levels of nitrogen *viz.,* 0, 75, 100 and 125 kg N $ha^{-1}$ from ammonium sulphate. The highest grain and straw yields (6163 and 8536 kg $ha^{-1}$, respectively) of rice were recorded with Si application of 600 kg $ha^{-1}$ whereas, nitrogen application @ 125 kg $ha^{-1}$ gave 6445 and 8658 kg $ha^{-1}$, grain and straw yields, respectively. Silicon application had increased the Zn and Cu contents in grain by 14 and 12% over check, respectively. Nitrogen application had increased grain and straw contents by 18 and 16% over check, respectively. However, the silicon application significantly decreased the Fe and Mn contents in rice grain as well as straw. The effect of Si and N and their interaction was found significant for Fe, Mn, Zn and Cu contents in rice gain and straw.

***Keywords*:** Rice, Silicon, Nitrogen, Yield, Micronutrient contents

Rice is considered to be a Si accumulator plant and tends to actively accumulate Si to tissue concentrations of 5 per cent or higher (Epstein, 1999). Application of N fertilizers is an important practice for increasing rice yields. However, when applied in excess may limit yield because of lodging, promote shading and susceptibility to insects and diseases. These effects could be minimized by the use of Si (Munir *et al.,* 2003). Information on the importance of Si in Indian rice farming system is limited (Prakash, 2002). Rice is prone to various stresses if the available soil silicon is low for absorption. Production of 5 t $ha^{-1}$ of grain yield of rice is estimated to remove about 230-470 kg elemental Si from soil, depending upon soil and plant factors. Absorption will be about 108 % more than the N content. Adequate supply of silicon to rice from tillering to elongation stage increases the number of grains $panicle^{-1}$ and the percentage of ripening (Korndorfer *et al.,* 2001). Silicon has been reported to raise the optimal level of nitrogen in rice.

Silicon (Si) is one of the most abundant elements found in the earth's crust, but is mostly inert and only slightly soluble. Rice is known to absorb more Si than any other mineral nutrient accumulates in the plant. Response to silicon fertilization has been documented in some areas of the world but the reason for this plant response or yield increase is not fully understood and several mechanisms have been proposed. Plant growth studies indicate that rice yield responses to silicon may be associated with induced resistance to biotic and abiotic stresses such as disease and pest resistance, Al, Mn and Fe toxicity alleviation, increased P availability, reduced lodging, improved leaf and stalk erectness, freeze resistance, and improvement in plant water economy. Si also alleviates the effects of other abiotic stresses including salt stress, metal toxicity, drought stress, radiation damage, nutrient imbalance, high temperature, and freezing (Ma and Takahashi, 2002). Ma and Takahashi (1991) suggested that silicic acid did not increase P availability in soil. According to them, the overall beneficial effect of silicon may be attributed to a higher P: Mn ratio in the shoot due to the decreased Mn and Fe uptake and thus indirectly to improve P utilization within the paddy plants. They had concluded that the interaction between phosphorus and silicon was indirect in phosphorus deficient soil. Therefore, the present study was conducted to explore the effect of silicon and nitrogen application on yield and Fe, Mn, Zn and Cu content in rice (*Oryza sativa* L.).

## MATERIAL AND METHODS

Field experiments were conducted during the Kharif seasons of 2014 and 2015 at Agriculture Research Station, Anand Agricultural University, Jabugam, India, which is situated at 22°17'37.70" north latitude, 73°46'41.02" east longitude with an elevation of 92 meters above mean sea level. The climate of Jabugam region is semi-arid and sub-tropical with hot summer and cold winter. The total rainfall of the region is about 800-1000 mm. Average minimum and maximum temperature of both the year of study was 19.6°C and 33.3°C, respectively. The soil was loamy sand, with a sand, fine sand, silt and clay composition of 49.8, 26.6, 10.0

and 12.1%, respectively. The soil chemical analysis indicated that the pH was 6.32, EC= 0.43 $dSm^{-1}$, OC= 6.32 g $kg^{-1}$, available N= 313 kg $ha^{-1}$, Si= 190.8 kg $ha^{-1}$, $P_2O_5$= 88 kg $ha^{-1}$, $K_2O$= 221 kg $ha^{-1}$, Fe=1.04 mg $kg^{-1}$, Mn=21.6 mg $kg^{-1}$, Zn=1.45 mg $kg^{-1}$ and Cu=1.62 mg $kg^{-1}$.

The experiment was laid out in randomized block design with factorial concept encompassing three replications and sixteen combined treatments with plot size was 5.0m×3.6m, GAR 13 (Gujarat Anand Rice 13) variety was used in this experiment with four levels (0, 75, 100 and 125 kg $ha^{-1}$) of N were applied through ammonium sulphate in 3 equal splits (1/3 basal, 1/3 at active tillering stage and 1/3 at panicle initiation stage) and four levels (0, 200, 400 and 600 kg $ha^{-1}$) of Si were applied through calcium silicate at the time of sowing. Other cultural operations were followed as per the recommendations.

Grain and straw yields were recorded at harvest. Soil and plant samples were analyzed for nutrient contents at harvest following standard methods as suggested by Lindsay and Norvel (1978) and Jackson, (1973), respectively.

## RESULTS AND DISCUSSION

**Grain and straw yield:** The rice grain and straw yield was significantly influenced by silicon application (Table 1). The significantly higher grain (6163 kg $ha^{-1}$) and straw (8536 kg $ha^{-1}$) yields recorded due to silicon application at 600 kg $ha^{-1}$. The increase in rice yield might be due to increased availability and beneficial effects of silicon *viz.,* decreasing mutual shading by improving leaf erectness, decreasing susceptibility to lodging, decreasing the incidence of infections with root parasites and pathogens, leaf pathogens and preventing manganese and iron toxicity or both. Increased water use efficiency observed with the application of Si, probably might be due to prevention of excessive transpiration. During the reproductive stage, silicon is preferentially transported into the flag leaves, and interruption of silicon supply at this stage is detrimental for spikelet fertility (Ma *et al.* 2006). Chen *et al.* (2011) stated that silicon application increased grain yield by increase of spikelet number, filled spikelet percentage and 1000-seed weight. Mauod *et al.* (2003) reported that grain yield increased by silicon application. The interaction effect between N and Si on grain and straw yields of rice was not significant.

The application of nitrogen had significant effect on grain yield of rice and maximum grain (6445 kg $ha^{-1}$) and straw (8658 kg $ha^{-1}$) yields were recorded due to application of 125 kg N $ha^{-1}$ significantly. The increase in yield as a result of nitrogen application could be due to marginal nitrogen content of soil, improvement in root development and vegetative growth as well. The improvement in yield attributing traits may be ascribed to the improved vegetative growth due to N fertilization, facilitating photosynthesis, thereby increasing translocation of organic food materials towards the reproductive organs; which enhanced the formation of panicles with fertile grains. Sudhakar *et al.* (2006) also observed 16.7 per cent increase in grain yield with application of N at 160 kg $ha^{-1}$ as compared

**Table 1.** Effect of nitrogen and silicon on yield and micronutrient contents in grain and straw at harvest of rice crops (pooled 2 years)

| Treatments | Nutrient contents (mg $kg^{-1}$) | | | | | | | | Yield (kg $ha^{-1}$) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Fe | | Mn | | Zn | | Cu | | Grain | Straw |
| Nitrogen levels (kg $ha^{-1}$) | Grain | Straw | Grain | Straw | Grain | Straw | Grain | Straw | | |
| N 0 | 35.1 | 105.7 | 75 | 264 | 13.7 | 49.84 | 2.44 | 5.39 | 5241 | 6961 |
| N 75 | 35.6 | 109.4 | 79 | 269 | 15.1 | 54.27 | 2.63 | 5.66 | 6040 | 7982 |
| N 100 | 35.6 | 99.5 | 79 | 270 | 16.3 | 55.21 | 2.52 | 5.89 | 6163 | 8541 |
| N 125 | 34.4 | 101 | 75.5 | 276 | 16.1 | 57.82 | 2.53 | 5.69 | 6445 | 8658 |
| CD (p=0.05) | NS | NS | NS | NS | 0.94 | 3.88 | NS | NS | 221 | 422 |
| Silicon levels (kg $ha^{-1}$) | | | | | | | | | | |
| Si 0 | 39.8 | 116.6 | 90.3 | 299 | 13.9 | 46.56 | 2.34 | 5.16 | 5693 | 7319 |
| Si 200 | 37.4 | 104.6 | 83.7 | 294 | 15.9 | 52.97 | 2.52 | 5.69 | 5944 | 7934 |
| Si 400 | 34.5 | 98.4 | 69.5 | 252 | 16 | 55.3 | 2.6 | 5.96 | 6091 | 8354 |
| Si 600 | 28.9 | 96 | 65 | 235 | 15.2 | 62.32 | 2.64 | 5.82 | 6163 | 8536 |
| CD (p=0.05) | 2.45 | 6.6 | 5.11 | 20 | 0.94 | 3.88 | 0.16 | 0.38 | 221 | 422 |
| N x Si | NS | Sig | Sig | Sig | Sig | Sig | NS | Sig | NS | NS |
| CV % | 12.1 | 11 | 11.5 | 12.6 | 10.7 | 12.4 | 10.8 | 11.5 | 6.2 | 9.5 |

to 80 kg N $ha^{-1}$. Above all, excess N also prolongs the vegetative growth at the cost of reproductive growth, thus, diminishing the production of carbohydrates (Mauod *et al.* 2003). Singh *et al.* (2012) reported that the grain yield increased significantly due to 120 kg N $ha^{-1}$ contributing in three times (transplanting, tillering and panicle initiation).

**Micronutrient Content in Grain and Straw at Harvest**

**Fe (mg $kg^{-1}$) content:** The effect of different levels of nitrogen on content of Fe in rice grain and straw did not result in any significant change (Table 2). The treatment 600 kg Si $ha^{-1}$ gave significantly lowest Fe content in grain (28.91 mg $kg^{-1}$) and straw (96.0 mg $kg^{-1}$) compared to other treatments, which received lower levels of silicon doses. The interaction effect of N x Si was found significant. The significantly lowest Fe content in straw was recorded under Si application at 600 kg $ha^{-1}$ combined with N application at 125 kg $ha^{-1}$ (90.4 mg $kg^{-1}$). It is possible to postulate five different mechanisms of Fe toxicity reduction by Si-rich compounds. Firstly, monosilicic acid can increase soil pH (Lindsay, 1979). Secondly, monosilicic acid can be adsorbed on Fe hydroxides, impairing their mobility (Panov *et al*., 1982). Thirdly, soluble monosilicic acid can form slightly soluble substances with ions of Al (Horigushi, 1988). Another possibility for Fe toxicity reduction by Si-rich compounds can be strong adsorption of mobile Fe on silicon surfaces (Shulthess and Tokunda, 1996). Fifthly, mobile silicon compounds can increase plant tolerance to Fe (Rahman *et al*., 1998). All of these mechanisms may work simultaneously, with certain ones prevailing under various soil conditions. These results confirm the earlier findings of Esfahani *et al*. (2014), Malav *et al*. (2015) and Pati *et al*. (2016).

**Mn content*:*** The **a**pplication of silicon resulted in significant decrease in Mn content in rice grain and straw over the control (Table1). The treatment 600 kg Si $ha^{-1}$ gave significantly lowest Mn content in grain (65.03 mg $kg^{-1}$) and straw (235 mg $kg^{-1}$) compared to other treatments which received lower levels of silicon doses. The interaction effect of N x Si was found significant in grain and straw (Table 3). The significantly lowest Mn content in grain was recorded under Si application at 600 kg $ha^{-1}$ combined with N application at 125 kg $ha^{-1}$ (50.98 mg $kg^{-1}$). Whereas, the lowest Mn content in rice straw (202 mg $kg^{-1}$) was observed under combined application of 75 kg N and 400 kg Si $ha^{-1}$. Interaction between Si and Mn occurs in solution, probably by the formation of Mn-Si complexes, a non-toxic form. However, monosilicic acid concentration in the soil initiated decomposition of secondary minerals that control numerous soil properties (Marsan and Torrent, 1989). A second negative effect of reduced monosilicic acid concentration in the soil is decreased Mn concentration; thereafter it leads to plant disease and pest resistance (Epstein, 1999).

**Zinc content*:*** The Zn content in rice grain and straw at harvest was affected by different treatments of nitrogen. The treatment 100 kg N $ha^{-1}$ gave significantly higher Zn content in grain (16.26 mg $kg^{-1}$). Whereas, the highest Zn content in straw (57.82 mg $kg^{-1}$) was observed at 125 kg N $ha^{-1}$. The application of silicon had significant effect on Zn content in rice grain and straw. The treatment 400 kg Si $ha^{-1}$ gave significantly higher Zn content in grain (15.99 mg $kg^{-1}$). Whereas, the maximum Zn content in rice straw (62.32 mg $kg^{-1}$) at harvest was with the application of Si at 600 kg $ha^{-1}$.

The interaction effect between N and Si application on Fe content in grain was found significant. Among all treatment combinations, the highest Fe content in grain (18.72 mg $kg^{-1}$) was observed under combined application of 100 kg N $ha^{-1}$ and 200 kg Si $ha^{-1}$; which was at par with combinations of $N_{100}Si_{400}$ and $N_{125}Si_{200}$. However, the highest Zn content in straw (65.12 mg $kg^{-1}$) was observed under combined application of 100 kg N $ha^{-1}$ and 600 kg Si $ha^{-1}$; which was at par with different combinations of N and Si *i.e.* $N_0Si_{600}$, $N_{75}Si_{400}$, $N_{75}Si_{600}$, $N_{100}Si_{200}$, $N_{125}Si_{400}$ and $N_{125}Si_{600}$ (Table 3). These results confirm the earlier findings of Esfahani *et al*. (2014), Malav *et al*. (2015) and Pati *et a*l. (2016). In soil solution monosilicic acids are able to combine with Zn in

**Table 2.** Interaction effect of N x Si on Fe and Cu content in straw at harvest of rice (pooled 2 years)

| Fe and Cu content in straw (mg $kg^{-1}$) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Treatments | Nitrogen levels (kg $ha^{-1}$) | | | | | | | |
| Silicon levels (kg $ha^{-1}$) | $N_0$ | | $N_{75}$ | | $N_{100}$ | | $N_{125}$ | |
| | Fe | Cu | Fe | Cu | Fe | Cu | Fe | Cu |
| $Si_0$ | 121.3 | 4.4 | 117.6 | 5.9 | 106 | 5.2 | 122 | 5.1 |
| $Si_{200}$ | 98.1 | 5.4 | 116.4 | 5 | 110.3 | 6.7 | 93.5 | 5.6 |
| $Si_{400}$ | 105.5 | 6 | 98.9 | 6 | 90.5 | 5.6 | 98.5 | 6.2 |
| $Si_{600}$ | 97.8 | 5.7 | 104.7 | 5.7 | 91.2 | 6.1 | 90.4 | 5.8 |
| CD (p=0.05) | Fe=13.2 | | Cu=0.75 | | | | | |
| CV % | Fe=11.0 | | Cu=11.5 | | | | | |

**Table 3.** Interaction effect of N x Si on Mn and Zn content in grain and straw at harvest (pooled 2 years)

| Mn content in grain and straw (mg kg$^{-1}$) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Treatments | Nitrogen levels (kg ha$^{-1}$) | | | | | | | |
| Silicon levels (kg ha$^{-1}$) | $N_0$ | | $N_{75}$ | | $N_{100}$ | | $N_{125}$ | |
| | Grain | Straw | Grain | Straw | Grain | Straw | Grain | Straw |
| $Si_0$ | 86.06 | 275 | 93.34 | 318 | 86.64 | 257 | 95.3 | 344 |
| $Si_{200}$ | 80.15 | 271 | 87 | 303 | 81.31 | 342 | 86.5 | 258 |
| $Si_{400}$ | 68.55 | 307 | 67.24 | 202 | 72.86 | 228 | 69.2 | 271 |
| $Si_{600}$ | 65.35 | 204 | 68.59 | 252 | 75.21 | 253 | 51 | 232 |
| | Grain | | | | Straw | | | |
| CD (p=0.05) | 10.21 | | | | 39 | | | |
| CV % | 11.5 | | | | 12.6 | | | |
| **Zn content in grain and straw** | | | | | | | | |
| | Nitrogen levels (kg ha$^{-1}$) | | | | | | | |
| | $N_0$ | | $N_{75}$ | | $N_{100}$ | | $N_{125}$ | |
| | Grain | Straw | Grain | Straw | Grain | Straw | Grain | Straw |
| $Si_0$ | 12.46 | 34.85 | 14.22 | 52.72 | 13.2 | 44.37 | 15.9 | 54.29 |
| $Si_{200}$ | 13.43 | 49.68 | 14.62 | 43.7 | 18.72 | 64.01 | 17 | 54.47 |
| $Si_{400}$ | 13.92 | 56.9 | 16.3 | 59.25 | 17.75 | 47.36 | 16 | 57.69 |
| **$Si_{600}$** | 14.93 | 57.94 | 15.16 | 61.39 | 15.4 | 65.12 | 15.4 | 64.84 |
| | Grain | | | | Straw | | | |
| CD (p=0.05) | 1.88 | | | | 7.77 | | | |
| CV % | 10.7 | | | | 12.4 | | | |

soluble complex compounds (Schindler *et al*., 1976) and poorly soluble as Zn silicate (Lindsay, 1979). Low concentration of monosilicic acids in the solution leads to formation of complexes of a Zn with a silicic acid anion. As the result of this reaction, the content of Zn increases the concentration of monosilicic acids in the solution slightly increases (Bocharnikova *et al*., 1995).

**Cu content:** The effect of different levels of nitrogen on content of Cu in rice grain and straw did not result in any significant change (Table 1). The treatment 600 kg Si ha$^{-1}$ gave significantly higher Cu content in grain; which was at par with 200 and 400 kg Si ha$^{-1}$. Whereas, significantly the higher Cu content in straw was observed with the application of Si at 400 kg ha$^{-1}$; which was at par with 200 and 600 kg Si ha$^{-1}$. The interaction effect between N and Si application on Cu content in straw was found significant. Among all treatment combinations, the highest Cu content in straw (6.74 mg kg$^{-1}$) was observed under combined application of 100 kg N ha$^{-1}$ and 200 kg Si ha$^{-1}$.

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# Effect of Planting Method and Nutrient Management Practices on Seed Yield of Brown Sarson (*Brassica rapa* L.)

**Shabir H. Wani, Gowhar Ali, M. Ashraf Bhat, Javeed A. Lone, Asif M. Iqbal[1], Zahoor A Dar[2], Ajaz A. Lone[2] and Mojtaba Kordrostami[3]**

*Division of Genetics and Plant Breeding, FoA, Wadura Sopore-193 201, SKUAST-Kashmir, India*
*[1] Mountain Research Centre for Field Crops, Khudwani, Anantnag-192 102 SKUAST-Kashmir, India*
*[2]Dryland (Karewa) Agriculture Research Station Budgam-191 113, SKUAST-Kashmir, India*
*[3]Faculty of Agricultural Sciences, University of Guilan- 41335 Rasht, Iran*
*E-mail: shabirhussainwani@gmail.com*

***Abstract***: Field experiments were carried out to investigate the effect of planting method and fertilizer doses on yield and yield components of brown sarson. The seed yield and yield related traits including plant height, the number of siliquae plant$^{-1}$, seed weight, days to flowering, days to maturity and secondary branches were evaluated. All the growth and yield parameters of mustard plant were significantly affected by fertilizer dose and planting methods. The combination of 125% RFD + line sowing had a significant impact on the majority of yield-related traits in brown sarson. At the same time, it was also demonstrated that the use of boron can affect the important traits such as seed yield and number of siliqua plant$^{-1}$. In addition, the line sowing was a better method for increasing the seed yield because of less competition for light, space and nutrients.

***Keywords***: Brown sarson, Boron, Sowing method, Yield, Rapeseed-mustard

Oilseeds are grown to extract the oil from their seeds but also considered as a valuable source of protein. Both oil and meals are equally important and require special analysis (Singh *et al.,* 2000). Brassicaceae have a broad distribution all over the world. This genus is the main oilseed in the moderate climates of Europe, North America, Asia and Africa; but they don't grow well in the humid tropical lands Vassilina *et al.* (2012). In India, rapeseed and mustard are the major oilseed crops, traditionally grown everywhere in the country due to their high adaptability in conventional farming systems and occupy an area of over 8.4 thousand hectares, with a total production of 3.6 thousand tons with an average yield of 4.3 q ha$^{-1}$. Brown sarson is the most important crop, which is related to the rapeseed-mustard group. Its origin is Eastern Afghanistan and adjoining parts of India and Pakistan, fits well in the oilseed – paddy rotation (Majumdar and Sandhu, 1989). Brown sarson (*Brassica rapa* L.) is predominantly grown oilseed crop in Kashmir. Winter hardiness and particularly short duration makes it the crop of choice in the prevailing rice-oilseed cropping sequence (Rather *et al.,* 2012; Akhter *et al.,* 2015).

Planting methods and nutrient management are the most important factors in increasing the productivity of crop plants. Planting methods depend heavily on the farmer's resources, management conditions and soil conditions and thus furrow method; broadcast, line sowing and broad bed are common planting methods for rapeseed-mustard. In an experiment on toria (*Brassica rapa* var. toria), broadcast method was found to be more successful and higher seed yield was gained in broadcast planting method. Several studies have been done on the impact of nutrients on the performance of the mustard plants (Singh *et al.,* 2008; Mir *et al*., 2010; Narits, 2010; Vassilina *et al.,* 2012). The present experiment was conducted to find the appropriate fertilizer dose and best planting method for yield and yield components of Brown sarson (*Brassica rapa* L.).

## MATERIAL AND METHODS

The experimental field was located at Mountain Research Centre for Field Crops, Khudwani 34˚ N latitude; 74˚ E Longitude at a height of 1580 m above the mean sea level on Shalimar brown sarson1 variety. The experiment was laid out in factorial randomized block design with five replications in two years (2013 and 2014). one variety (Shalimar brown sarson1), Main plot: two planting systems (broadcasting and line sowing) and subplots: 4 fertilizer treatments (RFD, 125% RFD, 125% RFD+ B and 125%RFD+B+S). Recommended fertilizer dose (RFD) contained 60:30:20 kg ha$^{-1}$ of N: $P_2O_5$: $K_2O$, respectively. Sulphur (S) treatment was 25 kg ha$^{-1}$ through agricultural grade gypsum and Boron (B) treatment was 1.5 kg.ha$^{-1}$ through boric acid. The total number of experimental units was 16 (2 x 2 x 4). The size of each plot was 10m$^2$ (2.5m x 4m). The replications were separated from one another by 1

m spacing. Spacing between main plots was 30cm and sub-plots were 10cm. The weeds were controlled manually and removed from the field at regular intervals. When 90% siliqua were matured, the crop was harvested from each plot. The plants were sun dried by spreading the bundles on the threshing floor. The seeds were separated from the stover by beating the bundles with wooden sticks. Plant height, seed yield, seed weight, days to flowering, days to maturity, primary and secondary branches and number of siliqua were recorded. The combined analysis of variance was performed for combined data from three treatments in the experiment (year, main plot and subplot) to assess the effect of year, mainplot, subplot and these interaction using the SAS software ver. 9.2 SAS Institute (2010).

## RESULTS AND DISCUSSION

Three treatments (year, planting system and fertilizer) differed significantly for all evaluated traits except for days to flowering, days to maturity and primary branches. Due to various environmental conditions during these two years, the result were predictable. The planting methods showed significant differences for all the traits. This suggests that the changes in the planting method could have a significant impact on the studied traits. The fertilizer treatments also showed the similar trend.

Mean comparisons of the year × planting system × fertilizer interactions revealed that the most (950 kg ha$^{-1}$) and the least seed yield (368.66 kg ha$^{-1}$) were belonged to 2013: line sowing, 125% RFD and 2013: line sowing, RFD, treatments respectively (Table 1). The higher rate of fertilizer (especially N) had great impact on the seed yield. These results were consistent with Mirzashahi *et al*. (2000), Bani-Saeedi (2001) and Siadat *et al.* (2010). Furthermore, the least seed yield (368.66 kg ha$^{-1}$) was obtained in RFD. In this case, our results were consistent with Yousaf and Ahmad (2002), Danesh-Shahraki *et al*. (2008) and Kazemeini *et al*. (2010) where the higher seed yield of rapeseed was at higher levels of nitrogen. Mir *et al.* (2010) demonstrated that fertilizer dosage had a significant effect on the yield and yield components of mustard. Thus, line sowing had a great impact on the seed yield. In a similar research, at Shillongani, broadcasting method resulted in higher seed yield REF On the other hand, at Bhubaneshwar, line sowing of yellow sarson with 40 kgN ha$^{-1}$ produced maximum seed yield. However, Shekhawat *et al*. (2012) noted that planting methods depend heavily on the farmer's resources, management conditions and soil conditions.

The results of mean comparison showed that the seed weight increased with increasing the fertilizers application rates. Thus, the highest and lowest values of SW were from 2014: line sowing, 125% RFD and 2013: bradcasting, 125% RFD+B+S, treatments, respectively. Our results were in contrary with Angadi *et al*. (2003) and Danesh- Shahraki *et al*. (2008). They believed that seed weight is the stable part of yield and is not affected by fertilizers and planting method. This result was in agreement with Oad *et al*. (2001) and Hossain *et al*. (2013). They believed that using broadcasting method, the plant density is higher and therefore the competition for light, space, nutrients and environments is more than the line sowing method and therefore, number of branches plant$^{-1}$, siliqua plant$^{-1}$, seeds siliqua$^{-1}$ and seed weight will be decreased and ultimately we will observe a significant decrease in seed yield plant$^{-1}$.

The fertilizer dose and planting method affected plant height significantly (Table 1). The tallest plants (97.86 cm) were produced by 2014: broadcasting, 125% RFD and the shortest plants (78.43 cm) were produced by 2013: broadcasting, RFD treatments, respectively. Our results were in agreement with Hossain *et al*. (2013). They demonstrated that the shortest plant in the broadcasting method, closest spacing might cause a competition for nutrient and light among the plants. Secondary branches increased with increasing the fertilizers application rates. Thus, the highest (7.26) and lowest values of secondary branches (2.8) were belonged to 2013: line sowing, 125% RFD and 2014: broadcasting, 125% RFD+B+S, treatments respectively. Sharma *et al.* (2007) concluded that by increasing the fertilizers dose, only the number of primary branches increased significantly which are contrary with our results. However, Sah *et al.* (2006) believed that increasing the nitrogen level up to 90 kg ha$^{-1}$ increased the number of secondary branches plant$^{-1}$, number of siliqua plant$^{-1}$, and seed yield. On the other hand, line sowing method resulted in to the highest value of the secondary branches. Again, the superiority of this method can be attributed to the less competition for nutrient and light among the plants Oad *et al.* (2001) and Hossain *et al.* (2013).

Fertilizer dose and planting method affected the number of silique plant$^{-1}$ significantly. Maximum number of silique plant$^{-1}$ (187) was obtained from 2013: line sowing, 125% RFD + B and the minimum (57.66) were obtained from 2014: broadcasting, RFD treatments respectively. In this research, the application of boron increased the number of silique plant$^{-1}$, significantly. These results confirmed the other researchers (AICRP-RM, 2005a; 2005b). They concluded that the seed yield and its components (seeds silique$^{-1}$ and 1000 seed weight) increased significantly with the application of boron indicating the importance role in seed formation. At the same time, the results showed that the number of siliqua was significantly influenced by the fertilizers dose (N:P:K)

**Table 1**. Mean comparison of year × planting method × fertilizer dose interaction for morphological and physiological traits of mustard plants

| Year | Main Plot | Sub plot | Seed yield Kg (ha) | Seed weight (gm) | Plant height (cm) | Secondary branches (no.) | No. of silique plant$^{-1}$ |
|---|---|---|---|---|---|---|---|
| 2013 | Broadcasting | RFD | 650.00$^{e}$ | 3.10$^{abc}$ | 83.73$^{fg}$ | 4.53$^{d}$ | 173.36$^{c}$ |
| | | 125% RFD | 753.33$^{cd}$ | 3.27$^{ab}$ | 78.43$^{h}$ | 6.80$^{a}$ | 159.70$^{d}$ |
| | | 125% RFD+B | 810.00$^{bc}$ | 3.30$^{ab}$ | 97.20$^{a}$ | 5.43$^{c}$ | 177.33$^{bc}$ |
| | | 125% RFD+B+S | 756.66$^{cd}$ | 2.80$^{d}$ | 85.4$^{ef}$ | 4.43$^{d}$ | 163.00$^{d}$ |
| | Line sowing | RFD | 810.00$^{bc}$ | 3.30$^{ab}$ | 89.33$^{cd}$ | 6.93$^{a}$ | 179.03$^{b}$ |
| | | 125% RFD | 950.00$^{a}$ | 3.30$^{ab}$ | 87.30$^{de}$ | 7.26$^{a}$ | 179.5$^{b}$ |
| | | 125% RFD+B | 840.00$^{b}$ | 2.90$^{cd}$ | 89.66$^{bcd}$ | 6.06$^{b}$ | 187.00$^{a}$ |
| | | 125% RFD+B+S | 766.66$^{bcd}$ | 3.20$^{ab}$ | 80.73$^{gh}$ | 5.40$^{c}$ | 162.73$^{d}$ |
| 2014 | Broadcasting | RFD | 368.66$^{h}$ | 3.33$^{ab}$ | 92.66$^{b}$ | 2.90$^{f}$ | 57.66$^{i}$ |
| | | 125% RFD | 693.33$^{de}$ | 2.80$^{d}$ | 97.86$^{a}$ | 3.06$^{ef}$ | 96.30$^{ef}$ |
| | | 125% RFD+B | 530.66$^{f}$ | 2.80$^{d}$ | 97.56$^{a}$ | 3.53$^{e}$ | 99.60$^{e}$ |
| | | 125% RFD+B+S | 504.66$^{fg}$ | 3.06$^{bcd}$ | 91.06$^{bc}$ | 2.80$^{f}$ | 92.60$^{f}$ |
| | Line sowing | RFD | 469.33$^{fg}$ | 3.20$^{ab}$ | 96.10$^{a}$ | 3.13$^{ef}$ | 94.06$^{f}$ |
| | | 125% RFD | 443.66$^{gh}$ | 3.36$^{a}$ | 89.86$^{bcd}$ | 3.23$^{ef}$ | 61.00$^{hi}$ |
| | | 125% RFD+B | 486.333$^{fg}$ | 2.86$^{cd}$ | 87.23$^{de}$ | 2.80$^{f}$ | 83.26$^{g}$ |
| | | 125% RFD+B+S | 373.33$^{h}$ | 3.33$^{ab}$ | 90.26$^{bcd}$ | 3.10$^{ef}$ | 64.80$^{h}$ |

and planting method (line sowing). Considering these two cases, it can be concluded that by increasing in the number of siliqua, the nitrogen source within each plant drastically reduced and competition within plants and different parts of each plant for receiving assimilates increases. So, the plants need more nitrogen for having more siliqua; otherwise, they will witness the siliqua abscission. The highest number of silique plant$^{-1}$ was observed in line sowing method and the lowest one was observed in broadcasting method. It is because the line sowing method allows the plants to absorb more moisture, light, and nutrients than the broadcast method Hossain *et al.* (2013).

The results of mean comparison for fertilizer × planting method showed that 125% RFD + B+ S and line sowing treatment had the greatest impact and increased the duration of flowering (Fig. 1), and 125% RFD and broadcasting treatment had the least impact on the days to flowering and decreased it. Our results were in contrary with Olmstead *et al.* (2005). They believed that higher amounts of fertilizers (especially nitrogen) will decrease the flowering period. This research specified that flowering period is increased using boron application. But in various articles, the impact of boron on flowering period has not been investigated yet. Results of mean comparison for fertilizer × planting method showed that 125% RFD and line sowing treatment had the greatest impact on maturity and increased the maturity duration and 125% RFD + B and line sowing had the least impact on the days to maturity and decreased it. These results were in contrary with Hossain *et al*. (2012). The boron application elongated the maturity duration. In our research, boron application decreased the days to maturity significantly Figure 2.

Several studies have been conducted on the impact of nutrients on the performance of the mustard plants (Singh *et al.,* 2008) conducted an experiment using 0, 15, 45 and 60 kg ha$^{-1}$ Sulfur and reported that grain yield, total S-uptake, oil yield increased with successive increase in S-application up to 45 kg ha$^{-1}$ in comparison to that of the control. Mean increase of seed yield and oil content to S was 159kg ha$^{-1}$ and 3.7%, respectively. Mir *et al*. (2010) demonstrated that fertilizer dosage had a significant effect on the yield and yield contributing characters of mustard. The maximum amount for plant height, number of primary branches, seed weight, dry matter weight and the seed yield were obtained at the rate of 78.46 kg N ha$^{-1}$. Narits (2010) found that nitrogen fertilization had a positive effect on seed yield and seed protein content. On the other hand, nitrogen fertilization, especially in higher rates, had a negative effect on oil content. Vassilina *et al.* (2012) performed an experiment during the 2008-2011 to evaluate the effect of mineral, organic fertilizers and their combination on yield and quality of mustard (*Brassica juncea*) in three-year crop rotations. The results showed that annual application of $N_{75}P_{70}K_{45}$ mineral fertilizers three times a year is necessary to get the seed yield between

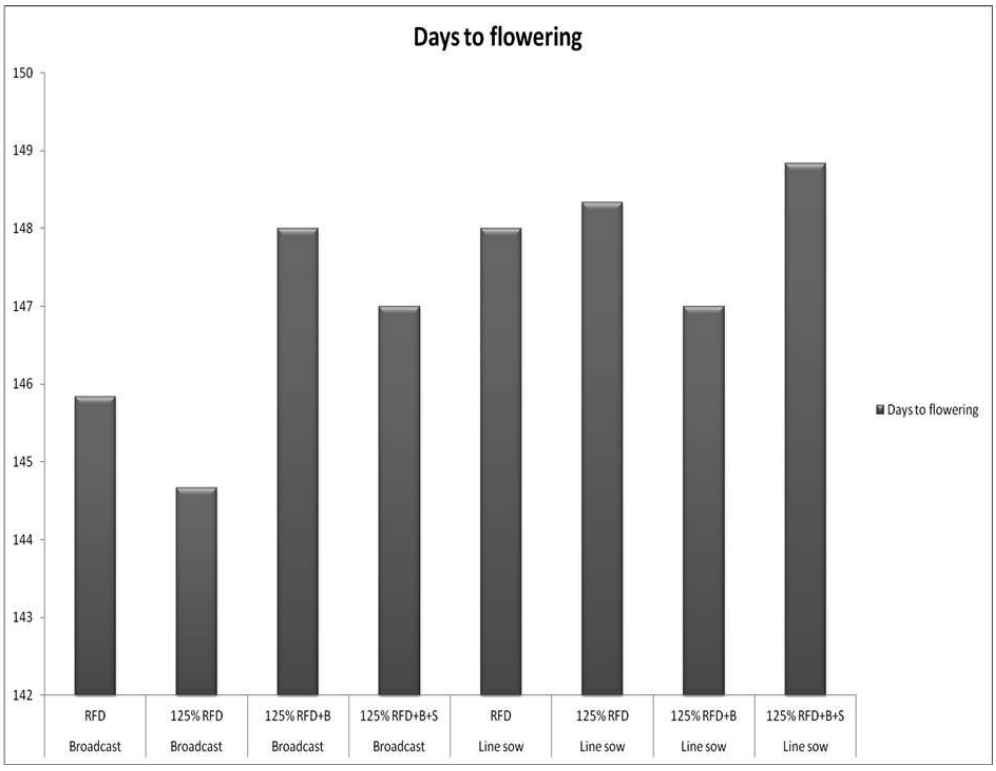


**Fig. 1**. Effect of planting method × fertilizer dose, on days to flowering of mustard plants

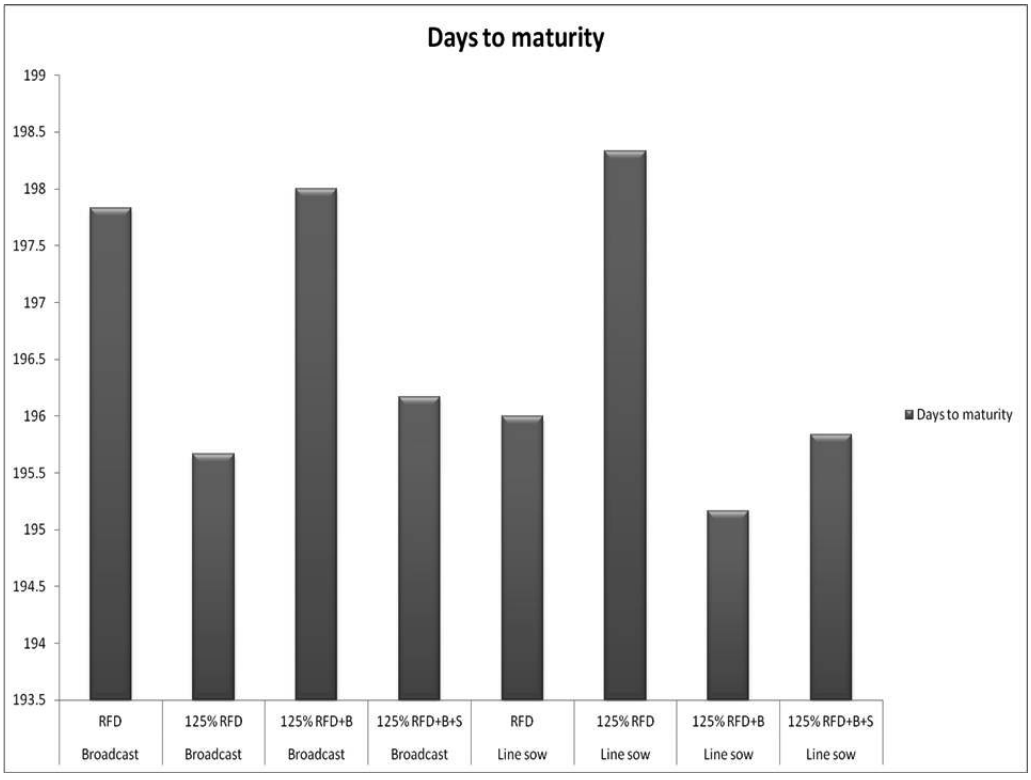


**Fig. 2**. Effect of planting method × fertilizer dose, on days to maturity of mustard plants

23 and 24 q $ha^{-1}$. The results also showed that this level could enhance oil content

## CONCLUSION

Hence the results revealed that the combination of 125% RFD + line sowing had a significant impact on the majority of yield-related traits in the brown sarson. At the same time, the results showed that the use of boron can affect the important traits such as seed yield and number of siliqua $plant^{-1}$. Also, the line sowing is a better method for increasing the seed yield because of less competition for light, space, nutrients.

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# Response of *Bt* Cotton to Nutrient Omission and Site Specific Nutrient Management in Vertisols under Irrigation

**B.M. Chittapur, P.S. Pyati[1], M.R. Umesh, A.S. Halepyati and T. Satyanarayana[2]**

*University of Agricultural Sciences, Raichur-584 104, India*
*[1] University of Agriculture and Horticultural Sciences, Shivamogga-577 204, India*
*[2] Director, South Asia Program, International Plant Nutrition Institute, Gurgaon-122 001, India*
*E-mail: mrumeshagri@gmail.com*

***Abstract***: Study on identification of critical nutrient and realization of target yield through site specific nutrient management (SSNM) comprising of five treatments *viz*., SSNM for target yield of 4 t ha$^{-1}$, N omission, P omission, K omission and Farmers' practice was carried out on farmers' fields on participatory mode. Among all, significantly higher number of bolls plant$^{-1}$ (43.8), average boll weight (5.38 g) and seed cotton yield plant$^{-1}$ (217.3 g plant$^{-1}$ and 4384 kg ha$^{-1}$) were recorded with SSNM treatment followed by farmers' practice. The lower values for these attributes were recorded with nitrogen omission (36.4, 4.52g, 174.5g and 3707 kg ha$^{-1}$, respectively) followed by K and P omission treatments. SSNM treatment also recorded higher gross return (Rs. 188526 ha$^{-1}$), net return (Rs. 136183 ha$^{-1}$) and B:C ratio (3.60) while N omission recorded lower gross return (R.s 159408 ha$^{-1}$), net return (Rs. 108567 ha$^{-1}$) and B:C (3.13). Thus, the study revealed possibility of realizing pre-set yield target ($\geq$4.0 t ha$^{-1}$) with site specific nutrient management. Further, N appeared to be the most critical element in cotton production followed by K in the North eastern dry zone in TBP command.

***Kewords***: Bt Cotton, SSNM, Nutrient Omission, Target yield

In the era of precision agriculture, the concept of fertilizing the crop is of much importance than fertilizing the soil. In this context, site-specific nutrient management (SSNM) approach is one such option, which focuses on balanced and crop need-based nutrient application (Johnston *et al*., 2009). The dissemination of such technologies would go a long way in improving the productivity and profitability of farming and being a major fertilizer responsive crop cotton is not an exception. Site-specific nutrient management is a tool, which intends for balanced precision nutrition of N, P and K along with secondary and micronutrients based on the nutrient supplying capacity of the soil, the nutrient requirement of a particular crop to produce a unit quantity of yield and the pre-set yield target (Umesh, 2008). Further, SSNM is a need based feeding approach paying close attention to the Four Rights (4R's) of fertilizer application *i.e.* applying the right nutrient source, at the right rate, at the right time in the growing season, and in the right place. This approach aims at increasing farmers' profit by achieving the goal of maximum economic yield of crops (Umesh *et al*., 2014).

Cotton is one crop which needs special attention because of its commercial significance and high use rate of fertilizer is next only to sugarcane. Among the cotton growing states, Karnataka ranks fifth in area, fourth in production and fifth in productivity. *Bt* cotton is intensively cultivated in the north eastern dry zone and northern dry zone of the state (Zone 2 and 3) covering partly the Tungabhadra and Upper Krishna irrigation Commands (TBP and UKP) on black soil. The area under this crop in these commands has been increasing distinctly over the past half decade, while the productivity is on the decline. There are several reasons for the low yields and the important one among them is inadequate and unbalanced application of plant nutrients. Therefore, an investigation on response of cotton to nutrient omission and site specific nutrient management (SSNM) on farmers' fields in a participatory mode was carried out during growing season of 2015-16 at Raichur, Karnataka.

## MATERIAL AND METHODS

Raichur is situated in north eastern dry zone (Zone-2) of Karnataka with mild winter and hot summer and an average rainfall of 675 mm spreading from June to November with a mild peak during July and a major peak during October. In the selected Farmers' fields general irrigated *Bt* cotton was raised in the previous season with uniform inputs and management practices. Earlier to that the fields were under drill sown rice. The experiment was conducted on six farmers' fields at Kasabe camp, Raichur during growing season of 2015-16 (16.18° N, 77.27° E). Across farmers, the soils were deep black, slightly alkaline (pH 7.5-8.4), non-saline (EC 0.19 to 0.32 dS/m), low to medium in organic carbon (0.37–0.6 %), low in available N (70-235 kg ha$^{-1}$), medium to high in $P_2O_5$ (42-75 kg ha$^{-1}$) and high in $K_2O$ (295-675 kg ha$^{-1}$).

There were five treatments, $T_1$-SSNM (320:112:114 kg ha$^{-1}$ N, $P_2O_5$ and $K_2O$, respectively) for target yield of 4 t ha$^{-1}$, $T_2$ – N omission, $T_3$ - P omission, $T_4$ - K omission and - $T_5$ Farmers' practice (340:120:75 kg ha$^{-1}$ N, $P_2O_5$ and $K_2O$, respectively) and six replications (farmers' sites) analysed using randomized block design. The gross plot size was 9.0 m x 6.0 m. New generation *Bt* cotton hybrids viz., Challenge and Ajeet as preferred by farmers with stacked genes, Cry1Ac and Cry2Ab were used. **C**rop was sown in II fortnight of July using rains and subsequently crop was irrigated using canal water. Two seeds per hill were dibbled by maintaining 60 cm space between two hills in a row spaced 90 cm apart to ensure even stand, gap filling was done 7 days after sowing, and per hill one plant was retained after thinning at 15 DAS.

A yield target of 4 t ha$^{-1}$ was considered for SSNM treatment and fertilization was done as per recommendation of International Plant Nutrition Institute (IPNI). Fifty per cent of nitrogen and potassium and full dose of phosphorus fertilizer were applied at the time of sowing and the remaining 50 per cent of nitrogen and potassium were top dressed twice equally at 30 days interval. Recommended prophylactic measures were undertaken to keep the pest and diseases below economic threshold. Required biometric and yield attributes were collected and nutrient uptake and post-harvest soil available nutrient status and economics were carried out.

## RESULTS AND DISCUSSION

Significant differences existed in plant population in treatments (Table 1). SSNM had significantly higher population (126.8 plants) and farmers' practice (124.5 plants) was at par with it, while nitrogen omission had lower population among all the treatments. The average plant height differed significantly between the nutrient omission treatments and the farmers' practice and farmers' practice (Table 2). Significantly higher plant height was observed with SSNM treatment (174.5 cm) compared to all other treatments. The lower plant height was recorded in N omission treatment (149.8 cm) followed by P and K omission treatments. Similarly, the monopodials and sympodials plant$^{-1}$ varied significantly among the treatments. SSNM treatment recorded the maximum number of monopodials and sympodials (2.20 and 26.8, respectively) nutrient omission treatments and the farmers' practice (Table 1).

The average number of bolls plant$^{-1}$ also varied significantly among different nutritional treatments (Table 1). Among all, significantly higher number of bolls plant$^{-1}$ was recorded with SSNM treatment (43.8), while farmers' practice was on par (41.0). The lower average number of bolls plant$^{-1}$ was recorded in N omission treatment (36.4) followed by P and K omission treatments which were at par with each other. Similarly, the average boll weight due different nutritional treatments differed significantly (Table 1). Among all, SSNM treatment registered significantly higher average boll weight (5.38 g) followed by farmers' practice which was at par with it. The lower average boll weight was recorded in N omission treatment (4.52 g). P and K omission treatments were comparable to farmers' practice.

As a consequence of superiority of growth and yield parameters over omissions of major nutrients, SSNM

**Table 1**. Growth and yield components and yield of cotton as influenced by SSNM and omission of major nutrients

| Treatment | Average plant height (cm) | Average monopodials (No. plant$^{-1}$) | Average sympodials (No. plant$^{-1}$) | Average plant population |
|---|---|---|---|---|
| SSNM (4 t ha$^{-1}$) | 174.5 | 2.20 | 26.3 | 126.8 |
| Nitrogen omission | 149.8 | 1.37 | 21.9 | 112.2 |
| Phosphorus omission | 158.1 | 1.75 | 23.9 | 119.0 |
| Potassium omission | 157.6 | 1.68 | 24.5 | 119.3 |
| Farmers' practice | 160.4 | 1.91 | 24.4 | 124.5 |
| **CD (P= 0.05)** | **14.7** | **0.19** | **2.4** | **7.5** |
| | Average number of bolls plant$^{-1}$ | Average boll weight (g) | Seed cotton yield (g plant$^{-1}$) | Seed cotton yield (kg ha$^{-1}$) |
| SSNM (4 t ha$^{-1}$) | 43.8 | 5.38 | 217.3 | 4,384 |
| Nitrogen omission | 36.4 | 4.52 | 174.5 | 3,707 |
| Phosphorus omission | 40.1 | 5.01 | 193.8 | 4,006 |
| Potassium omission | 39.3 | 4.80 | 174.8 | 3,783 |
| Farmers' practice | 41.0 | 5.04 | 195.2 | 4,072 |
| **CD (P= 0.05)** | 2.9 | **0.35** | **12.1** | **250** |

SSNM – Site specific nutrient management

treatment recorded significantly higher seed cotton yield (217.3 g plant$^{-1}$) among all treatments (Table 1). Seed cotton yield with farmers' practice (195.2 g plant$^{-1}$) was next in the order and P omission treatment was comparable statistically. Seed cotton yield with K omission was next lowest while N omission had the lowest seed cotton yield per plant among all (174.5 g plant$^{-1}$). Seed cotton yield per ha followed yield per plant and in that SSNM treatment recorded the highest yield of 4384 kg per ha (Table 1). Farmers' practice recorded next higher value (4072 kg ha$^{-1}$) and P omission (4006 kg ha$^{-1}$) was on par with SSNM treatment, while K omission had next lower value. Significantly lower seed cotton yield among all was recorded with N omission treatment (3707 kg ha$^{-1}$).

Yield increase with SSNM over omission of nitrogen, phosphorus and potassium was to the tune of 18.3, 9.4 and 15.9 per cent. Haung *et al.* (1999) also reported the yield rise by 19.8% with SSNM over control. Comparable yields with farmers' practice could be attributed to application of similar levels of nitrogen and a little higher $P_2O_5$ as with SSNM. The little lower yield than SSNM may be attributed to difference in supplied K in farmers' practice which was lower than that of SSNM and the response of *Bt* to readily available K in spite of high native K status.

After crop harvest soil pH and soil organic carbon did not reveal any significant differences among the treatments while, Aladakatti *et al.* (2012) reported decrease in soil organic carbon 0.50 to 0.35 % with nitrogen omission after two seasons. SSNM treatment, farmers' practice, nitrogen omission treatment recorded pH of 8.1, 8.1 and 8.2 respectively (Table 2). However, the EC varied significantly among treatments and EC values with SSNM, farmers' practice, and potassium and phosphorus omission treatments were on par with one another (0.25 dS m$^{-1}$each) while nitrogen omission treatment recorded significantly lower EC among all (0.20 dS m$^{-1}$) (Table 3).

The reasons for variation in yield could also be related to varied uptake of mineral nutrients. Nitrogen uptake by the plant varied significantly due to different manurial treatments (Table 2). Among all, significantly higher nitrogen uptake was recorded with SSNM treatment (284 kg ha$^{-1}$) owing to higher nitrogen content (2.4 %). Omission of P and K had comparable N content and uptake as that of SSNM treatment. Farmers' practice had next lower N uptake while N omission had the lowest N uptake among all (173 kg ha$^{-1}$) due lower N content (1.43 %). Similarly, among all, significantly higher phosphorus uptake was recorded with SSNM treatments (26.0 kg ha$^{-1}$), and farmers' practice and K omission treatments were at par while N omission treatment had next lower value but P omission had the lowest P uptake among all (16.8 kg ha$^{-1}$) (Table 2).

Potassium uptake, however, did not vary significantly among different treatments though, higher potassium uptake was recorded with SSNM treatment (222 kg ha$^{-1}$) followed by farmers' practice (212 kg ha$^{-1}$). The lower potassium uptake was recorded with K omission treatment (211 kg ha$^{-1}$). The potassium content in plant was higher in case of SSNM treatment (0.78%) followed by phosphorus omission treatment (0.70%) and the lowest was in case of potassium omission treatment (0.44%). Sulphur uptake also did not reveal any significant differences among the treatments (Table 2). Higher sulphur uptake was recorded with nitrogen, phosphorus and potassium omission treatments. The lower sulphur uptake was recorded in SSNM treatment followed by farmers' practice.

Further, soil available nutrient status varied significantly due to nutritional treatments (Table 3). Significantly higher available nitrogen in soil was recorded with potassium omission treatment (140 kg ha$^{-1}$) followed by SSNM treatment, farmers' practice, and phosphorus omission treatment while significantly lower soil N was observed in nitrogen omission treatment (113 kg ha$^{-1}$). Soil available P status also varied significantly due to mineral nutrition

**Table 2.** Post-harvest soil physico-chemical properties and crop nutrient uptake as influenced by SSNM and omission of major nutrie**nts**

| Treatment | Soil physico-chemical properties | | | Nutrient uptake | | | |
|---|---|---|---|---|---|---|---|
| | pH | EC (dS m$^{-1}$) | OC (g kg$^{-1}$) | N (kg ha$^{-1}$) | P (kg ha$^{-1}$) | K (kg ha$^{-1}$) | S (mg kg$^{-1}$) |
| SSNM (4 t ha$^{-1}$) | 8.1 | 0.25 | 0.25 | 284 | 26.0 | 222 | 21.6 |
| N omission | 8.2 | 0.20 | 0.23 | 173 | 23.1 | 212 | 22.3 |
| P omission | 8.2 | 0.24 | 0.24 | 281 | 16.8 | 214 | 22.5 |
| K omission | 8.2 | 0.25 | 0.24 | 280 | 25.1 | 211 | 22.5 |
| Farmers' Practice | 8.1 | 0.25 | 0.24 | 242 | 25.9 | 216 | 21.8 |
| **CD (P= 0.05)** | **NS** | **0.03** | **NS** | **15** | **1.6** | **NS** | **NS** |

SSNM – Site specific nutrient management NS – Not significant

**Table 3**. Available of nitrogen, phosphorus and potassium in soil and economics as influenced by SSNM and omission of major nutrients

| Treatment | N (kg ha$^{-1}$) | P (kg ha$^{-1}$) | K (kg ha$^{-1}$) | S (mg ha$^{-1}$) |
|---|---|---|---|---|
| | **Residual soil nutrient status** | | | |
| SSNM (4 t ha$^{-1}$) | 137 | 23.5 | 470 | 16.3 |
| Nitrogen omission | 113 | 23.5 | 467 | 11.1 |
| Phosphorus omission | 136 | 19.0 | 495 | 16.7 |
| Potassium omission | 140 | 24.1 | 340 | 15.4 |
| Farmers' practice | 136 | 23.4 | 469 | 16.4 |
| **CD (p= 0.05)** | **11** | **2.5** | **55** | **1.4** |

| | Cot of fertilizers (Rs. ha$^{-1}$) | Cost of cultivation* (Rs. ha$^{-1}$) | Gross returns (Rs. ha$^{-1}$) | Net returns (Rs. ha$^{-1}$) | B:C |
|---|---|---|---|---|---|
| | **Economics** | | | | |
| SSNM (4 t ha$^{-1}$) | 11242 | 41101 | 188526 | 136183 | 3.60 |
| Nitrogen omission | 9740 | 41101 | 159408 | 108567 | 3.13 |
| Phosphorus omission | 10425 | 42071 | 172258 | 120732 | 3.33 |
| Potassium omission | 9506 | 41101 | 162676 | 112069 | 3.20 |
| Farmers' practice | 9194 | 42071 | 175103 | 123837 | 3.42 |
| **CD (p= 0.05)** | **-** | **-** | **10752** | **10741** | **0.22** |

SSNM – Site specific nutrient management * Cost of fertilizer excluded
Labour charges-Rs.250 day$^{-1}$; Bullock pair with men- Rs.300 h$^{-1}$; Tractor-Rs.350 h$^{-1}$; Picking- Rs.3 kg$^{-1}$

treatments. Higher available phosphorus in soil was recorded in case of potassium omission treatment (24.1 kg ha$^{-1}$) and was followed by SSNM treatment, farmers' practice, nitrogen omission treatment. Among all significantly lower soil available P and K were observed with phosphorus omission treatment (19.0 and 495 kg ha$^{-1}$) followed by SSNM treatment, farmers' practice, and nitrogen omission treatments while, significantly lower available K status was observed with K omission (340 kg ha$^{-1}$) among all the treatments. Significantly higher available sulphur in soil was also recorded with phosphorus omission (16.7 mg kg$^{-1}$) followed by farmers' practice, SSNM treatment, and potassium omission which were at par, while significantly lower available soil S was observed in nitrogen omission (11.1 mg kg$^{-1}$) treatment. Earlier working with cotton, Aladakatti *et al*. (2012) also reported a reduction in soil available N, P and K to the extent of 61, 7.1 and 161.9 kg ha$^{-1}$ with respective nutrient omissions after second crop of cotton with a corresponding yield decrease to the tune of 41, 9.3 and 27.3%, respectively.

As a consequence of variation in seed cotton yield due to nutritional variations, returns due to SSNM and omission of major nutrients varied significantly (Table 3). Among the treatments, significantly higher gross and net returns were recorded with SSNM treatment (Rs. 188526 and 136183 ha$^{-1}$, respectively) followed by farmers' practice, while, significantly lower returns were obtained with N omission treatment while P and K omissions had intermediate returns. Consequently, benefit: cost was significantly higher with SSNM treatment (3.60) followed by farmers' practice (which was on par with on par with SSNM treatment), while the lowest B:C ratio was observed with N omission. Biradar *et al.* (2011) also reported lowest returns and benefit cost ratio with nitrogen omission which were about 50 and 13% less than those obtained with SSNM practice. They also reported 25% reduction in net income with potassium omission, while, Hussain *et al.* (2014) reported N as the most limiting nutrient with seed cotton yield reduction to the tune of 28% followed by K (14.5%) and P (6.5%) omissions.

Thus, nutrient omission and SSNM revealed importance of balanced nutrition in an exhaustive crop like cotton for higher yields and favourable post-harvest available nutrient status. A yield of 4 t ha$^{-1}$ with SSNM could be considered with confidence from an early July (1$^{st}$ fortnight) planted crop. Apart from the above revelations from the study on farmers' fields, there emerge two more important points. First, among the major nutrients nitrogen is the key element which cannot be neglected. The lower differences in the yields between SSNM and nitrogen could be attributed to previous crop history of land and land management. The lands were under paddy during the previous season and were perfectly levelled (zero levelled plots). Probably presence of fair amount of organic carbon from previous paddy (medium range) and good spread of rain/irrigation water due to table top surface

might have masked nitrogen omission effect fairly well otherwise a reduction of more than 50 per cent of yield would not have been uncommon as mentioned earlier (Biradar *et al*., 2011). Second point of interest is the response to applied potassium fertilizer (omission), though soil had higher available potassium status. This point brings forth the fact that hybrid cotton responds to readily available potassium from fertilizer source than to labile soil pool of K. Of late this has been a common response in most of the crops across the country as per studies on SSNM (Hussain *et al.,* 2014).

Overall, the study revealed that a yield target of 4 t $ha^{-1}$ from planting up to 1$^{st}$ fortnight of July and through SSNM is possible and nitrogen is the most critical nutrient for achieving potential yields followed by potassium in deep black soils of TBP command, Karnataka in cotton production; however, importance of balanced nutrition cannot be overlooked from the point of yields, monetary returns and favourable post-harvest soil fertility.

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# Effect of Planting Season, Interval and Nitrogen Fertilizer on Survival and Growth of *Populus deltoides* Under Degraded Sites of North Western Himalayas

**Tahir Mushtaq, Rakesh Banyal and Mir Awsaf Ahmad**

*Sher-e-Kashmir University of Agriculture and Technology, Shalimar, Srinagar 190 025, India*
*E-mail: tahirmushtaq333@gmail.com*

***Abstract***: The existing land of the experimental site had three types of land problems amely: degraded underutilized (scrub dominated), degraded pastures/grazing lands, barren rocky/stony waste. Therefore, Two planting seasons, three planting intervals and four nitrogen levels were analyzed for survival and growth of plantation. The autumn planting was better with respect to survival and growth parameters compared to spring planting. The planting interval I ($15^{th}$ Nov. to $30^{th}$ Nov., 2013 in autumn planting and $15^{th}$ Feb. to $28^{th}$ Feb., 2014 in spring planting) showed better results for survival and growth compared to II and III. Survival and growth was higher in $N_2$ @ 150 Kg $ha^{-1}$ compared to100 and 200 kg $ha^{-1}$.

***Keywords***: *Populus deltoides*, Survival, Growth, Season, Plantation, Nitrogen

*Populus deltoides* locally called as '*Fras'* make a striking and important contribution to the landscape and economy of Jammu and Kashmir. Poplars are known for their fast growth, easy vegetative propagation and enriching the soil with litter, and provide high production (10-30 $M^3$/hectare/ year) on a short rotation of 8-12 years. The poplars have the potential for narrowing down the gap between demand and supply of wood. Therefore, various attempts have been made in the past for raising this economically important species on problematic lands in different parts of the world. Jammu and Kashmir is predominantly a hilly state with forest cover of 20230 $km^3$ accounting for 19.95 per cent of the total geographical area. About $2/3^{rd}$ of the states' total area is under recorded forest and the substantial part of this is non-conducive for the growth, being under permanent snow, glaciers and cold deserts (Digest of Forest Statistics, 2012). The total problematic area of the state is about 45.70 per cent. This area is prone to soil erosion and other forms of degradation leaving behind the denuded and degraded soils with poor service for mankind. The degradation of forest resources in Jammu and Kashmir has been accelerating, owing to the rapid growth of population, coupled with the development of agriculture and urban construction. The situation is further aggravated by faulty forest management practices in use. Inappropriate and faulty landuse systems and population growth have led to land degradation in the hills and plains. The efforts of the planners, foresters and scientists have brought heavy chunk of areas under plantation but success is heading to low year after year. At present, the knowledge about the planting techniques on problematic sites is very limited and moreover specific to specific areas. Therefore, there is urgent need to undertake such work on scientific lines to develop techniques in tune with the existing problems.

The present study is hereby proposed to address the problems of degraded sites through scientific lines for higher survival and growth of the plantations. The study was conducted to study the effect of planting seasons with intervals on survival and growth of plantations and elucidate the effect of nitrogen fertilizer on survival and growth of plantations under degraded sites.

## MATERIAL AND METHODS

The plantation of *Populus deltoides* was done on degraded land of the Faculty of Forestry, SKUAST-Kashmir, Benihama Campus, Ganderbal, Jammu and Kashmir at an altitude of 5850 feet above mean sea level. The existing land of the experimental site had three types of land problems namely: degraded underutilized (scrub dominated), degraded pastures/grazing lands and barren rocky/stony waste. The experimental site falls in a mid to high altitude characterized by hot summers and very cold winters. The average precipitation is 690 mm most of which is received from December to April in the form of snow and rains. The mean metrological data for the plantation season was obtained from the meteorological observatory Ganderbal.

The total rainfall received during the experimentation period was 281.2 and 418.80 mm during 2013 and 2014, respectively. The minimum temperature ranged from -1 to -6°C and 3.4 to 14.1°C, and maximum temperature from 17.7 to 24.4°C and 21.7 to 32.5°C and the average maximum relative humidity from 74.5 to 95.1 % and 70.4 to 90.8 %, whereas, mean minimum relative humidity ranged from 43.1 to 78.7 % and 37.1 to 80.1 % during the plantation season of *Autumn* 2013 and Spring 2014, respectively.

**Experimental details:** The experiment was laid out in randomized completely block design with three planting intervals of 15 days interval in two seasons *i.e.,* autumn season 2013 ($PI_1$ =15$^{th}$ Nov. to 30$^{th}$ Nov., $PI_2$ = 1$^{st}$ Dec. to 15$^{th}$ Dec. and $PI_3$ = 16$^{th}$ Dec. to 31$^{th}$ Dec.) and spring season 2014 ($PI_1$ =15$^{th}$ Feb. to 28$^{th}$ Feb., $PI_2$ = 1$^{st}$ March to 15$^{th}$ March and $PI_3$= 16$^{th}$ March to 31$^{st}$ March) and four levels of nitrogenous fertilizers in the form of urea ($N_0$ =Control, $N_1$ =100 kg ha$^{-1}$, $N_2$ =150 kg ha$^{-1}$ and $N_3$=200 kg ha$^{-1}$.) with three replications were tested to study survival and growth of *Populus deltoids* plantation on problematic site. However, phosphorous and potassium was applied as the basic dose at the time of out planting. Before going for plantation, the area for each experiment was marked with the help of colored sticks using measuring tape. After demarcation, the area was cleared, pits were dug and the field was laid out on the basis of statistical model used in the experiment. One year old seedlings of *Populus deltoides* were uprooted from the nursery beds. The seedlings were planted at a spacing of 2 x 2 m by line planting in the experimental fields. No plant protection measure with regard to disease/insect pest control was taken due to non- observance of such problems.

## RESULTS AND DISCUSSION

There was significant variation among two seasons for survival percentage. Autumn planting recorded highest survival percentage (76.38 %) followed by spring planting (66.66%) and were found significantly different with one another (Table 1). Tomar *et al.* (2003) have also reported the same trend in *Acacia auriculiformis* and *Acacia nilotica* on calcareous soils in Bir reserved forest Hisar. Among the planting intervals, planting interval I recorded highest survival percentage, followed by planting interval II and planting interval III in both the seasons and were found significantly different. In both the seasons, survival percentage of *Populus deltoides* increased with increase in nitrogen dosage from $N_0$ (control) to $N_2$ (150 kg ha$^{-1}$) and then decreased in both the seasons and were found significantly different with respect to each other.

Individual factors were evaluated to determine the best possible factor for *Populus deltoides* plantation on problematic sites. Among three planting intervals, planting interval I having survival percentage (77.07 %) was best for *Populus deltoides* plantation followed by planting interval II (70.82 %) and planting interval III (66.73 %) and were significantly different with each other. It was because of the reason that ample moisture was present on the plantation site during planting interval I for establishment of seedlings as compared to planting interval II and planting interval III. These results are in conformity with the earlier reports of Pal and Sharma (2001). It was also also observed that among four nitrogen levels applied to the plantation, $N_2$ recorded highest percentage survival (86.35 %), followed by $N_1$, $N_3$ and $N_0$ and were found to be significantly different with each other.

Plant height increment is the increase in tree height during one growing season. Plant height increment of *Populus deltoides* was influenced by planting season, planting interval and nitrogen levels. Autumn planting (31.48 cm) was the best season for plant height increment as compared to spring planting (31.13 cm) and were found significantly different with each other. This is due to the reason that seedlings planted in autumn had enough time to get established compared to spring planting. Similar results were recorded by Barnett *et al*. (1988) for *Eucalyptus camaldulensis* in Zomba, Malawi. In both the planting

**Table 1.** Effect of planting season, interval and nitrogen fertilizer on percentage Survival of *Populus deltoides*:

| Season → | Autumn Planting | | | | | Spring Planting | | | | | Factor means | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nitrogen levels Planting Interval | $N_0$ | $N_1$ | $N_2$ | $N_3$ | Mean | $N_0$ | $N_1$ | $N_2$ | $N_3$ | Mean | Planting Interval | | Nitrogen levels | | Planting Season | |
| $I_1$ | 66.66 | 83.33 | 100 | 83.33 | 83.33 | 66.66 | 66.66 | 83.33 | 66.66 | 70.82 | $I_1$ | 77.07 | $N_0$ | 63.88 | $S_1$ | 76.38 |
| $I_2$ | 66.66 | 83.33 | 83.33 | 66.66 | 74.99 | 66.66 | 66.66 | 83.33 | 50.00 | 66.66 | $I_2$ | 70.82 | $N_1$ | 72.21 | $S_2$ | 66.66 |
| $I_3$ | 66.66 | 66.66 | 83.33 | 66.66 | 70.82 | 50.00 | 66.66 | 83.33 | 50.00 | 62.64 | $I_3$ | 66.73 | $N_2$ | 86.35 | | |
| Mean | 66.66 | 77.77 | 88.88 | 72.21 | 76.38 | 61.10 | 66.66 | 83.83 | 55.55 | 66.66 | | | $N_3$ | 63.68 | | |

**CD ($p \leq 0.05$): I=1.48 , S=2.38 , N=0.48, N×S =1.57, N×I=2.67, S×I=NS, N×S×I=NS**

seasons, planting interval I recorded highest plant height increment followed by planting interval II and planting interval III and were found significantly different (Table 2). Among the four levels of nitrogen applied to the plantation, maximum plant height increment was recorded for nitrogen level $N_2$ (31.79 cm), followed by $N_3$ and $N_1$ and were significantly different with each other. In spring planting, maximum height increment was recorded for $N_2$ (31.30 cm), followed by $N_1$ and $N_3$ and were also significantly different with respect to each other.

The collar diameter increment of *Populus deltoides* was influenced by planting season, interval and nitrogen fertilizer on problematic sites (Table 3). Collar diameter increment was higher in autumn planting (5.51 mm) as compared to spring planting (5.19 mm) and were found significantly different with each other. The reason for this difference is that seedlings planted in autumn season get enough time to establish on plantation site compared to seedlings planted in spring season. Also abundant moisture present on plantation site in autumn season help in seedling establishment. Among the planting intervals, interval 1 ha had more collar diameter increment as compared to other two intervals in both the seasons and were significantly different to each other. Nitrogen fertilization had a significant effect on color diameter increment of *Populus deltoides*. Among the four levels studied, $N_2$ (150 kg $ha^{-1}$) showed higher color diameter increment compared to rest in both the seasons. All the nitrogen levels were significantly different with each other in Autumn season. In spring season $N_1$, $N_2$ and $N_3$ were significantly different, but $N_0$ and $N_3$ were found at par with each other. Similar trend was observed for height and diameter increment.

The leaf area of *Populus deltoides* is significantly affected by planting season, interval and different nitrogen levels (Table 4). Highest leaf area growth (343.08 $cm^2$) was for autumn planting and minimum (340.10 $cm^2$) for spring planting and were significantly different with each other. The reason being greater plant height and maximum number of branches that was in autumn planting compared to spring planting. Among the three planting intervals, planting interval I recorded highest leaf area, followed by planting interval II in both the seasons. The planting interval I, II and III were found significantly different when compared with each other. The reason being planting interval I produced maximum plant height and more number of roots, which ultimately resulted in more number of leaves because they received optimum environment. The different nitrogen levels applied to the *Populus deltoides* plantation significantly affected leaf area growth in both the seasons. Leaf area increased with increasing nitrogen dose upto certain limit from C to $N_3$ and then decreases at $N_4$ level. In autumn season, the nitrogen levels $N_1$, $N_2$ and $N_3$ were found significantly different, but $N_1$

**Table 2.** Effect of planting season, interval and nitrogen fertilizer on plant height increment (cm) of *Populus deltoides*

| Season→ | Autumn Planting | | | | | Spring Planting | | | | | Factor means | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nitrogen levels Planting Interval | $N_0$ | $N_1$ | $N_2$ | $N_3$ | Mean | $N_0$ | $N_1$ | $N_2$ | $N_3$ | Mean | Planting Interval | | Nitrogen Levels | | Planting Season | |
| $I_1$ | 31.33 | 31.56 | 32.10 | 31.77 | 31.69 | 31.10 | 31.33 | 31.56 | 31.17 | 31.29 | $I_1$ | 31.49 | $N_0$ | 31.08 | $S_1$ | 31.48 |
| $I_2$ | 31.20 | 31.42 | 31.71 | 31.53 | 31.46 | 31.01 | 31.19 | 31.21 | 31.00 | 31.10 | $I_2$ | 31.28 | $N_1$ | 31.30 | $S_2$ | 31.13 |
| $I_3$ | 31.00 | 31.27 | 31.56 | 31.33 | 31.29 | 30.91 | 31.09 | 31.15 | 30.95 | 31.02 | $I_3$ | 31.15 | $N_2$ | 31.54 | | |
| Mean | 31.17 | 31.41 | 31.79 | 31.54 | 31.48 | 31.00 | 31.20 | 31.30 | 31.04 | 31.13 | | | $N_3$ | 31.29 | | |
| **CD ($p \leq 0.05$): I= 0.05, S= 0.06, N= 0.03, N×S = 0.07, N×I= 0.06, S×I= 0.07, N×S×I= 0.11** | | | | | | | | | | | | | | | | |

**Table 3.** Effect of planting season, interval and nitrogen fertilizer on collar diameter increment (mm) of *Populus deltoides*

| Season→ | Autumn Planting | | | | | Spring Planting | | | | | Factor means | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nitrogen levels Planting Interval | $N_0$ | $N_1$ | $N_2$ | $N_3$ | Mean | $N_0$ | $N_1$ | $N_2$ | $N_3$ | Mean | Planting Interval | | Nitrogen levels | | Planting Season | |
| $I_1$ | 5.53 | 5.62 | 5.98 | 5.42 | 5.63 | 5.29 | 5.36 | 5.49 | 5.20 | 5.33 | $I_1$ | 5.48 | $N_0$ | 5.27 | $S_1$ | 5.51 |
| $I_2$ | 5.40 | 5.56 | 5.77 | 5.28 | 5.50 | 5.11 | 5.27 | 5.36 | 5.05 | 5.19 | $I_2$ | 5.34 | $N_1$ | 5.39 | $S_2$ | 5.19 |
| $I_3$ | 5.31 | 5.50 | 5.62 | 5.21 | 5.41 | 5.00 | 5.05 | 5.21 | 4.96 | 5.05 | $I_3$ | 5.23 | $N_2$ | 5.57 | | |
| Mean | 5.41 | 5.56 | 5.79 | 5.30 | 5.51 | 5.13 | 5.22 | 5.35 | 5.07 | 5.19 | | | $N_3$ | 5.18 | | |
| **CD ($p \leq 0.05$): I= 0.05, S= 0.08, N= 0.07, N×S = 0.10, N×I= 0.09, S×I= 0.10, N×S×I= 0.10** | | | | | | | | | | | | | | | | |

**Table 4.** Effect of planting season, interval and Nitrogen fertilizer on leaf area growth ($cm^2$) of *Populus deltoides*

| Season→ | Autumn Planting | | | | | Spring Planting | | | | | Factor means | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nitrogen levels Planting Interval | $N_0$ | $N_1$ | $N_2$ | $N_3$ | Mean | $N_0$ | $N_1$ | $N_2$ | $N_3$ | Mean | Planting Interval | | Nitrogen Levels | | Planting Season | |
| $I_1$ | 342.61 | 343.11 | 347.12 | 343.50 | 344.09 | 340.53 | 341.11 | 342.50 | 339.12 | 340.82 | $I_1$ | 342.45 | $N_0$ | 340.46 | $S_1$ | 343.08 |
| $I_2$ | 341.52 | 342.33 | 346.27 | 342.13 | 343.06 | 339.54 | 340.42 | 341.09 | 339.58 | 340.16 | $I_2$ | 341.61 | $N_1$ | 341.41 | $S_2$ | 340.10 |
| $I_3$ | 340.42 | 341.50 | 345.28 | 341.17 | 342.09 | 338.13 | 339.98 | 340.11 | 339.03 | 339.31 | $I_3$ | 340.70 | $N_2$ | 343.73 | | |
| Mean | 341.52 | 342.31 | 346.22 | 342.27 | 343.08 | 339.40 | 340.50 | 341.23 | 339.24 | 340.10 | | | $N_3$ | 340.76 | | |
| **CD ($p \leq 0.05$): I= 0.11, S= 0.13, N= 0.12, N×S = 0.14, N×I= 0.15, S×I= 0.13, N×S×I= 0.17** | | | | | | | | | | | | | | | | |

and $N_3$ levels were at par with each other. Whereas, in spring season all the nitrogen levels were found significantly different. Same trend was observed by Medhurst and Beadle (2001) for *Eucalyptus nitens*.

Individual factors were evaluated to determine the best possible factor for leaf area growth. Planting interval I recorded highest leaf area (342.45 $cm^2$), followed by planting interval II and III and were found significantly different with respect to one another. Planting interval I recorded maximum survival, plant height, color diameter and number of leaves $plant^{-1}$ due to favorable environment, which finally resulted into maximum leaf area. These findings are in agreement with the findings of Asner *et al*. (2003). Out of four nitrogen levels applied to the plantation, $N_2$ recorded highest leaf area (343.73 $cm^2$), followed by $N_1$ and $N_3$ and were significantly different.

The current study suggested that out of two planting seasons, survival and growth parameters (plant height, collar diameter and leaf area) showed better results for autumn planting compared to spring planting due to availability of moisture in the soil. Planting interval I recorded highest survival and growth compared to other two planting intervals planting interval II and III. Among the nitrogen levels applied, $N_3$ (150 kg $ha^{-1}$) showed better survival and growth of plantation compared to other levels $N_1$, $N_2$, $N_4$ and control ($N_0$) on the problematic site.

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# Use of Municipal Garbage as Potting Media in Nursery Production of *Ailanthus triphysa* (Dennst.) Alston *S*eedlings

**K. Vidyasagaran and Vikas Kumar***

*Department of Forest Management and Utilization*
*College of Forestry, Vellanikkara, Kerala Agricultural University, Thrissur-680 656, India*
**E-mail: vkskumar49@gmail.com*

***Abstract :*** The present investigation was conducted suitability of two weeks decayed or stored waste materials as component of potting media and its influence on the seedling performance of *Ailanthus triphysa (Matti)* seedlings. The municipal waste, coir waste and tea wastes were mixed with sand and soil in different concentrations. Results of the study indicated that the growth attributes like height (44.72cm), girth (11.79 mm), biomass {above (12.66g) and below ground (8.60g), quality index (527.25) and biovolume (1.29) highest values were observed in soil: partly decayed municipal waste in 1:1. Similarly, chlorophyll content was recorded highest in soil: partly decayed tea waste: sand in 1:1:1. The nitrogen content of the tissue recorded maximum value in the potting media of soil: partly decayed municipal waste in 1:1, potassium content in tissue was maximum in soil: partially decayed municipal waste: sand.

***Key Words*:** *Ailanthus triphysa*, Potting media, Quality index, Municipal waste, Biomass production, Vigour index

*Ailanthus triphysa* commonly known as matti (Family: Simaroubaceae), is a deciduous prominent multipurpose tree species in the traditional land use systems of Kerala, India. Waste generated in the urban and suburban areas consists of household wastes, construction and demolition debris, sanitary residues and wastes from the residential areas, street, hotels, hospitals, etc. (Sharma, 2002). Due to the advent of industrialization, urbanization and overpopulation in the country, waste generation has reached at alarming proportions and the society is facing the problem of safe disposal of huge quantities of waste. The studies conducted elsewhere revealed that the waste materials like municipal garbage could be used for cultivation of vegetables and ornamentals particularly when supplemented with some nutrients (Clark *et al.,* 2000). Only limited studies have been conducted on the effect of these solid wastes on the growth and vigour of tree seedlings either in the nursery or in the plantation (Gopikumar, 2009; Ajeesh *et al.,* 2014; Vikas *et al.,* 2014; Vidyasagaran *et al.,* 2014 a,b,c). Scientific information on the influence of municipal garbage on growth, nutrient uptake, biomass production, chlorophyll production and leaf growth behaviour of seedlings will be extremely useful for the production of healthy seedlings in the nursery at low cost, same time paving a way for the easy disposal of these waste materials. The present investigation was framed to study the effect of two weeks decayed or stored municipal garbage as component potting media on the growth and vigour of teak seedlings in the nursery.

## MATERIAL AND METHODS

The experiment was conducted at College of Forestry, Kerala Agricultural University, Vellanikara, Thrissur district during 2009-2012. The nursery area is located at 40 meters above mean sea level at $10^0$32'N latitude and $76^0$26'E longitude. The area experiences a warm and humid climate with distinct rains from south-west as well as north-east monsoons. Mature ailanthus seeds obtained from Kerala Forest Research Institute, Peechi were soaked in water for 12 hours to facilitate the germination. Seeds were sown in standard nursery beds. Uniform vigorous seedlings were transplanted in polythene bags of 10”x5” size filled with different treatment media and arranged in separate rows in the green house. Seedlings were Irrigated regularly. Municipal waste materials were collected from the drenching site of Thrissur Corporation. Tea waste was collected from Tea factory, Wayanad and coir waste from Coir mill, Kandassamkadavu, Thrissur. Fresh wastes brought to the experimental site of the college in Vellanikkara and, municipal waste chopped into small pieces kept for curing before preparing for the potting media. The 7 potting media were prepared by thoroughly mixing the components. T1 - Soil: sand: cow dung (1:1:1 ratio- control treatment); T2- Soil: partially decayed municipal waste (1:1); T3 - Soil: partially decayed coir waste (1:1); T4- Soil: partially decayed tea waste (1:1); T5 - Soil: partially decayed municipal waste: sand (1:1:1); T6 - Soil: partially decayed coir waste: Sand (1:1:1); T7 - Soil: partially decayed tea waste: sand (1:1:1). The experiment was laid out in Randomized Complete Block Design (RBD) with three replications. A total of one thousand and fifty seedlings were kept for conducting growth studies in the nursery. The seedlings after transplanting to the polybags were kept under green house conditions. Necessary plant

protection measures were also adopted.

The observations like height, girth and fresh weight of shoots were recorded on 180th day of transplanting. Representative seedlings were uprooted and the tap root length, number of lateral roots formed and root fresh weight observations were made. After finding out the fresh weights, the shoot and root portion separated was dried in hot air oven at a temperature of 70ºC ± 2ºC for about 48 hours. Drying and weighing were continued till constant weights obtained. Biovolume index, which is a non-destructive quick method to calculate the above-ground portion of the tree seedlings was calculated using the formula suggested by Hatchell (1985) i.e., Biovolume index = plant height (cm) x stem diameter (mm). Quality index, which is a measure to assess the quality of seedling based on the height, stem diameter and dry biomass was also calculated using the standard formula (Hatchell, 1985). Above and below biomass were calculated and the ratio of above: below biomass were also calculated. The physiological observations like number of leaves and fresh weight of leaves were taken and after oven drying, the dry weight of leaves was recorded. Drying and weighing were continued till constant weights were obtained. Representative samples were taken from each treatment and leaf area and weight of leaves per plant were recorded. The specific leaf area, specific leaf weight and relative growth rate were calculated. Leaf samples were collected from the selected plants and chlorophyll content measured by using chlorophyll meter.

The shoot portion of the plants used for destructive sampling were dried and powdered. This fine powder was used for the estimation of Nitrogen, Phosphorous and Potassium at monthly intervals. Ammonia was distilled by KEL PLUS automatic distillation system and nitrogen was estimated. The phosphorous content calorimetrically by the Vanado-Molybdo Phosphoric yellow colour method. Potassium in the extract was determined flame photometrically using potassium filter (Jackson, 1976).

## RESULTS AND DISCUSSION

The significant variations were observed among various treatments with regard to height of seedlings. Treatment T7 recorded the maximum height of 49.09 cm, which was immediately followed by T2 and T5. Similar results were also observed in other species (Mehmood *et al.,* 2013 and Sharifian *et al.,* 2014). The girth values ranged from 4.70 mm (T6) to 11.79 mm (T2). The above ground biomass accumulation ranged from 0.54 (T6) to 12.66 gm (T2). Below ground biomass of the seedlings among various treatments followed the same trend. Among treatments, the potting media carrying coir waste produced less growth than tea waste and municipal waste. Addition of coir waste to soil proved less on girth and height in matti.

The root length varied from 12.33 (T3) to 18.33 cm (T1), whereas, T7 showed more number of roots (50.00) (Table 1). Gopikumar and Chandran (2002) have reported that treatments containing partially decomposed municipal waste had better effect in comparison to other treatments with regard to root growth parameters and physiological attributes in the case of *Ailanthus triphysa* seedlings.

The biovolume index was maximum recorded for treatment T5 and also nearly same value was observed for T2 and least was recorded for T3, similar trend was reflected in quality index (Table 1).

There exist significant differences among the treatments with regard to the number of leaves produced by the seedlings (Table 2). Maximum number of leaves ranged from 8.23 (T6) to 14.70 (T2). Leaf fresh/dry weight was recorded maximum in T2, which significantly varied from other treatments. Specific leaf area among different treatments ranged from 34.12 (T2) to 51.93 (T6). Studies on leaf characters of *Ailanthus triphysa* revealed that maximum specific leaf weight was observed in treatment T1 and minimum by T6 and T3. While examining the response of leaf characters to various potting media treatments, performance was proved better when sand is

**Table 1**. Growth parameters of *Ailanthus triphysa* seedlings under different treatments in the nursery

| Treatments | Growth parameters | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Height (cm) | Girth (mm) | Above ground biomass (g) | Below ground biomass (g) | Tap root length (cm) | Number of lateral roots | Biovolume index | Quality index |
| T1 | 40.64$^{c}$ | 9.76c | 7.40$^{bc}$ | 6.02$^{b}$ | 18.33$^{b}$ | 38.67$^{b}$ | 1.16$^{b}$ | 396.65$^{c}$ |
| T2 | 44.72$^{cd}$ | 11.79$^{e}$ | 12.66$^{c}$ | 8.60$^{b}$ | 18.00$^{b}$ | 43.00$^{bc}$ | 1.29$^{a}$ | 527.249$^{a}$ |
| T3 | 12.49$^{a}$ | 5.92$^{b}$ | 0.44$^{a}$ | 0.57$^{a}$ | 12.33$^{a}$ | 23.33$^{a}$ | 0.40$^{c}$ | 73.941$^{d}$ |
| T4 | 34.12$^{b}$ | 9.30$^{c}$ | 6.67$^{b}$ | 6.21$^{b}$ | 16.33$^{b}$ | 43.67$^{bc}$ | 1.25$^{a}$ | 317.316$^{c}$ |
| T5 | 44.24$^{cd}$ | 10.59$^{c}$ | 9.38$^{bc}$ | 8.37$^{b}$ | 17.00$^{b}$ | 36.33$^{b}$ | 1.31$^{a}$ | 468.502$^{b}$ |
| T6 | 13.96$^{a}$ | 4.70$^{a}$ | 0.54$^{a}$ | 1.14$^{a}$ | 13.00$^{a}$ | 27.00$^{a}$ | 0.48$^{c}$ | 65.612$^{d}$ |
| T7 | 49.09$^{d}$ | 10.64$^{d}$ | 7.81$^{bc}$ | 6.51$^{b}$ | 17.67$^{b}$ | 50.00$^{c}$ | 1.15$^{b}$ | 522.32$^{a}$ |

* Significant at 0.05 levels

*Means with same superscript letter are homogeneous*

added along with soil and partially decomposed waste. Herrera *et al.* (2008) observed the number of leaves/seedling and leaf area was significantly higher in compost-containing mixtures. By contrast, no significant variations were found for specific leaf area (SLA) or leaf area ratio (LAR) between the substrates studied. Significant variation in the chlorophyll content was among treatments but relative growth rate did not vary significantly. The chlorophyll content ranged from 34.63 (T6) to 47.53 (T7). There was no uniform trend on the effect of treatments on the chlorophyll content of seedlings in various treatments. Sharifian *et al.* (2014) observed that 50 per cent and 75 per cent compost had no significant effect on chlorophyll content. Level of 100 per cent compost decreased the total chlorophyll content.

Nitrogen content was found maximum in T4 and T7 (Table 3). Similar to N, the effect of potting media on phosphorous content of the seedlings showed maximum value in T7 and minimum value in T3. Phosphorous and potassium content at end of the study, showed a significant variation among treatments. The phosphorous content varied from 0.15 (T3) to 0.31% (T7), whereas, potassium content varied from 0.66 (T2) to 0.75 % (T5). In a similar potting media experiment, Adersh (2001) reported that in the case of teak and mangium seedlings, shoot growth is reported to be highly influenced by nitrogen. The quantity and form of nitrogen present in manure or compost is important in shaping the quality of the material (Moldes *et al.,* 2007).

In the present study, increased concentration of phosphorous and potassium in the seedlings grown in potting media containing decomposed garbage was due to increased availability of phosphorous and potassium in these media. Mehmood *et al.* (2013) reported that application of municipal waste as potting media can improve the nutrient content and chemical properties of soil.

Municipal waste in potting media has no detrimental but rather stimulatory effects on emergence, growth and biomass of *Ailanthus triphysa* seedlings and has thus considerable potential for substituting the high cost sand and FYM potting substrates. The growth rate of matti seedlings can be altered by the substrate mixture used to raise seedlings. The current results also highlighted the effects in the nutrient concentration, an aspect that has been ignored in the literature so far.

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**Table 2.** Physiological parameters among different treatments of *Ailanthus triphysa* seedlings in the nursery

| Treatments | Physiological parameters | | | | | | |
|---|---|---|---|---|---|---|---|
| | Number of leaves | Leaf fresh weight (g) | Leaf dry weight (g) | Specific leaf area | Specific leaf weight (g/cm$^2$) | Relative growth rate (day$^{-1}$) | Chlorophyll content (mg/g) |
| T1 | 13.54$^{cd}$ | 19.00$^{b}$ | 9.08$^{b}$ | 36.84$^{ab}$ | 0.08$^{e}$ | 0.01$^{a}$ | 42.70$^{bc}$ |
| T2 | 14.70$^{e}$ | 31.13$^{c}$ | 15.55$^{c}$ | 34.12$^{a}$ | 0.06$^{de}$ | 0.01$^{a}$ | 44.10$^{bc}$ |
| T3 | 10.20$^{b}$ | 2.17$^{a}$ | 0.98$^{a}$ | 44.01$^{b}$ | 0.02$^{ab}$ | 0.02$^{b}$ | 38.72$^{ab}$ |
| T4 | 12.77$^{c}$ | 16.39$^{b}$ | 7.93$^{b}$ | 46.59$^{ab}$ | 0.04$^{bcd}$ | 0.01$^{ab}$ | 44.07$^{bc}$ |
| T5 | 13.77$^{d}$ | 20.11$^{bc}$ | 12.95$^{c}$ | 40.76$^{ab}$ | 0.06$^{cde}$ | 0.01$^{a}$ | 44.21$^{bc}$ |
| T6 | 8.23$^{a}$ | 2.00$^{a}$ | 1.09$^{a}$ | 51.93$^{b}$ | 0.01$^{a}$ | 0.01$^{a}$ | 34.64$^{a}$ |
| T7 | 14.10$^{de}$ | 18.60$^{b}$ | 14.78$^{c}$ | 48.5$^{ab}$ | 0.04$^{bc}$ | 0.01$^{a}$ | 47.53$^{c}$ |

* Significant at 0.05 levels
Means with same letter as superscript are homogeneous

**Table 3.** The nutrient content of *Ailanthus triphysa* seedlings under different treatments in the nursery

| Treatments | Nitrogen (%) | Phosphorous (%) | Potassium (%) |
|---|---|---|---|
| T1 | 0.95$^{c}$ | 0.30$^{e}$ | 0.72$^{ab}$ |
| T2 | 1.00$^{c}$ | 0.28$^{d}$ | 0.66$^{a}$ |
| T3 | 0.48$^{a}$ | 0.15$^{a}$ | 0.67$^{a}$ |
| T4 | 1.35$^{d}$ | 0.21$^{c}$ | 0.70$^{ab}$ |
| T5 | 1.30$^{d}$ | 0.28$^{d}$ | 0.75$^{b}$ |
| T6 | 0.72$^{b}$ | 0.17$^{b}$ | 0.68$^{ab}$ |
| T7 | 1.35$^{d}$ | 0.31$^{e}$ | 0.74$^{b}$ |

* Significant at 0.01 levels
Means with same letter as superscript are homogeneous

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# Human Leopard Conflict in Bandhavgarh Tiger Reserve: The Emerging Drift and Community Perspective

**Sandeep Chouksey, Somesh Singh[1], Virat Singh Tomar, R.P.S.Baghel[2], S.B. Lal and Arvind Bijalwan[3]**

*School of Forestry and Environment-SHUATS, Allahabad-211 007, India*
*[1] School of Wildlife Forensic and Health, NDVSU, Jabalpur-482 001, India*
*[2]College of Veterinary Science and Animal Husbandry, NDVSU, Jabalpur-482 001, India.*
*[3]Indian Institute of Forest Management, Bhopal-462 003, India*
*Email: sandeepchouksey@hotmail.com*

***Abstract***: A study was conducted on the status and management of human leopard conflict in Bandhavgarh Tiger Reserve of Madhya Pradesh, India with special reference to people perception and community based conservation. The Tiger Reserve with an area of 1161.471 $km^2$ is situated in Uamria, Madhya Pradesh. There were 13 villages in the Core Zone of the Reserve and 152 revenue villages within 5 km radius of the Reserve with 97,556 human populations and 1,14,533 cattle population. A total of 345 livestock depredation cases were recorded during this period, out of which 84.64% were of cow/ox followed by goat and buffalo. Maximum (77) cases were recorded during 2010 and minimum (5) in 2001. The result shows a gradual rise in the cases from 2001 to 2011. The mean loss of livestock by leopard attack was 48.66, 3.16 and 5.67 deaths per range for cow/ox, buffalo and goat between 2001 to 2011, respectively. A total of 6 human mauling cases were reported from 2001 to 2011. The questionnaire survey revealed that livestock depredation by Leopards created a psychological impact on local residents, and they started treating the animals like a threat resulting sometimes in retaliation killing. To balance such losses and create compassion for wild animals the Forest Department of Madhya Pradesh had provision for *ex-gratia* compensation. However, 56.11% were not satisfied with the compensation system. They were unhappy over lengthy process involved, less compensation and delay in the payment. Conservation and development of habitat and water holes, development of grassland and rangeland, capture and translocation of problematic animals, bio fencing, livestock insurance, easygoing compensation process, proper housing of livestock and community based conservation could be some solution to reduce the manage the human Leopard conflict in the area.

***Keywords:*** Human Leopard conflict, Bandhavgarh Tiger reserve, Livestock depredation, Human mauling

Leopards, *Panthera pardus* (Linnaeus, 1758) are widely distributed in India and are a highly adaptable species that live in and around many human dominated and agricultural landscapes. Leopards are nature's most efficient killers, but the expansion of human settlements and ever-increasing pressure on natural resources has intensified the issue of human-Leopard conflict in a wide variety of situations and population of Leopard is declining. One of the major causes of this decline is attributed to the conflicts with local communities due to livestock depredation by Leopards throughout their range (Karanth and Sunquist 1995; Ogada *et al*. 2003 and Edgaonkar, 2008). Conflict can have multiple implications ranging from fear evoked by the presence of the carnivore (Quammen, 2003), to fatal attacks on humans (Loe and Roskaft, 2004). Several cases of Leopard attack were reported in Maharastra and Madhya Pradesh (Chellam, 2010). Human Leopard conflict has been a well known problem in and around the protected and non protected areas in India. A large Leopard population is living in human dominated landscapes of rural and semi-urban India. Leopard densities of nine animals per 100 $km^2$ was reported in human-dominated rural landscape of Maharastra, in India (Chellam, 2010). When an animal kill or predate upon human or livestock, and damage the property, they are called as problem animals, and humans often kill such animals. Therefore, it is necessary to monitor the extent of such conflicts so as to manage the same involving local communities.

Bandhavgarh is one of the famous Tiger Reserve in Central India. The reserve has good population of wild animals including Leopards. According to the 2004 estimation the population of Leopards was 58 in the Reserve. The major problem faced due to Leopard in and around the Tiger Reserve was livestock predation. Because of the increasing density of Leopards, they often keep moving out of the reserve. Cattle of the surrounding areas of the reserve became easiest prey (Prakasam, 2005). The present paper reveals intensity of human Leopard livestock conflict in and around the Bandhavgarh Tiger Reserve with special reference to people perception and their participation in conflict mitigation for sustainable conservation of Leopards.

## MATERIAL AND METHODS

The Bandhavgarh Tiger Reserve lies in Zone 6E – Deccan Peninsular Central Highlands. It supports a corresponding platitude of fauna. Located between the Vindhyan and the Eastern flanks of Satpura hill ranges the reserve falls mostly in Umaria District of Madhya Pradesh and a chunk of 19.26 km$^2$ in Katni districts of Madhya Pradesh (Fig. 1). The area of the Tiger Reserve is 1161.471 km$^2$ including both the units of protected area and buffer area. The reserve lies between 23º30' 08" to 23º57' 01" North latitude and 80 º 47'05" to 81 º11'43" East longitude. The Tiger Reserve has 6 ranges namely Tala, Kalwah, Patour, Magdhi, Khitoli and Panpatha (Fig. 2).

**Data collection from primary resources:** A questionnaire was prepared to know the attitude of local residents toward existing human Leopard conflict in BTR. Multistage Random Sampling was used to select survey villages (Singh and Sharma, 2011). Total 180 respondents from 12 villages of six different ranges namely Tala, Kalwah, Patour, Magdhi, Khitoli and Panpatha from the periphery of Tiger Reserve were randomly chosen. The pre testing of questionnaire was done. Discussions were held with the village council and locals to gather the basic information about existing conflict. Visits were also made to the conflict site/village to collect the desired information.

**Data collection from secondary resources:** The information in the form of published literature such as management plan, government document, official statistics, previous studies on the human-leopard conflict, technical report, scholarly journals, review articles, books, computerized database, the world wide database magazines and newspaper were recorded (Shell, 1997; Cnossen, 1997). Data was collected from the Forest Department archives regarding human casualties (i.e. death and injury) and livestock depredation.

## RESULTS AND DISCUSSION

**Human injuries/ casualties:** Data from the Forest Department shows no human deaths. However, 6 cases of human injuries by Leopard were reported with 1 human injury case reported in each range between the years 2007 to 2011 with an average of 1 injury per year (Table 1).

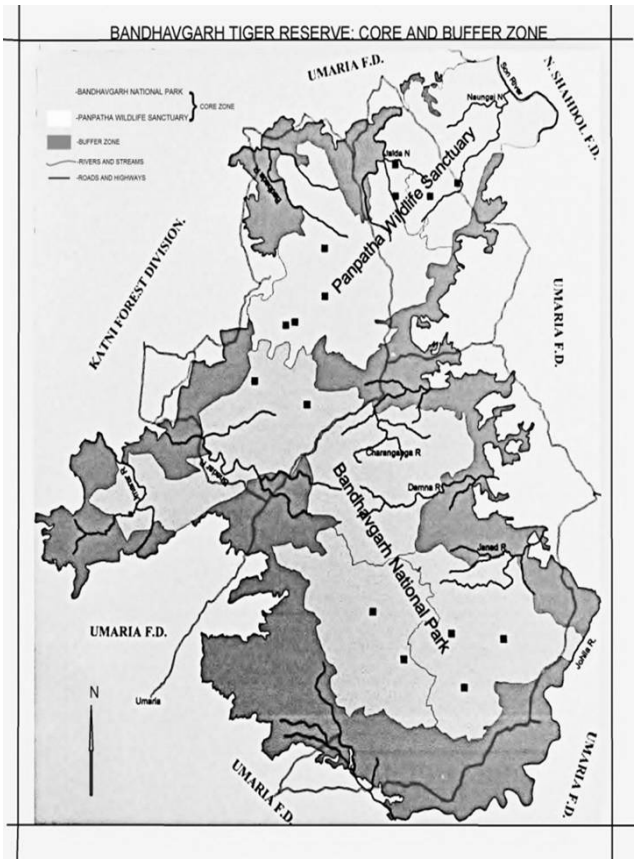


**Fig. 1.** Map showing the location of Bandavgarh Tiger Reserve in Umaria district of Madhya Pradesh, India

**Livestock depredation:** Total 345 livestock were killed by Leopard with an average of 27.01 between 2001 to 2011. Out of the 345, maximum deaths were recorded for cow/ox (292) followed by goat (34) and buffalos (19). The mean loss of cow/ox was 26.54 followed by goat 3.09 and buffalos 1.72 per year (Table 2). Results showed increasing trend of livestock depredation. Most affected species by Leopard attacks was cow during all the years along.

Out of 345, maximum livestock killings were recorded in Kalwah forest range followed by Khitoli, Patour, Panpatha, Magdhi and Tala. Out of this, maximum was cow/ox with an average of 48.66 deaths, followed by goat (5.67) and buffalos (3.16) per range (Table 3).

**Attitude of local peoples toward existing human carnivore conflict:** Out of 180 respondents, 27 % blamed

**Table 1.** Human injuries by leopard in BTR

| Year | Name of the Forest Range | | | | | | Total |
|---|---|---|---|---|---|---|---|
| | Panpatha | Kalwah | Patour | Khitoli | Tala | Magdhi | |
| 2007 | 0 | 1 | 0 | 0 | 0 | 1 | 2 |
| 2009 | 1 | 0 | 1 | 0 | 0 | 0 | 2 |
| 2011 | 0 | 0 | 0 | 1 | 1 | 0 | 2 |
| Total | 1 | 1 | 1 | 1 | 1 | 1 | 6 |

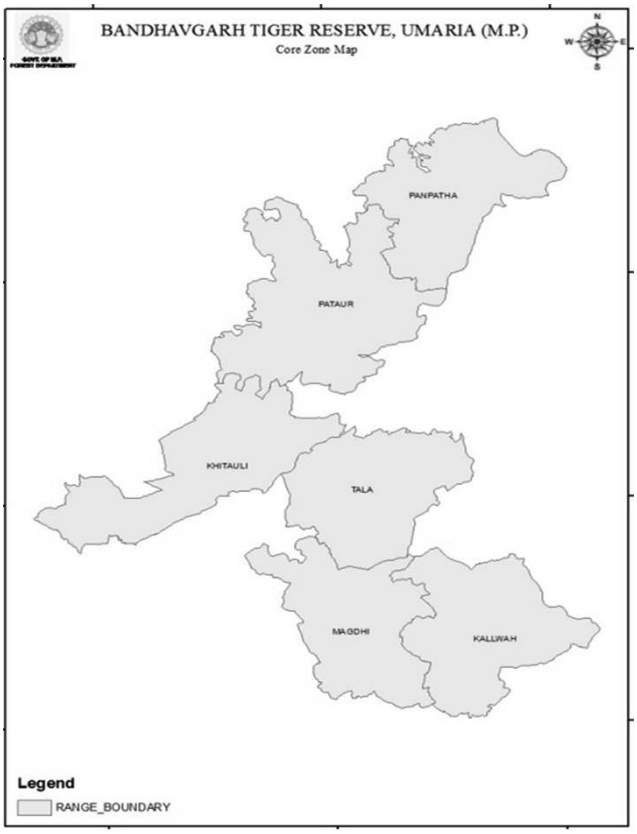


**Fig. 2.** Map of Bandhavgarh Tiger Reserve

Leopards for livestock depredation and 73% blamed other carnivores. Of 180, 35% observed livestock grazing in protected area, 17.22% think that natural prey of carnivores are less in TR, 28.34% opined livestock are easy prey, 11.11% felt wild animals attack on livestock is by chance, while 8.33% considered other reasons for the major causes of livestock depredation (Fig. 3c).

Although human mauling cases due to Leopard attack were less, however majority of respondent (45.55%) considered illegal human entry in the habitat of animals, followed by 12.22% MFP's and timbers collection, 33.88% find attacks on humans being an easy prey, 6.68% illegal livestock grazing and 1.67% felt illegal hunting the main reasons behind carnivores attack. Out of 180 respondents, 61.66% said that problematic animals should be relocated, 21.11% felt government should install fence, 10.56% opined use of lethal methods against problematic animals, while 6.67% suggested other methods for minimizing the existing conflict.

When asked, the opinion regarding satisfaction level to the present compensation system out of 180, only 32.22% showed satisfaction, while 11.67% did not replied, 56.11% were not satisfied with 32.67% dissatisfied due to lengthy process, 46.54% due to less amount and 20.79 % due to delay in the payment.

**Table 2.** Livestock depredation by Leopard in BTR between 2001 to 2011

| Year | Cow/Ox | Buffalo | Goat | Total |
|---|---|---|---|---|
| 2001 | 4 | 0 | 1 | 5 |
| 2002 | 5 | 2 | 0 | 7 |
| 2003 | 12 | 1 | 0 | 13 |
| 2004 | 16 | 1 | 3 | 20 |
| 2005 | 12 | 1 | 0 | 13 |
| 2006 | 21 | 1 | 4 | 26 |
| 2007 | 22 | 2 | 2 | 26 |
| 2008 | 14 | 3 | 2 | 19 |
| 2009 | 61 | 3 | 7 | 71 |
| 2010 | 71 | 3 | 3 | 77 |
| 2011 | 54 | 2 | 12 | 68 |
| Total | 292 | 19 | 34 | 345 |
| Mean | 26.54 | 1.72 | 3.09 | 31.36 |
| Standard Error | 7.15 | 0.30 | 1.09 | 8.14 |

**Management of conflict in Bandhavgarh Tiger Reserve:** Forest department has adopted some of the mitigation measure to resolve the conflict in the Tiger Reserves.

**Compensation:** The compensation is paid to the villagers for human life loss and injury and livestock depredation. Amount of Rs. 100,000 is paid for human death, 75,000 Rs given for permanent disability and Rs. 20,000 for injuries caused by wild animals. There is provision of paying Rs. 10,000 in case of depredation of adult cow/buffalo/horse, Rs. 5,000 for their young ones and Rs. 1000 for goat.

**Fencing:** Fencing is one of the measures taken by the Forest department around the villages which is located near the core zone of TR (Fig. 3d). Total 92.202 km fencing is done in and around the Core Zone of BTR. Out of this, 13.39 km was in Tala range, 5 in Patour range, 40.262 in Kalwah range, 11.55 in Magdhi range, 13 in Panpatha range and 9 in Khitoli range.

**Eco-development:** Forest department established Eco Development Committee (EDC) in the villages, 50 EDCs are formed in 6 different ranges of BTR. 13 EDCs were in Tala range, 8 in Patour, 10 in Kalwah, 8 in Magdhi, 9 in Panpatha and 12 in Khitoli Range. Eco-development is right perspective that uplifts the socio-economic growth of the local inhabitants and reduces their dependence on the protected area thus minimizes human-animal conflict.

**Relocation of villages:** Relocation of the villages situated in core zone is also being done by the forest department as part of minimizing the conflict.

**Measures adopted by villagers: T**raditional practices are used by villagers to avoid the conflict situation in BTR. Fencing made by bamboo, cactus and thorny twigs is used in the surrounding of houses for keeping animals away from the

**Table 3.** Livestock depredation due to Leopard in different ranges of BTR during 2001 to 2011

| Livestock species | Tala | Kalwah | Pataur | Magdhi | Panpatha | Khitoli | Total | Mean | SE |
|---|---|---|---|---|---|---|---|---|---|
| Cow/Ox | 3 | 68 | 65 | 47 | 49 | 60 | 292 | 48.66 | 9.75 |
| Buffalo | 0 | 8 | 0 | 4 | 3 | 4 | 19 | 3.16 | 1.22 |
| Gaot | 0 | 0 | 1 | 10 | 14 | 9 | 34 | 5.67 | 2.48 |
| Total | 3 | 76 | 66 | 61 | 66 | 73 | 345 | 57.5 | 11.12 |

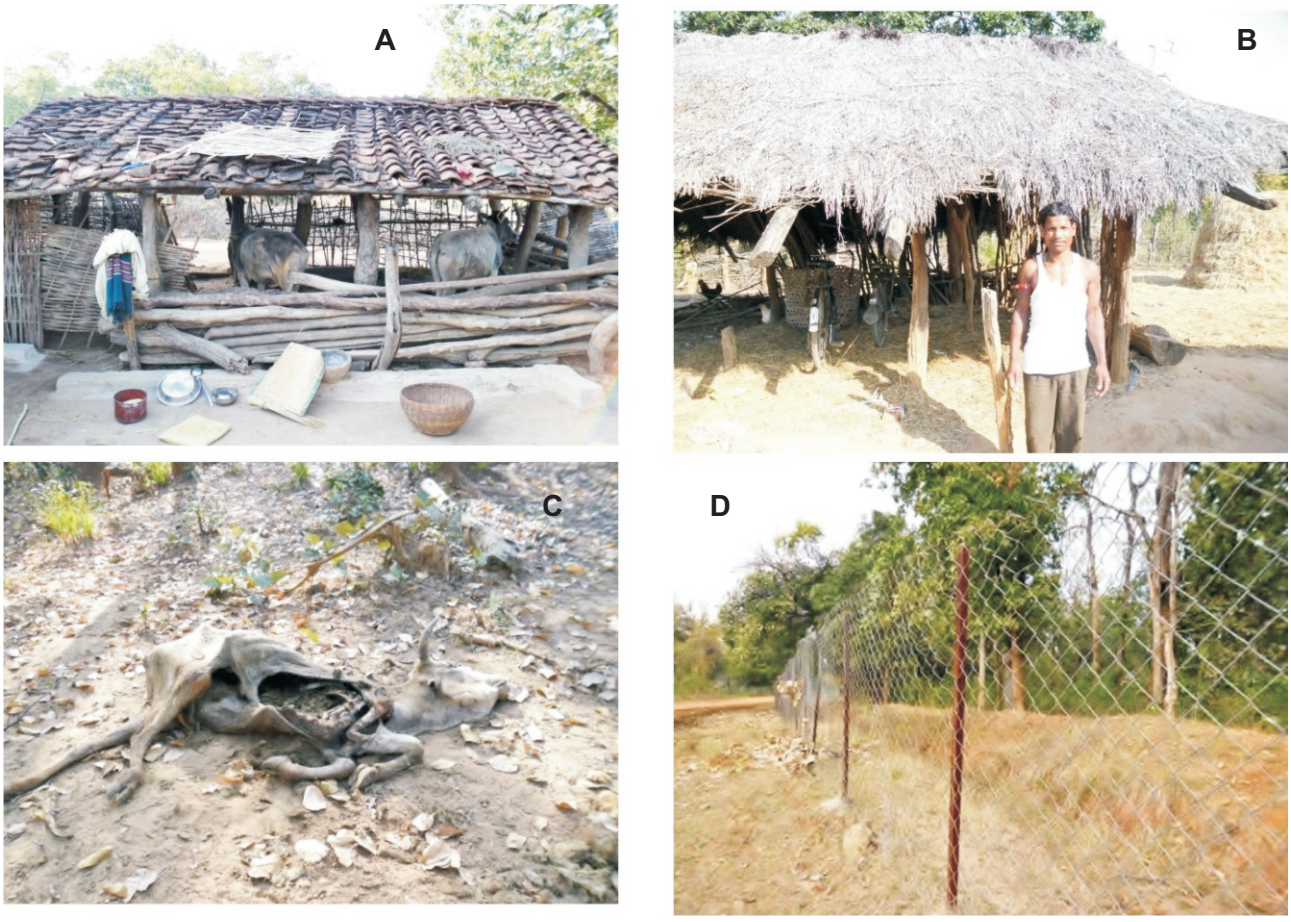


**Fig. 3. A & B.** Photograph showing the poor livestock shed used by farmers for livestock housing in BTR.
**C.** A case of livestock depredation by Leopard at Mardari village in BTR.
**D.** Photograph showing the fencing done by Forest Department to prevent animal entry in villages.

houses. Villagers keep their cattle into the traditional livestock shelters during night (Fig. 3A & B). The wall of the shelters is made by bamboo stick and lantana branches and not fully covered from top. Though, these shelters do not safeguard the livestock from carnivores effectively. Carnivores like Leopard often lift the animals from these shelters. At the time of moving in the forest and during the livestock grazing, villagers keep stick with them. When an animal charge or attack, they use stick as a weapon to scare the wild animals.

The reserve has 13 villages in the core zone and 152 revenue villages within 5 km. radius. Large human population lives in around the reserve. The main source of livelihood is agriculture and livestock rearing. The Reserve has 97,556 human populations and 114,533 cattle population (Prakasam, 2005). Livestock grazing in the wildlife habitat appeared to be the major cause behind the livestock depredation. The villagers keep large herds of unproductive and poor quality cattle. This huge cattle population exerts tremendous biotic pressure on the resources of the Reserve. The study conducted (Bhattarai, 2009) in Bardia National Park reported the livestock grazing and human intrusion into wildlife habitat besides poor husbandry being the causes of conflict.

Leopards often come close to the human habitation and attacks on human and livestock. Earlier studies (Chauhan *et*

*al.,* 2000) stated that Leopard visits to agriculture fields and human habitations not for attacking the human but for livestock as prey. Predating the livestock is comparatively easy for Leopard. Thus, scarcity of wild prey species and looking for easy prey leads to attack on human or livestock. Leopards are known to be bold and not uncommonly found in proximity to human habitats, where they prey upon livestock (Odden and Wegge, 2005).

Cattle lifting from the livestock shed by Leopard during night hours were also reported in the villages around the Bandhavgarh Tiger Reserve. The animal sheds made up of thorny bushes, bamboo shoots and branches and covered only from the top, were not fully protected. Similar observations (Rahalkar, 2008) were found in Agriculture land of Maharastra, where Leopards used to lift the cattle of farmers from poor livestock sheds.

Conservation education and awareness of local people may be a useful tool in conflict mitigation strategy. Conservation education can change the attitude and behavior of people and increases the tolerance of losses (Matarasso, 2004). Many workers stressed that conservation education focusing on behavior and ecology of wildlife may also reduce the conflict (Oli *et al*. 1994; Nyhus and Tilson 2004; Gurung *et al*., 2008).

Adequate compensation for human death/injuries, livestock depredation is best tool for minimizing the dissatisfaction level of local people. The process of compensation should be simple and flexible. Compensation of losses is a fundamental strategy to reduce the human-wildlife conflict through the increased tolerance level of the community towards wildlife (Ogra and Badola, (2008). The problematic animals should be captured and translocated to rescue centers. Such rescue centers with trained manpower should be developed within the reserve. Besides this a well equipped and advanced wildlife health care facility is needed for livestock and wild animals in distress. Eco-development is also the right perspective to support the socio- economic growth of the local villagers and minimize the man animal conflict.

The expansion of human settlements and rising pressure on natural resources has intensified the conflict between human-Leopard-livestock. The management strategies and policies require collaborative efforts between the government departments, NGOs and local communities considering conservational ethics and local needs as well.

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# Osmotic Pre-treatment of Kinnow Peel Slices

**Navneet Sidhu, Maninder Arora[1] and Mohammed Shafiq Alam[2]**

*College of Basic Science and Humanities,*
*[1,2]College of Agricultural Engineering and Technology,*
*Punjab Agricultural University, Ludhiana-141 004, India*
*E-mail:navneetsidhu25.ns@gmail.com*

***Abstract*:** The objective of the present work was to study the effect of osmotic process temperature, concentration and immersion time of osmotic sugar solution on the water loss, solute gain and water loss to solute gain ratio during osmotic pre-treatment of kinnow peel slices. Osmotic pre-treatment was carried out using sugar as osmotic agent, varying the concentration of the osmotic solution (55-75˚Bx), temperature (35-75˚C) and immersion time (30, 60, 90 and 120 min),keeping solution to peel ratio constant 4:1 (v/w) in a water bath with controlled temperature. Water loss and solute gain were positively influenced by osmotic process temperature concentration and immersion time. Water loss and solute gain showed an increasing trend with an increase in a concentration and immersion time. Water loss initially increased followed by a decrease with an increase in osmotic process temperature.Solute gain decreased with increase in osmotic process temperature. Maximum water loss and solute gain was recorded at osmotic process temperature 55˚C, concentration 75˚Bx and immersion time of 120 min.The optimized process variables i.e. solution temperature, concentration and immersion time for osmotic pre-treatment were 74.9˚C, 75˚Bx and 60 min., respectively optimized by response surface methodology.

***Keywords*:** Kinnow peel, Osmotic pre-treatment, Water loss, Solute gain, Water loss to solute gain ratio

Citrus is the leading fruit crop of the world and India is the leading producer of citrus fruits with an area of 763 lakh hectares with annual production of 599 lakh tones. Among citrus, kinnow bears highest place in production, juice content and fruit quality (Anonymous, 2015). Kinnow (*Citrus reticulate* Blanco), a hybrid of *Citrus nobilis*Watt × *Citrus deliciosa* Ten belongs to the citrus family and is an important fruit of North India (Panesar*et al.,* 2009). Processing and utilization of kinnow into various products eventually leads to generation of waste in form of peels and pulp.The peel of the fruit, which is generally considered a waste is more nutritious than juice and can be processed.

Consumer demand has increased for processed products that keep more of their original characteristics. Among drying and dehydration, osmotic dehydration gained attention recently due to its potential application in the food processing industry (Rastogi *et al.,* 2002, Kumar *et al.,* 2008). Osmotic dehydration is one of most effective treatment and food preservation technique in the processing of dehydrated foods, since it presents some benefits such as reducing the damage of heat to the flavor, color, inhibiting the browning of enzymes and decreases the energy costs (Alakali *et al.,* 2006; Khan, 2012).These processes are normally designed with the aim of maximizing water removal while restraining solid uptake, to obtain a product whose taste and flavor have little changes in respect to that of the fresh food. The ratio of water loss to solid uptake is a good index of the efficiency of the process (Ramallo and Mascheroni, 2005). Drying is one of the most common methods of food preservation for a long time for the quality improvement. Drying has become necessary because most fruits are highly perishable owing to their high moisture content and the need to make them available all year round and at locations where they are not produced (Omolola *et al.,* 2015). The purpose of this study was to investigate the effect of concentration, temperature and immersion time on mass transfer kinetics (WL, SG, WL/SG ratio) of osmotic pre-treated kinnow peel slices. The osmotic pre-treatment process was optimized to provide maximum water loss and minimum solute gain by using response surface methodology.

## MATERIAL AND METHODS

The kinnow peel was procured from the juice vendors in the local market. The osmotic agent (sugar) was selected for the study. Three concentrations of sugar (55, 65 and 75˚C) were prepared by the standard method (Ranganna, 2008a).The peels were subjected to blanching pre-treatment. To determine the optimum blanching time for the kinnow peel, peroxidase test was carried out. The blanching of kinnow peels was carried out in 2% salt solution at 95˚C, based on negative peroxidase test (Ranganna, 2008b). The peels were immediately rinsed with cold water after treatment to stop the reaction and gently blotted to remove surface water.

**Osmotic solution concentrations:**The osmotic solutions of different concentrations (55, 65 and 75˚Brix) were prepared

by dissolving required amounts of sugar in distilled water using stirrer. Concentrations were checked by HRN-18 hand refractometer.

**Osmotic pre-treatment:**Peel slices were immersed in sugar solution (55, 65 and 75˚Brix) at desiredsolution to peel ratio i.e. 4:1 (v/w). Experiments were performed at three temperature levels (35, 55 and 75˚C). The temperature of osmotic solution was maintained using hot water bath whose temperature was monitored by means of a thermometer. Sampling was performed in time intervals of 30, 60, 90 and 120 min, then the samples were rinsed quickly with distilled water to eliminate the solution from the surface and carefully blotted with tissue paper to remove the excess surface water. Each experiment was performed in triplicate.

**Mass transfer determinations:** In order to determine weight change, all samples were weighed before and after treatment using analytical weighing balance. The fresh and pre-treatedkinnow peel slices after each contact time were placed ina oven at 105˚C until constant weight (24 h) was obtained, in order to measure the moisture contents. All measurements were performed in triplicate. From these data, water loss (WL), solid gain (SG) and water loss to solute gain ratio (WL/SG) at different times(t), according to the following expressions were determined(Kar*et al.,* 2005).

$$\text{Water loss/100g fresh peel} = \frac{(W_0 - W_t) + (S_t - S_o)}{W_0} \times 100$$

$$\text{Solute gain/100g fresh peel} = \frac{(S_t - S_0)}{W_0} \times 100$$

Where $W_O$ is initial weight of peel taken for osmotic pre-treatment (g), $W_t$is final weight of peel after osmotic pre-treatment at any time t (g), $S_o$isinitial dry matter of fruit (g) and $S_t$ is dry matter of fruit after osmotic pre-treatment for any time t (g).

**Experimental design and statistical analysis:** The optimization was done for each response variable with the help of response surface methodology (RSM) by using commercial statistical package, Design Expert DX 9.0.5.1 (Statease Inc., Minneapolis, USA, Trail Version 2015). The optimization of the osmotic pre-treatment process aimed at finding the levels of independent variables viz. osmotic solution concentration, temperature and immersion time, which could give minimum possible water loss and maximum solute gain. The experimental design applied was a 3 × 3 × 4 factorial design in a frame of Complete Randomized Design (CRD) to check the significant effect (5%) corresponding to three sugar solution concentrations, three temperatures and fourimmersion time intervals. CPCS1 software developed by PAU, Ludhiana was used for statistical analysis.

## RESULTS AND DISCUSSION

**Optimization of blanching time:** Kinnow peel showed uneven blanching with appearance of reddish brown specks as analyzed by peroxidase enzyme activity test. Blanching for 120 sec in boiling water gave uniform blanching with no color development, showing negative enzyme test (Table 1). Further increase in time of blanching, increased the softening of the slices and lead to loss in weight. The results were in harmony with Kucner *et al.* (2014), who reported adequate blanching of highbush blueberry fruits at 95˚C for 2 min.

**Table 1.** Standardization of blanching time for kinnow peel slices prior to osmotic pre-treatment

| Holding time (seconds) | Appearance | Peroxidase enzyme activity test |
|---|---|---|
| 0 | Dark brown | +ve |
| 30 | Brown | +ve |
| 60 | Light brown | +ve |
| 90 | Specks of brown colour | +ve |
| 120 | No colour | -ve |

**Effect of variables on water loss:** Waterloss showed an increasing trend with an increase in a concentration and immersion time whereas with an increase in osmotic process temperature it showed initial increase followed by a decrease in a water loss (Table 2). The temperature and concentration of osmotic solution had relevant effect on the osmotic pre-treatment process. This might be due to swelling and plasticizing of cell membrane with increase in osmotic process temperature and concentration. During mass transfer kinetics of kinnow peel slices in sugar osmotic solution the maximum value for water loss (42.595 g/100g FF) was observed at osmotic process temperature 55˚C, concentration 75˚Bx and immersion time of 120 min. Among the process variables studied the immersion time, witnessed maximum effect on water loss. This might be due to the fact that higher immersion time promoted faster water loss.Water loss was significantly affected by concentration, temperature and immersion time followed by interaction of concentration with osmotic process temperature and interaction of immersion time withosmotic process temperature at 5% level of significance.However,an interaction ofconcentration with immersion time and interaction of osmotic process temperature, concentration and immersion timewas not significant. These results were in accordance with those obtained by the other researchers (Bansal *et al.,* 2012, Khatir*et al.,* 2013; Kowalski *et al.,* 2013).

**Effect of variables on solute gain:** The solute gain decreased with increase in osmotic process temperature. The maximum value of solute gain (23.554 g/100g FF) at osmotic process temperature 55˚C, concentration 75˚Bx and

immersion time of 120 minutes. The solute gain increased with the increase in concentration and immersion time (Table 3). Solute gain was highly affected by solution immersion time followed by concentration. The water loss was significantly affected by osmotic process temperature, concentration and immersion time individually followed by interaction of temperature with immersion time, temperature with concentration and concentration with immersion time at 5% level of significance whereas, interaction of osmotic process temperature, concentration and immersion time were not significant at 5 % level of significance. Similar results were observed by Rahimzade and Hesari (2007) in apricot, Lombard *et al.*. (2007) in pineapple, Jalali *et al.* (2008) in banana, Mundada *et al.* (2011) in pomegranate arils and Ganjloo and Bimakr (2015) in eggplant cubes.

**Effect of variables on water loss/solute gain ratio:** The maximum value for WL/SG ratio (2.117g/100g FF) at osmotic process temperature 35˚C, concentration 75˚Bx and immersion time of 120 min. The WL/SG ratio was found to be constant with the increase in temperature at initial phase but

**Table 2.** Water loss (WL) during sugar osmotic pre-treatment

| Concentration (˚Bx) | Immersion time (min) | Water loss (g/100g FF) | | | |
|---|---|---|---|---|---|
| | | 35˚C | 55˚C | | 75˚C |
| 55 | 30 | 23.23 | 28.62 | | 27.41 |
| 55 | 60 | 24.42 | 30.79 | | 28.55 |
| 55 | 90 | 30.19 | 33.51 | | 30.93 |
| 55 | 120 | 31.86 | 37.54 | | 32.52 |
| 65 | 30 | 26.14 | 29.49 | | 28.42 |
| 65 | 60 | 26.40 | 31.66 | | 31.93 |
| 65 | 90 | 33.29 | 35.79 | | 34.08 |
| 65 | 120 | 34.42 | 40.63 | | 36.35 |
| 75 | 30 | 28.04 | 34.38 | | 31.29 |
| 75 | 60 | 28.92 | 37.56 | | 34.36 |
| 75 | 90 | 33.25 | 38.86 | | 37.85 |
| 75 | 120 | 37.33 | 42.59 | | 37.24 |
| CD (p=0.05) | | A=0.55 | B=0.55 | | C=0.63 |
| | | AB=.95 | BC=NS | AC=1.1 | ABC=NS |

A: Osmotic process temperature B: Concentration C: Immersion time

**Table 3.** Solute gain (SG) during sugar osmotic pre-treatment

| Concentration (˚Bx) | Immersion time (min) | Solute gain (g/100g FF) | | | |
|---|---|---|---|---|---|
| | | 35˚C | 55˚C | | 75˚C |
| 55 | 30 | 13.19 | 15.21 | | 17.47 |
| 55 | 60 | 13.74 | 15.65 | | 18.49 |
| 55 | 90 | 17.56 | 17.73 | | 18.92 |
| 55 | 120 | 18.45 | 18.70 | | 19.64 |
| 65 | 30 | 13.69 | 15.47 | | 19.55 |
| 65 | 60 | 13.63 | 18.27 | | 21.11 |
| 65 | 90 | 18.45 | 19.39 | | 20.82 |
| 65 | 120 | 18.65 | 21.16 | | 21.54 |
| 75 | 30 | 15.55 | 19.51 | | 21.73 |
| 75 | 60 | 16.45 | 21.37 | | 21.45 |
| 75 | 90 | 17.63 | 20.41 | | 21.11 |
| 75 | 120 | 17.63 | 23.55 | | 21.82 |
| CD (p=0.05) | | A=0.55 | B=0.55 | | C=0.64 |
| | | AB=0.96 | BC=1.1 | AC=1.1 | ABC=NS |

A: Osmotic process temperature B: Concentration C: Immersion time

**Table 4.** Water loss to solute gain (WL/SG) ratio during sugar osmotic pre-treatment

| Concentration (˚Bx) | Immersion time (min) | Water loss/Solute gain ratio (g/100g FF) | | |
|---|---|---|---|---|
| | | 35˚C | 55˚C | 75˚C |
| 55 | 30 | 1.76 | 1.88 | 1.59 |
| 55 | 60 | 1.77 | 1.97 | 1.54 |
| 55 | 90 | 1.72 | 1.88 | 1.63 |
| 55 | 120 | 1.72 | 2.00 | 1.65 |
| 65 | 30 | 1.91 | 1.90 | 1.45 |
| 65 | 60 | 1.93 | 1.73 | 1.51 |
| 65 | 90 | 1.80 | 1.84 | 1.63 |
| 65 | 120 | 1.84 | 1.92 | 1.68 |
| 75 | 30 | 1.80 | 1.76 | 1.44 |
| 75 | 60 | 1.76 | 1.76 | 1.60 |
| 75 | 90 | 1.88 | 1.76 | 1.79 |
| 75 | 120 | 2.11 | 1.90 | 1.70 |
| CD (p=0.05) | | A=NS | B=.51 | C=.59 |
| | | AB=.89 | BC=1.03 | AC=NS ABC=NS |

A: Osmotic process temperature B: Concentration C: Immersion time

**Table 5.** Experimental data of sugar osmo-pre-treated kinnow peel slices for response analysis

| Temperature (˚C) | Concentration (˚Bx) | Time (minutes) | Water loss (g/100g FF) | Solute gain (g/100g FF) | WL/SG (g/100g FF) |
|---|---|---|---|---|---|
| 35 | 55 | 90 | 30.703 | 18.924 | 1.622 |
| 35 | 65 | 60 | 26.871 | 14.383 | 1.868 |
| 55 | 65 | 90 | 35.490 | 19.328 | 1.836 |
| 55 | 75 | 120 | 41.282 | 21.902 | 1.884 |
| 75 | 65 | 120 | 36.313 | 21.739 | 1.670 |
| 55 | 65 | 90 | 36.676 | 20.455 | 1.792 |
| 75 | 65 | 60 | 30.543 | 20.682 | 1.476 |
| 55 | 65 | 90 | 35.227 | 18.402 | 1.914 |
| 55 | 65 | 60 | 29.867 | 14.592 | 2.046 |
| 35 | 65 | 120 | 34.364 | 19.117 | 1.797 |
| 55 | 55 | 60 | 23.992 | 13.130 | 1.827 |
| 35 | 75 | 90 | 32.844 | 17.302 | 1.898 |
| 75 | 75 | 90 | 37.218 | 20.258 | 1.837 |
| 55 | 75 | 60 | 28.624 | 17.163 | 1.667 |
| 55 | 65 | 60 | 33.318 | 17.293 | 1.926 |
| 55 | 55 | 120 | 38.018 | 18.274 | 2.080 |
| 75 | 55 | 90 | 29.86 | 19.744 | 1.512 |

decreases rapidly at later phase as soon as it reaches the higher temperature (Table 4). The WL/SG ratio decreased with an increase in concentration whereas increased with an increase in immersion time. Solute gain was highly affected by solution immersion time followed by concentration. The water loss was significantly affected by concentration and immersion time individually followed by interaction of osmotic process temperature withconcentration and concentration with immersion whereas, osmotic process temperature, interaction of osmotic process temperature with immersion time, osmotic process temperature, concentration with immersion time were not significant

**Optimization :** The optimization of the process parameters for osmotic pre-treatment process for kinnow peel slices in sugar solution, three factor three level Box-Behnken factorial design was used respectively (Table 5). The optimum

**Table 6.** Optimum solutions for each process variable of sugar osmo-pretreated kinnow peel slices

| Process parameters | Goal | Experimental range | Optimum conditions | Desirability |
|---|---|---|---|---|
| OPT (˚C) | maximize | 35-75 | 74.9 | |
| CONC (˚Bx) | maximize | 55-75 | 75 | |
| IT (min) | minimize | 60-120 | 60 | |
| Responses | | | | 0.805 |
| WL (g/100g FF) | minimize | 23.99 - 43.28 | 32.46 | |
| SG (g/100g FF) | maximize | 13.13 – 21.90 | 18.94 | |
| WL/SG (g/100g FF) | in range | 1.47 – 2.08 | 1.80 | |

operating conditions for each process variable and responses are given in Table 6. The optimized process parameters for osmotic pre-treatment of kinnow peel slices in sugar were osmotic process temperature 74.9˚C, concentration 75˚Bx and immersion time of 60 minutes.

## CONCLUSION

Response surface methodology was effective in optimizing process parameters for osmotic pre-treatment of kinnow peel slices in osmotic solution of sugar having concentration in the range of 55, 65 and 75˚Bx sugar, temperature 35, 55 and 75˚C, solution to peel ratio 4:1 and immersion time 30,60, 90 and 120 minutes. All three process variables (i.e. solution concentration, solution temperature and immersion time) had direct effects on both water loss and solute gain. The optimized values for the dominating process variables i.e. solution temperature, concentration and immersion time were found to be of 74.9˚C, 75˚Bx and 60 min respectively.

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# Status and Distribution Pattern of Sour Cherry (P*runus cerasus* l.) in Moist Temperate Region of Jammu & Kashmir

**P.A. Paray and R. Banyal**[1*]

*Faculty of Forestry, Sher-e-Kashmir University of agricultural sciences & Technology of Kashmir Benhama, Ganderbal, J&K-191 201, India*
*[1]Division of Soil and Crop Management, ICAR-Central Soil Salinity Research Institute, Karnal-132 001, India*
**E-mail:drbanyal08@gmail.com*

***Abstract***: The survey on sour cherry (*Prunus cerasus* L.) was conducted at village level by incorporating block and panchayat through transit walk, informal interview and questionnaire methods wherein the entire Kashmir valley was divided into North, South and Central zones. The survey study revealed its presence in all the districts of Kashmir with varying proportion having sporadic distribution. The species was not found so promising across the valley but it's occurrence was higher in south zone than north and central zones. The health of the trees growing in south part is better than north and central part of the province as per the growth parameters. The observations revealed that the species did not had influence the economy of the farmers directly.

***Keywords***: Distribution, Kashmir Valley, SourCherry, Status, Survey, Temperate

The moist temperate zone of Jammu and Kashmir falls in Kashmir province & its forests consist mostly of evergreen conifers dotted with broad leaved tree species as well. *Prunus cerasus* L. (sour cherry) is one of the broad leaved tree species grown in the Kashmir valley and is best known representative of the family *Rosaceae* (the rose family). The sour cherry tree is locally known as Aulichi-kul in Kashmir.The origin of sour cherry is reported to be between Caspian and Black sea that too around the mediterranean region. It is mainly grown in three pacific coast states and Michigan and is also known by tart or pie cherry. In India, sour cherry is mainly grown in Shimla hills, Kullu valley in Himachal Pradesh and Kashmir in J&K at an altitude of 1500 m above mean sea level (Yadav *et al*., 1996). The tree is medium sized and usually less than 10m tall and kept less than 4.5m in height in cultivation. The bark is red to gray-brown with predominant horizontal lenticels and often peels. The leaves of PRUNUSCERASUS are oval/elliptic in shape. They generally have less than 8 pairs of veins and the leaves are 2-5 inches long. Wood is used for making furniture and other domestic articles. These trees are good for honeybees and for the development and improvement of marginal lands. The tree species has the medicinal value. Its bark is astringent, bitter & febrifuge. The seed is nervine (Chopra *et al.,* 1986). An infusion of bark has been used in the treatment of fevers, coughs and colds. The root bark has been used as a wash for old sores and ulcers (Moerman, 1998). The fruit of sour cherry is edible, used in pies, preserves or dried for later use. Its leaves are used as a tea substitute (Facciola, 1990). This tree species has other uses as well. Oil obtained from the seed is used in cosmetics. The gum obtained from the stem is used as an adhesive. Plants can be grown as a hedge. A green dye can be obtained from its leaves and a dark grey to green dye can also be obtained from the fruit (Grae, 1974). An attempt was made with the objective to generate the information of status and distribution pattern of sour cherry. The results of the findings would be useful to devise the strategies to rejuvenate the sour cherry in the region.

## MATERIAL AND METHODS

The survey at block, panchayat and village levels of all districts of Kashmir valley was done to give the actual status of sour cherry. The observations with regard to status and distribution pattern of growing *Prunus cerasus* trees in the area were recorded. Besides, the information was also collected for its socio-economic aspect. The survey for assessing the status of sour cherry was restricted to the revenue lands. The forest lands were excluded from the preview of this study. The entire province is divided into three zones namely South, North and Central zone purposely as per the prevailing climatic and topographic conditions. The detail of the zones is presented in the table1 here as under:

The adopted outline of the survey plan in each selected district is presented in flow chart diagram as given fig. 1.

The data collected with regard to the status and distribution of the sour cherry in the Kashmir valley were tabulated and analyzed for giving the holistic preview of the trees growing in the region. The information was collected through standard procedures and methods already in vogue

**Table 1.** Division of Kashmir province as per zones

| Zone(s) | Name of District(s) | Number of districts |
|---|---|---|
| North | Baramulla, Kupwara and Bandipora | 3 |
| Central | Srinagar, Ganderbal and Budgam | 3 |
| South | Anantnag, Kulgam, Pulwama and Shopian | 4 |
| Total | | 10 |

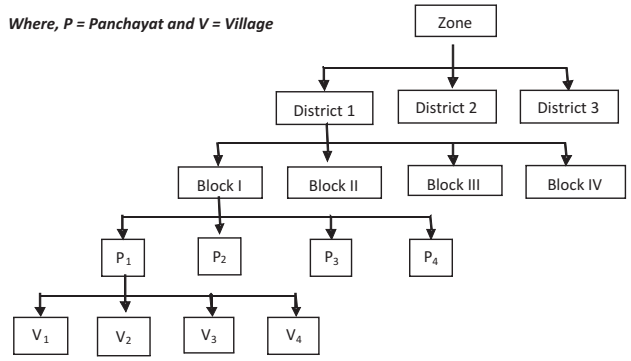



**Fig. 1.** Flow chart of survey plan

and given here as under:

**Questionnaire method:** A questionnaire prepared for the purpose was filled on spot during interaction with local inhabitants. Questionnaire consisted of both the open ended and close ended questions.

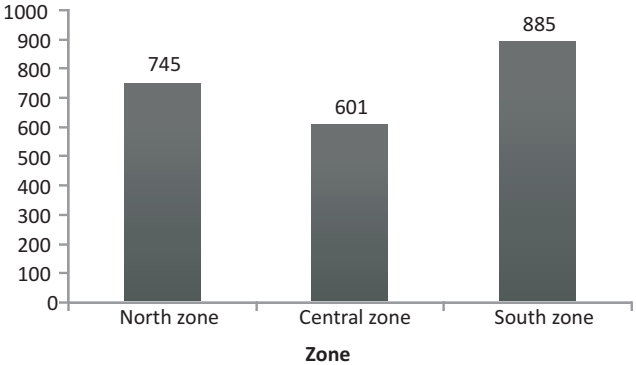
**Informal interview method:** Information was collected during informal talks with the local inhabitants including oldest and respectable citizens of the concerned areas. Generally open-ended questions were asked for getting the information.

**Transit walk method:** Information was collected during transit walk of the villages. Transit walk gave more space to discuss with local inhabitants freely in their farmlands, while walking through their farms. Problems and prospects of the questioned tree in relation to agro-forestry farming were also discussed.

## RESULTS AND DISCUSSION

The results obtained after conducting comprehensive survey of all the districts of Kashmir valley pertaining to the status and distribution pattern of Sour cherry revealed that it was found almost in all the districts of Kashmir valley with sporadic distribution (Table 2). The highest number of sour cherry trees was found in the South zone (Anantnag, Kulgam, Pulwama and Shopian districts) followed by North zone (Baramulla, Kupwara and Bandipora districts) and Central zone (Srinagar, Ganderbal and Budgam districts), respectively (Fig. 2). The total number of trees in the surveyed sampled area of Kashmir valley was 2,231. Out of this total number, 885 trees were found in South zone, 745 in North zone and 601 in Central zone, respectively. In South zone, the number of Sour cherry trees was 203, 223, 320 and 139 in Anantnag, Kulgam, Pulwama and Shopian districts, respectively. In the North zone, the number of trees was 263, 253 and 229 in Baramulla, Kupwara and Bandipora districts, respectively. The data in table-3 show that the number of trees was 132, 272 and 197 in Srinagar, Ganderbal and Budgam districts of Central zone, respectively. During the survey, the growth characteristics i.e. average tree age in years, average tree height in meters and average girth in cm were also recorded and presented in table-3. The recorded information regarding growth characteristics revealed that the average age of sour cherry trees ranged from 8-18 years, the average height ranged from 3.5-8.0m, whereas, the average girth ranged from 9.0-25.0cm in the study area. These trees were found on non-agricultural lands i.e. on village common lands, farm bunds/boundaries, roadsides, graveyards, etc. The sour cherry trees commonly found on farm lands were being used as root stock for sweet cherry results in low population. It was observed that the trees did not contribute directly to the economy of the farmer because sour cherry trees were converted to sweet cherry by grafting technique. Whatever, the production obtained after grafting is directly accounted with sweet cherry.

The survey also revealed that the number of sour cherry was in abundance in Kashmir valley in earlier times which has been reduced drastically as villagers used it indiscriminately for various purposes primarily for fuel-wood without thinking of its conservation aspect. The fruit of the sour cherry is preferred by the wild animals and keep the wildlife away from the habitation. But, in recent past the availability of the food items in the wild get reduced due to overuse of the tree species especially sour cherry forced the wildlife to enter into man-animal conflict. Therefore, this may be considered as




North zone = Baramulla, Kupwara and Bandipora districts
Central zone = Srinagar, Budgam and Ganderbal districts
South zone= Anantnag, Kulgam, Pulwama and Shopian districts

**Fig. 2.** Population of sour cherry trees

**Table 2.** Occurrence and distribution pattern of Sour cherry (*Prunus cerasus* L.) in Kashmir province

| Name of the district | Blocks in the district | Blocks selected randomly | Percentage of blocks selected | Occurrence | Frequency | Average age (yrs) | Average height (m) | Average girth (cm) | Distribution |
|---|---|---|---|---|---|---|---|---|---|
| **Zone A - North Kashmir (Baramulla, Kupwara and Bandipora districts)** | | | | | | | | | |
| Baramulla | Twelve | Tangmarg | 33.00 | + | 112 | 9-16 (12.5) | 5-7 (6) | 10-20 (15) | Sporadic |
| | | Pattan | | + | 43 | 9-18 (13.5) | 4.5-8 (6.25) | 11-24 (17.5) | |
| | | Wagoora | | + | 60 | 10-18 (14) | 5-8 (6.5) | 12-24 (18) | |
| | | Zainageer | | + | 48 | 8-18 (13) | 4.5-8 (6.25) | 10-25 (17.5) | |
| | | | | Sub-total | 263 | 8-18 (13.25) | 4.5-8 (6.25) | 10-25 (17.0) | |
| Kupwara | Eleven | Kralpora | 36.36 | + | 75 | 9-17 (13) | 5-7.5 (6.25) | 11-25 (18) | Sporadic |
| | | Trehgam | | + | 59 | 9-17 (13) | 4-7 (5.5) | 11-23 (17) | |
| | | Sogam | | + | 62 | 8-18 (13) | 4-8 (6) | 12-24 (18) | |
| | | Kupwara | | + | 57 | 9-18 (13.5) | 4-8 (6) | 10-22 (16) | |
| | | | | Sub-total | 253 | 8-18 (13.13) | 4-8 (5.94) | 10-25 (17.25) | |
| Bandipora | Five | Bandipora | 80.0 | + | 66 | 9-16 (12.5) | 4-7 (5.5) | 11-22 (16.5) | Sporadic |
| | | Hajin | | + | 52 | 11-18 (14.5) | 5-8 (6.5) | 14-25 (19.5) | |
| | | Sumbal | | + | 69 | 8-16 (12) | 4-7 (5.5) | 9-21 (15) | |
| | | Gurez | | + | 42 | 9-16 (12.5) | 4-8 (6) | 10-22 (16) | |
| | | | | Sub-total | 229 | 8-18 (12.88) | 4-8 (5.88) | 9-25 (16.75) | |
| | | | | Sub-total of Zone- A | 745 | 8-18 (13.09) | 4-8 (6.02) | 9-25 (17.0) | |
| **Zone B - Central Kashmir (Srinagar, Ganderbal and Budgam districts)** | | | | | | | | | |
| Srinagar | One | Srinagar | 100.0 | + | 94 | 10-15 (12.5) | 4-7 (5.5) | 12-20 (16) | Sporadic |
| | | Soura | | – | – | – | – | – | |
| | | Srinagar | | – | – | – | – | – | |
| | | Hazratbal | | + | 38 | 8-14 (11) | 4-6.5 (5.25) | 10-20 (15) | |
| | | | | Sub-total | 132 | 8-15 (11.75) | 4-7 (5.38) | 10-20 (15.5) | |
| Ganderbal | Four | Ganderbal | 100.0 | + | 86 | 9-16 (12.5) | 4-7 (5.5) | 10-24 (17) | Sporadic |
| | | Lar | | + | 64 | 9-15 (12) | 4-7 (5.5) | 10-20 (15) | |
| | | Kangan | | + | 47 | 8-15 (11.5) | 4-6 (5) | 9-19 (14) | |
| | | Wakura | | + | 75 | 9-16 (12.5) | 4-6.5 (5.25) | 11-20 (15.5) | |
| | | | | Sub-total | 272 | 8-16 (12.12) | 4-7 (5.31) | 9-24 (15.38) | |
| Budgam | Eight | B.K.Pora | 50.0 | + | 52 | 8-15 11.5) | 3.5-7 (5.25) | 10-20 (15) | Sporadic |
| | | Chadoora | | + | 48 | 8-16 (12) | 4-7.5 (5.75) | 9-23 (16) | |
| | | Khan-Sahib | | + | 55 | 9-15 (12) | 4-6.5 (5.25) | 10-20 (15) | |
| | | Nagam | | + | 42 | 9-17 (13) | 4-7 (5.5) | 10-24 (17) | |
| | | | | Sub-total | 197 | 8-17 (12.13) | 3.5-7.0 (5.44) | 9-24 (15.75) | |
| | | | | Sub-total of Zone-B | 601 | 8-17 (13.29) | 3.5-7 (5.38) | 9-24 (15.54) | |

Figures in parenthesis are average values

one of the factor for increasing man–animal conflict as this tree species served the food requirements of various animals including bear and birds. Hence, there is need to increase its number in the province for which afforestration on large scale has to be practiced which obviously requires knowledge on the status and distribution pattern aspect of this species. It was also observed during the survey that the sour cherry was extensively used for grafting purpose in North and Central zones. This may be the reason for less number of sour cherry trees in the said zones. The higher concentration of sour cherry trees was reported in south zone of Kashmir as per the findings of Bhat *et al.*(2007) in case of*Ulmus wallichiana*. The sweet cherry production was reported to be higher in north and central part than the southern part of the province. This means that maximum number of sour cherry trees was dedicated to the root stock in the zones where number is reported to be less. It is observed while comparing the average age among the zones that the sour cherry trees were older in south zone than the central and north part of the region. The trees existing in north zone were found to be younger than rest of the two provincial zones. The trends for growth attribute namely height and girth also followed the similar trends as that of average age parameter. It infers from the table 2that the trees found in south zone are in better condition than the rest of the zones. This is the fact that the south zone also carries higher number of trees than the north and central zones. It is observed that the distribution pattern is found to be sporadic in all the provincial zones. This may be linked to the low preference of the farming community towards the sour cherry as tree in their farm lands. But, the farmers using sour cherry as root stock due to its well adaptive and hardy behaviour for the prevailing climatic limitations. Therefore, there is need to sensitize the farmers about the significance of the sour cherry in various spheres of life predominantly climate moderation, wildlife management, biodiversity conservation and value addition to increase the economic usability of the tree in question.

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# An Analytical Study on the Tolerance Level of Livestock Owners' towards Wildlife Conflict in the Vicinity of Kalesar National Park, Haryana

**Mukesh Kumar, H.R. Meena, Pampi Paul, B.S. Meena and Ashutosh[1]**

*Dairy Extension Division, [1]Dairy Cattle Physiology, ICAR-National Dairy Research Institute, Karnal-132 001, India*
*E-mail: mukeshbhuag@gmail.com*

***Abstract*:** The emphasis on human–wildlife conflict has often been considered as a constraint to wildlife conservation, wildlife experts have highlighted their attention on minimizing negative interactions, rather than increasing positive relations between humans and wildlife. The focus of present investigation was to measure the tolerance level of livestock owners towards livestock owners-wildlife conflict situations. To identify the factors influencing tolerance among the farmers a scale was developed by following Likert's (1932) technique of scale construction. The statements were edited in the light of fourteen informal criteria suggested by Edwards (1957). On the basis of calculated 't' values for all statements, 10 statements were retained for the final scale. For present study a total 200 livestock owners from10 villages in the vicinity of national park were interviewed with the help of semi-structure interview schedule. The study found that majority (65.00%) of the respondents had medium level (2.97-3.65) of tolerance towards livestock wildlife-conflict (LWC) followed by 25 per cent high level and 10 per cent low level of tolerance. Further it was also be revealed that respondents who have avail livestock insurance scheme had more tolerance towild animals with weighted mean value of 81.70. On the basis of findings, it was concluded that need for imparting necessary training and raising awareness among the farming community in vicinity of national park for dealing the problem in an effective manner towards wildlife conservation.

***Keywords*:** Livestock, Livestock owners, Scale, Tolerance, Wildlife conflict

Human-wildlife conflict (HWC) is a multifaceted conservation issue and acknowledging the human dimensions of the problem is acute. Worldwide mammals are declining while habitat loss, habitat degradation and harvesting pose the greatest threat to mammals (IUCN, 2008) and these factors indirectly promote conflicts. As the declining wildlife habitats become smaller and fragmented, conflict between people and wildlife increases. Therefore HWC is recognized as a global priority (Manfredo, 2015) and an emerging research field (Cronin *et al.,* 2014) as it can incur major costs to rural people's livelihoods and lives, as well as reduce support for conservation projects in general (Redpath *et al.,* 2013). Crop damage by wildlife has negative impacts on rural food and livelihood security, resulting shortages of nutritional supplements and inadequate food reserves (Nyirenda *et al.,* 2013). Due to crop loss and livestock depredations, farming community developed negative perception and low tolerance towards invading wildlife species, which leads to and retaliatory injured/ killings of wildlife.

Human–wildlife interactions are defined by positive and negative impacts between human and wildlife; such events are influenced by an assessment of a situation or a previous experience (Organ *et al.,* 2006). Conflicts are real or perceived negative biological, economic, social, or political interactions between humans and wildlife (Messmer, 2009).Even when species cause conflicts, people can be tolerant toward wildlife, if species are perceived as beneficial to the personal, spiritual, cultural, economic, social, or political well-being of society (Madden, 2004). The concept of “tolerance” for a species or population has been explored in several studies focused on people's attitudes toward wildlife populations and preferences regarding wild animal's management (Naughton *et al.,* 2003; Treves, 2009; Treves & Martin, 2011). Tolerance can also be the result of adjustment for instance, when local inhabitants would be willing to accept loss caused by wildlife up to a threshold. People who do not interfere with or harm wild animals due to lack of interest, apathy, or other socio-personal and socio-cultural influences may be expressing tolerance toward and passive coexistence with wildlife. Those expressing higher levels of tolerance towards wild animal's activity also tended to seek out additional information about wild animals and wild animals natural history. Information sources, basic beliefs of people, and demographic characteristics may all affect risk perception (Siemer *et al.,* 2010) associated with anything, even risk perception can also affect tolerance for wildlife presence and activity. In general, costs associated with conservation, such as crop damage and livestock depredation by wild animals, have negative effects on local attitudes that lead to low tolerance. To contribute the future effective intervention plans and to improve the conservation

of wildlife that would be acceptable to farmers, an attempt has been made to measured livestock owners' tolerance towards wildlife with help of scale developed and validated for the present investigation.

## MATERIAL AND METHODS

The study was conducted in the vicinity of Kalesar National Park, Haryana. The park was declared as National Park on 8th December 2003 having an area of 11570 acres. On map it is located between $30^0$ 18' to $30^0$ 27' North latitude & $77^0$ 18' to $77^0$35' East longitude. In 2016, the annual two-month animal counting survey done by the Wildlife Institute of India using installed camera, found 19 species of mammalians including 42 Indian leopards were spotted at Kalesar National Park. Other animals recorded were leopard cat, rusty-spotted cat, jungle cat, Indian jackal, Asiatic elephant, chital, sambar, barking deer, goral, nilgai, Indian crested porcupine, small Indian civet, common palm civet, gray langur, rhesus macaque, Indian gray mongoose, wild pig and Indian hare. The entire National Park area is duly notified and demarcated on the ground with the help of pillars and natural boundaries like rivers and torrents.

To the North of National Parks Simbalwada Wildlife Sanctuary (Himachal Pradesh) is located, which is separated by ridge line and marked by pillars. To the East, Yamuna river makes boundary of park with Uttar Pradesh. To the South agriculture lands of villages viz., Tajewala, Araynwala, Naggal, Tiberian, Khizri, Baghpat, Khillanwala, Kansli, Darpur, Chicken, Jatanwal and Kot are situated. The western side is bounded by the crop fields of villages Faqirmajra and Ibrahimpur. Total 200 respondents from 10 villages (20 respondents from each village) were interviewed with the help of semi structure interviewand the method of summated rating suggested by Likert (1932) and Edwards (1957) was followed in the development of tolerance scale. The following steps were considered for construction of tolerance scale.

**Collection of statements**

Statements related to tolerance were collected by referring literatures and consulting specialists in the areas of Agriculture wildlife conservation, forest officers, wildlife inspector and progressive farmers.

**Editing**

Editing was done by following 14 informal criteria suggested by Edwards (1957) and17 statements were considered for final scale

**Response to raw statements**

17 raw statements on five point continuums i.e., strongly agree, agree, undecided, disagree and strongly disagree was sent to 50 experts and response of 32 experts were restrained for final calculation as it were unambiguous and meaningful.

**Item analysis**

Analysis of item was done based on the reply of the experts and their degree of agreement or disagreement for each statement

**Calculation of 't' values**

Calculation of t values for each statement was done by following the formula** given by Edwards (1957).

**Standardization of the scale**

To standardize the scale reliability and validity was measured by split half method and content validity respectively.

**Administration of the scale**

The final scale consisting of 10 statements were administered to the livestock owners on a five continuums viz., High Tolerable (HT), Mild Tolerable (MT), Undecided (UD),LoT (Low Tolerable) and Least Tolerable (LeT) with a score of 5,4,3,2 and 1, respectively for positive statements and for negative statements vice-versa.

$$**t = \frac{\bar{X}_H - \bar{X}_L}{\sqrt{\frac{\sum_{i=1}^{n}(X_H - \bar{X}_H)^2 + \sum_{i=1}^{n}(X_L - \bar{X}_L)^2}{n(n-1)}}}$$

Where,

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

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

$\bar{X}_H$ = The mean score on a given statement for the high group;

$\bar{X}_L$ = The mean score on a given statement for the low group;

$\Sigma X_H^2$= Sum of squares of the individual score on a given statement for high group

$\Sigma X_L^2$ = Sum of squares of the individual score on a given statement for low group

$\Sigma X_H$ =Summation of scores on given statement for high group

$\Sigma X_L$ = Summation of scores on given statement for low group

n = Number of subject in low and high group

t =The extent to which a given statement differentiate between the high and low group.

$\Sigma$ = Summation

The 't' value is a measure of the extent to which a given statement differentiates between the high and low groups. As a crude and approximate rule of thumb, we may regard any't' value equal to or greater than 1.75 as indicating that the average response of high and low groups to a statement differs significantly. Thus, 10 (8 positive and 2 negative) statements for measuring the livestock owners tolerance towards wildlife with significant't' values were retained for the final scale. To standardize the scale, reliability and validity was measured through spilt half and content validity method, respectively (Table 1).

## RESULTS AND DISCUSSION

Livestock owners tolerance towards wildlife: Based on the Likerts' method tolerance scale was developed, validated and finally response from livestock owners were taken in five point continuum such as high tolerant (HT), mild TOLERANT (MT), undecided (UD), low tolerant (LoT) and least tolerant (LeT). The data presented in table 2 indicated that 48.50 per cent of the respondents highly agreed with statement that when farmers avail livestock insurance scheme, they become more tolerance towards wildlife harm to their livestock followed by 43.5 per cent agreed with statement that when farmers avail agriculture insurance scheme, they become more tolerance towards wildlife, an equally 36 per cent of the respondents agreed with statement that farmers having alternate sources of income are more tolerant than single source of income (agriculture and / or dairy); surety of compensation and its easy process increase the tolerance towards wildlife menace, whereas, low to least tolerance were found with statement that farmers intolerable towards wildlife depredation especially to highly symbolic large dairy animals and agricultural depredation by wildlife create high intolerance among farmers. It was also observed that around 20 per cent of the respondents were undecided with same statement about livestock owner's wildlife conflicts as indicated in the same table. If developmental agencies particularly forest department educate farmers about the need and importance of wildlife they may become highly tolerant towards the wildlife, and play crucial role in conversation of wildlife in national parks.

**Categorization of livestock owners' based on the level of tolerance:** Based on the mean value of level of tolerance the respondents were classified in three (low, medium and high)

**Table 1.** A list of selected statements for final scale construction with their respective 't' values

| S.N | Statement | t-value |
|---|---|---|
| 1 | I believe that farmers who have more landholding; also possess high level of tolerance towards wildlife | 2.71 |
| 2 | I feel that when farmers avail agriculture insurance scheme, they become more tolerance towards wildlife | 1.94 |
| 3 | I feel that when farmers avail livestock insurance scheme, they become more tolerance towards wildlife harm to their livestock | 2.47 |
| 4 | The farmers having alternate sources of income are more tolerant than single source of income (agriculture and or dairy) | 3.06 |
| 5* | Agricultural depredation by wildlife create high intolerance among farmers | 2.07 |
| 6* | Farmers intolerable towards wildlife depredation especially to highly symbolic large dairy animals | 1.85 |
| 7 | Farmer tolerate the ordinary safety hazards associated with some wildlife | 3.31 |
| 8 | I believe that surety of compensation and its easy process; increase the tolerance towards wildlife menace | 2.15 |
| 9 | Economic benefits/ Social beliefs about the value of wildlife; improve the tolerance among farming community | 4.08 |
| 10 | In my view tolerance was linked to guarding and watching services | 1.86 |

*= Indicate Negative Statement

categories and the result presented in table 3 indicated that majority (65.00%) of the respondents fall in medium level (2.97-3.65) of tolerance towards livestock owners' wildlife conflict (LWC). Whereas, only 10 per cent respondents had high level of tolerance and 25 per cent possess low level of tolerance towards wildlife conflict. The finding is supported by the study of Senthil *et al.* (2016) from buffer zone of Tamil Nadu as the majority (61.70%) of the farmers had medium level of tolerance towards human-wildlife conflict (HWC). It can be interpreted from the findings that majority of the farmers fall in medium categories of tolerance which need to be more awareness about importance of wildlife, surety of compensation and its easy process and agriculture/ livestock insurance scheme. The developmental agencies should make plan for awareness campaigns and capacity building of farming community for their active participation in wildlife conservation.

**Respondents overall level of tolerance:** The data depicted in figure 1 indicated that respondents have higher tolerance towards wildlife depredation when farmers ensured their

**Table 2.** Distribution of respondents according to Tolerance towards wildlife conflict

| S.N. | Statement | HT | MT | UD | Lo T | LeT |
|---|---|---|---|---|---|---|
| 1 | I believe that farmers who have more landholding; also possess high level of tolerance towards wildlife | 27.00 | 20.50 | 21.50 | 30.50 | 0.50 |
| 2 | I feel that when farmers avail agriculture insurance scheme, they become more tolerance towards wildlife | 43.50 | 24.00 | 22.50 | 10.00 | 0.00 |
| 3 | I feel that when farmers avail livestock insurance scheme, they become more tolerance towards wildlife harm to their livestock | 48.50 | 23.50 | 17.50 | 9.50 | 1.00 |
| 4 | The farmers having alternate sources of income are more tolerant than single source of income (agriculture and or dairy) | 36.00 | 26.00 | 21.00 | 16.50 | 0.50 |
| 5* | Agricultural depredation by wildlife create high intolerance among farmers | 0.00 | 2.00 | 20.00 | 43.00 | 35.00 |
| 6* | Farmers intolerable towards wildlife depredation especially to highly symbolic large dairy animals | 0.00 | 1.50 | 10.00 | 51.50 | 37.00 |
| 7 | Farmer tolerate the ordinary safety hazards associated with some wildlife | 20.50 | 12.00 | 22.50 | 40.50 | 4.50 |
| 8 | I believe that surety of compensation and its easy process; increase the tolerance towards wildlife menace | 36.00 | 22.00 | 20.50 | 21.50 | 0.00 |
| 9 | Economic benefits/ Social beliefs about the value of wildlife; improve the tolerance among farming community | 4.50 | 21.00 | 23.00 | 39.00 | 12.50 |
| 10 | In my view tolerance was linked to guarding and watching services | 30.50 | 15.00 | 20.50 | 27.50 | 6.50 |

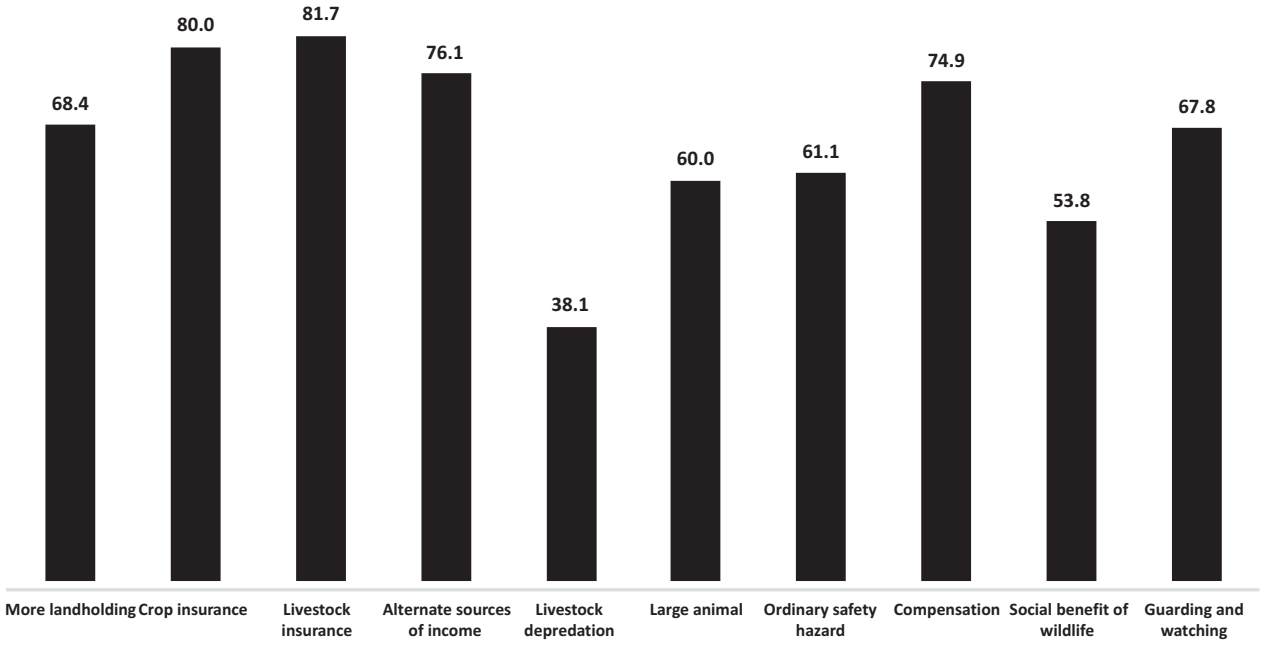


**Fig. 1.** Overall level of tolerance towards LWC

**Table 3.** Distribution of Livestock owners' according to tolerance towards LWC

| Level of tolerance (range) | Frequency | Per centage |
|---|---|---|
| Low (<2.97) | 50 | 25.00 |
| Medium (2.97-3.65) | 130 | 65.00 |
| High (>3.65) | 20 | 10.00 |

crops and livestock through insurance scheme; multiple sources of farmer income and surety of compensation and its easy process. While farmers were expressing more intolerance when animal depredation used to cause by the wild animals or when social beliefs about the value of wildlife and wildlife depredation especially for highly symbolic large dairy animals. It can be concluded from the findings that developmental agencies should motivated farming community of crop and livestock insurance and diversification of farm income.

## CONCLUSION

In the villages of vicinity of national park mixed farming practices was predominant. In various occasion conflicts between farming community and national park authority can be seen due to crop loss or livestock depredation by the wild animal and vice versa. An attempt has been made to measure livestock owners' tolerance with the help of a statistical device (tolerance scale) has been developed and validated. The finding of the study revealed that 48.50 per cent of respondents were **highly tolerable as they** have availed livestock insurance and the farmers who have ensured their crop by crop insurance scheme were more tolerant (43.50 %). The respondents were classified in three categories and the result indicated that majority (65%) of the respondents fall in medium (2.97-3.65) level categories followed by 10 per cent high level and 25 per cent low level of tolerance categories. Livestock owners' level of tolerance for wildlife and their support to conservation, risk diminishing due to disagreement between actual and perceived wildlife crop damage may be minimized through various strategies i.e., data driven planning and implementation of interventions, facilitating collective action by farming community, targeted environmental education and awareness creation, resolving human-wildlife conflicts through village committee, capacity building of farmers and wildlife inspectors/ guards through facilitated trainings and infrastructure such as wildlife restraining solar powered electric fences, and rational financial incentives.

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# Survey and Screening of Quantitative Trait Loci (QTL) Associated with Early Stage Cold Tolerance in Different Genotypes of Rice (*Oryza sativa L.*)

**Ashutosh Gautam, J. Suresh and M.S. Madhav[1]**

*Department of Genetics and Plant Breeding, Acharya N.G. Ranga Agricultural University, Hyderabad-522 034, India*
*[1]Department of Biotechnology, Directorate of Rice Research, Hyderabad-522 034, India*
*Email: ashutoshgtm9@gmail.com*

***Abstract:*** **A** study was conducted in 2013-14 to survey 37 QTLs using 84 SSR markers and have screened 14 QTLs, which are strongly associated with development of early stage cold tolerance in rice. Out of 52 rice genotypes studied, 13 genotypes had shown higher ability to overcome the cold stress and BR-11 which had shown presence of five QTLs. Out of 14 screened QTL, qCSH2 was present in five genotypes and contribute 16.6 per cent to cold stress tolerance.

***Keywords***: Rice, Cold tolerance, Germination, Screening, SSR, QTLs

Rice is cultivated around the globe in more than 100 countries, except for region of Antarctica, but more than 90% of world's rice is grown and consumed in Asia, of which about 55% accounted for by China, Taiwan and India alone. Like all other crops rice too suffers stress conditions caused by various biotic factors and abiotic factors. Among abiotic factors, the yield loss in rice due to cold or low temperature stress is about 45% at global level (Lafitte *et al.,* 2004). Low-temperature stress is common for rice (*Oryza sativa* L.) cultivated in temperate zones and high-elevation environments. An important breeding objective of these regions is to develop cultivars tolerant to low temperatures at critical growth stages (Nakagahra *et al*., 1997). The low temperature effects on seedlings can be manifested as poor germination, slow growth, discolouration or yellowing, withering after transplanting, reduced tillering and stunted growth.

To encounter the problem of yield loss due to low temperature, there have been various tactics in plant breeding and QTL approach is one of them. To date, QTLs for cold tolerance have been reported in all chromosome of rice, except for chromosome 10. QTLs which contribute 20% or more to phenotypic variability have been found very suitable to develop tolerance against cold stress. Present was conducted in 2013-14 to screen out the major QTL contributing to cold tolerance in early stage.

## MATERIAL AND METHODS

In this study, three parameters for defining the cold stress tolerance *viz.* germination after 5 days of sowing, seedling colour and seedling height after cold shock were taken in the account. Fifty two different genotypes of rice collected from ICAR-DRR (Directorate of Rice Research) Farm, located at ICRISAT (Hyderabad) were used in the study. These are grown extensively across Andhra Pradesh and India. Among these 52 genotypes, IR-28 and IR-50 were used as resistant and susceptible checks, respectively, for identification of QTLs on some particular chromosomes.

**Survey and screening of QTLs and Selection of SSR markers:** To identify the presence of QTLs we have used 84 SSR markers, 1-5 internal SSR markers were selected between the flanking regions of all the QTLs. For this purpose Rice TOGO Browser software was used. These internal markers were if more than one, then selected at uniform distances between the two flanking markers. Wherever the physical distance between flanking markers was less than 1 Mb, in that case only one interval marker was selected at intermediate distance.

**Phenotypic evaluation of selected genotypes:** Hundred healthy seeds of each genotype were subjected to germination in petri dishes. After five days of sowing, seedlings were given cold shock treatment using fully automated germinator (INDOSAN, single chamber type); this germinator has a programme of 24 hours, which is to be

**Table 1.** Programme of INDOSAN single chamber seed germinator

| Temperature | Treatment hours | Time | Photo-cyclic time |
|---|---|---|---|
| 8°C | 6 | 00:00 to 06:00 | Night |
| 10° C | 6 | 06:00 to 12:00 | Day |
| 10° C | 6 | 12:00 to 18:00 | Day |
| 8° C | 6 | 18:00 to 00:00 | Night |

specified for every 6 hours. After 7 days of cold shock treatment, seedlings were analyzed for germination, seedling height and colour. Based on these three parameters scoring was done and five groups of genotypes were formed *viz.* resistant, moderately resistant, moderately susceptible, susceptible highly susceptible. Genotypes with germination above 90%, dark green colour and seedling length 11 cm after cold shock were considered as resistant.

**Polymorphism in genotypes and molecular analysis:** The reference check was run with all resistant genotype (on the basis of results of phenotypic results) using 3% agarose gel (HiMedia) to identify the presence of cold tolerance QTL on particular chromosome. Seedlings of each genotype were grown separately as material for the DNA isolation. Samples of 10-15 grams were collected from the 5 days old seedlings for each genotype and were used for extraction of DNA. Genomic DNA was extracted from the samples taken from the seedlings using Cetyl trimethyl-ammonium bromide (CTAB) method. Extracted DNA samples were run through 0.8% agarose gel (0.5 X TBE) and after series of dilutions all samples were brought to uniform concentration of 20-25 ng/µl and these samples were tested for amplification using primers and run through 1% agarose gel (0.5 X TBE). First we have run the genomic DNA with reported flanking markers. If both flanking markers have shown their presence in particular genotype then we have to run the selected interval markers.

## RESULTS AND DISCUSSION

In this study, 30 genotypes have shown a germination of

**Table 2.** Genotype wise germination per cent, seedling height, seedling colour and score

| Genotypes | Germination % | Seedling mean | Seedling Colour | Score | S. No. | Genotypes | Germination % | Seedling mean | Seedling colour | Score |
|---|---|---|---|---|---|---|---|---|---|---|
| Tellahamsa | 89 | 10.9 | Dark green | 1 | 26 | Vandana | 81 | 14.3 | Light green | 3 |
| IR-28# | 90 | 15.1 | Dark green | 1 | 27 | Deshidhan | 39 | 10.4 | Light green | 3 |
| P-16 | 63 | 10.3 | Light green | 3 | 28 | VL-61 | 79 | 10.6 | Light green | 3 |
| HPR-2143 | 72 | 10.7 | Light green | 3 | 29 | VL-65 | 80 | 10.2 | Light green | 3 |
| RP-2421 | 84 | 12.2 | Light green | 3 | 30 | HUR-105 | 85 | 12.6 | Dark green | 1 |
| Annada | 87 | 11.2 | Dark green | 1 | 31 | Erramallelu | 72 | 8.1 | Light green | 3 |
| Anjali | 85 | 11.6 | Light green | 3 | 32 | Hira | 37 | 7.2 | Brown | 7 |
| VL-221 | 89 | 13.2 | Dark green | 1 | 33 | GS-3 | 33 | 5.5 | Dead | 9 |
| K-475 | 79 | 8.2 | Yellow | 5 | 34 | Vikas | 67 | 8.3 | Brown | 7 |
| Porichaya Boro | 88 | 13.6 | Dark green | 1 | 35 | P-47 | 76 | 7.8 | Brown | 7 |
| VLD-82 | 81 | 10.6 | Light green | 3 | 36 | Begami | 47 | 6.3 | Dead | 9 |
| VD-82 | 83 | 11.3 | Light green | 3 | 37 | Varalu | 78 | 6.4 | Yellow | 5 |
| Lahi Boro | 84 | 11.8 | Light green | 3 | 38 | Matali | 46 | 5.8 | Dead | 9 |
| K-332 | 81 | 13.2 | Dark green | 1 | 39 | GS-2 | 49 | 6.2 | Brown | 7 |
| NDR-97 | 83 | 11.3 | Light green | 3 | 40 | P-48 | 65 | 8.7 | Dead | 9 |
| Mokon Boro | 84 | 14.7 | Dark green | 1 | 41 | IR-64 | 78 | 9.6 | Light green | 3 |
| Govind | 76 | 9.3 | Yellow | 5 | 42 | Deval | 37 | 6.4 | Brown | 7 |
| Khiya boro | 86 | 15.2 | Dark green | 1 | 43 | Krishnahamsa | 87 | 11.3 | Dark green | 1 |
| MTU-1010 | 69 | 7.8 | Yellow | 5 | 44 | P-52 | 86 | 9.8 | Light green | 3 |
| BR-11 | 82 | 11.5 | Dark green | 1 | 45 | Sasyasree | 89 | 10.6 | Dark green | 1 |
| P-7 | 79 | 11.7 | Yellow | 5 | 46 | Kalinga-2 | 80 | 11.7 | Yellow | 5 |
| Bhrigudhan | 82 | 10.6 | Light green | 3 | 47 | Rasi | 90 | 11.8 | Dark green | 1 |
| Pankaj | 49 | 8.1 | Yellow | 5 | 48 | Sukardhan | 82 | 10.3 | Light green | 3 |
| GS-1 | 42 | 5.3 | Yellow | 5 | 49 | Tulasi | 41 | 6.3 | Yellow | 5 |
| Jattoo | 38 | 5.2 | Brown | 7 | 50 | IR-50* | 43 | 7.8 | Brown | 7 |
| P-43 | 68 | 11.7 | Yellow | 5 | 52 | Kola Boro | 71 | 9.2 | Yellow | 5 |

#Resistant check, *Susceptible check

**Scoring and specification:**

1= Resistance (dark green seedling), 3= Tolerant (light green seedling), 5= Moderately tolerant (yellow seedling)
7= Susceptible (brown seedling), 9= Highly susceptible (dead seedling)

80% or above along with a minimum 10 cm mean height of seedling and the score obtained by these genotypes were 1 and 3. Only 13 genotypes got score 1 and showing dark green colour of seedling, 17 genotypes scored 3, 11 genotypes scored 5, 7 genotypes scored 7 and 4 genotypes scored 9. IR-28 was among the genotypes, which got the score 1 and it also reported cold tolerant line while IR-50 got score 9 and it has already been reported as highly cold stress susceptible line. There were four genotypes namely GS-3, Matali, Begami and P-48, which could not stand cold treatment and died when exposed to low temperature.

Wu *et al.* (1997) while working on fab1 mutant of *Arabidopsis thaliana* showed that the low temperature in range of 6°C to 8°C allowed the saturation of membrane fatty acids and resulted in loss of fluidity of plasma membrane and gradually caused the death of plant. Thomashow (2001) gave the similar reason for the chilling injury to plants while working on cold acclimation. Germination of resistant genotypes i.e. with score 1 was in a range of 81-90% and mean seedling height was in a range of 10.9-15.2 cm and colour was dark green. Minimum germination and seedling height in these resistant genotypes was shown by K-332 and Sasyasree, respectively. Two genotypes namely IR-28 and Rasi had shown germination of 90%, which is considered excellent performance under cold stress conditions, IR-28 also showed the seedling mean height of 15.1 cm, which depicted the highly degree of resistance against cold stress. Similar results were obtained by Gonzales (1996) while working on stress tolerance in local rice germplasm in China.

Eleven genotypes have shown confirmed presence of QTLs and qCSH2 was present in five genotypes. QTL qCSH2 contribute 16.6 per cent in cold stress tolerance in rice (Han *et al.*, 2007) and is present on chromosome 2. Another QTL, qGR-1showed its presence in two genotypes

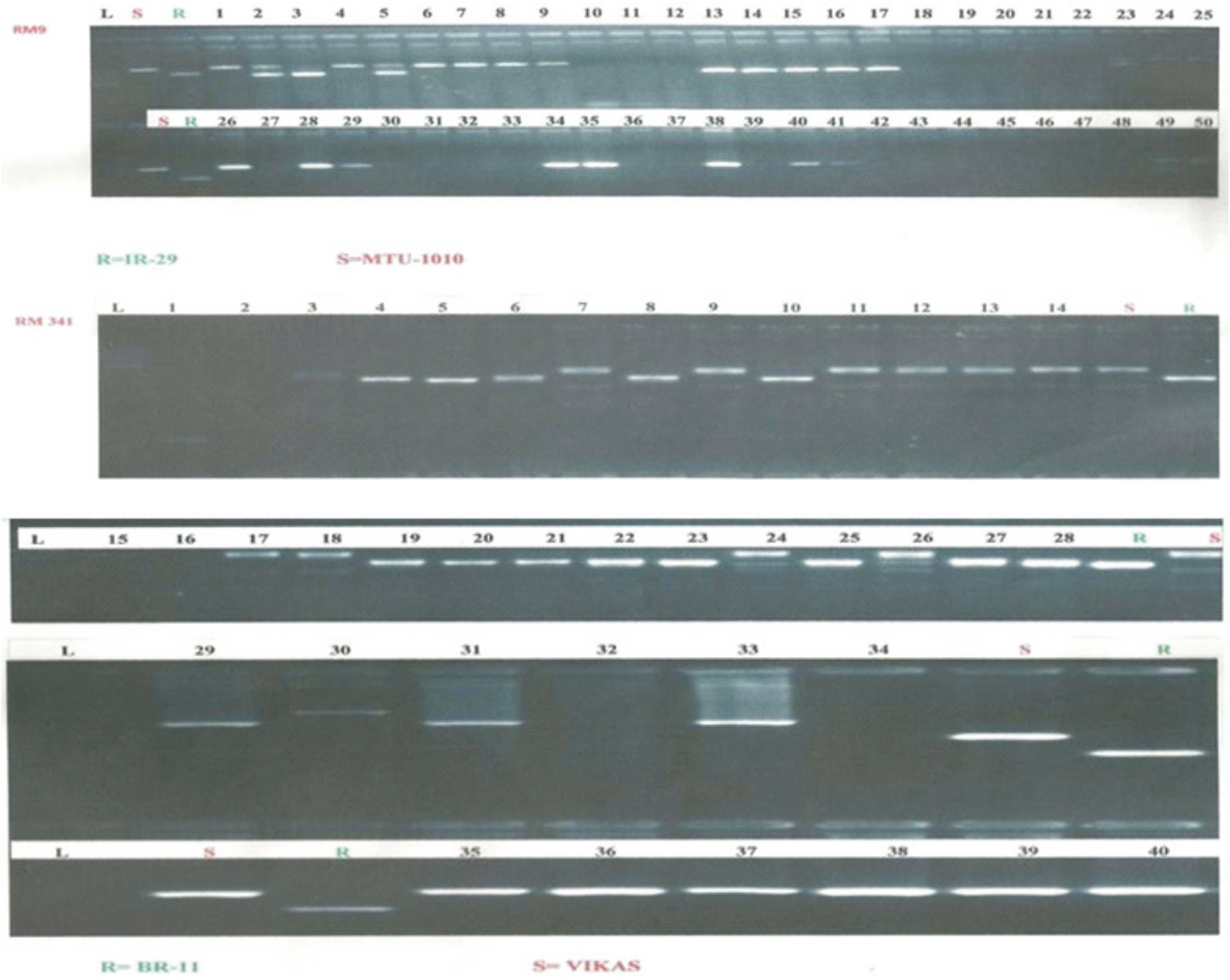


**Fig. 1.** Agarose gel electrophoresis for flanking markers RM9-RM341

**Table 3.** SSR markers shown strong association with cold tolerance

| SSR marker | Chr. | Physical location (Mb) | Stage | SSR marker | Chr. | Physical location (Mb) | Stage |
|---|---|---|---|---|---|---|---|
| RM 9 | 1 | 23.32 | Germination | RM 335 | 4 | 0.6 | Seedling and vegetative |
| RM 7075 | 1 | 15.12 | Germination | RM 261 | 4 | 6.5 | Seedling and vegetative |
| RM 11099 | 1 | 27.71 | Germination | RM 528 | 6 | 26.17 | Germination |
| RM 262 | 2 | 21.6 | Seedling | RM 340 | 6 | 28.21 | Germination |
| RM 263 | 2 | 26.75 | Seedling | RM 11 | 7 | 19.91 | Bud bursting |
| RM 3688 | 2 | 23.25 | Seedling | RM2752 | 7 | 23.20 | Bud bursting |
| RM 341 | 3 | 20.19 | Seedling | RM 1377 | 7 | 13.44 | Reproductive |
| RM13314 | 3 | 19.87 | Seedling | RM3767 | 7 | 9.07 | Seedling |
| RM 3719 | 3 | 34.42 | Booting | RM21393 | 7 | 11.04 | Seedling |
| RM16015 | 3 | 33.33 | Booting | RM 6356 | 8 | 1.55 | Germination |
| RM 569 | 3 | 18.89 | Reproductive | RM 22491 | 8 | 4.49 | Germination |
| RM231 | 3 | 24.53 | Reproductive | RM26281 | 11 | 6.47 | Seedling and Germination |

*viz.*, IR-28 and P-16 it provides cold tolerance at germination stage of rice. It is dispersed on chromosome 1 between RM9 and RM 7075 at a map distance of 45.8 Cm (Wang *et al.,* 2010). Among other confirmed QTLs, qPSST-3, qCTS4-1and qPSST-7 are other important one which showed their presence on total 4, 3 and 4 genotypes, respectively. Q PSST-7 provides cold tolerance at seedling as well as reproductive stage (Suh *et al.*, 2012).

Seedling height, colour and germination are three major parameters for cold stress tolerance in the early stage of rice. Farrell *et al.* (2006) reported that cold stress significantly reduced seedling height development, which is one of the most important criterions of cold tolerance. Out of 84 SSR markers used in the study, only 24 SSR markers have shown strong association with cold tolerance. Among these, 24 SSR markers 18 were closely associated with cold stress tolerance at germination/seedling stage.

## CONCLUSIONS

Out of fifty two genotypes used in our study, only thirteen genotypes have shown tolerance to cold stress in the early stage. Out of 84 SSR used to confirm the presence of QTLs and association of genomic SSR with cold tolerance, only 18 were found to have strong association with cold stress tolerance at germination and/or seedling stage. We have surveyed 37 QTLs and 14 among them were present in tolerant genotypes.

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# Genetic Diversity within Commercialized Paddy (*Oryza Sativa* L.) Cultivars

**Pradip Kumar and G. Singh**

*Department of Genetics and Plant Breeding, PG College, Ghazipur-233 001,India*
*VBS Purvanchal University, Jaunpur-222 001, India*
*E-mail: pk_dwr@yahoo.co.in*

***Abstract***: A set of thirty rice high yielding genotypes were evaluated to study the genetic diversity for yield and quality contributing traits. These genotypes were grouped into six clusters, 13 genotypes were grouped in cluster II but cluster I comprised of only two genotypes. Maximum inter cluster $D^2$ value was observed between cluster I and V (915) followed by cluster III and V (862). The greater distance between two clusters can be used in rice hybridization programme for improving grain yield. Maximum intra-cluster distance was observed in cluster VI indicating greater genetic divergence between the genotypes belonging to this cluster. Days to 50% flowering, 1000-grain weight, decorticated grain length, decorticated grain length-breadth ratio, elongation ratio, alkali spreading value contributed 92.05% of total divergence.

***Keywords***: Cluster analysis, Crop diversity, Genetic variability, Rice

Rice is one of the most important food crop and a primary food source for more than one third of world's population. In order to meet the food requirement of growing population, development of high yielding varieties is essential. The parents involved in the development of varieties should be divergent. The germplasm provides immense scope for wide variability. Genetic divergence is an efficient tool for an effective choice of parents for hybridization programme. Such study also selects the genetically divergent parents to obtain desirable combinations in the segregating generations. Diverse growing conditions have led to immense variability among rice cultivars. Initiation of a hybridization programme for improvement of rice requires knowledge of genetic diversity in order to get greatest likelihood of recovering promising segregants. Nevertheless, this beginning information (genetic variability) criterion cannot be successfully used for discrimination between parents without knowledge of genetic divergence (Ahmed and Borah, 1999). Selection of parents based on the extent of genetic diversity has been successfully used in different crops. Hence, the present investigation was carried out to ascertain the value and magnitude of genetic diversity among a set recently released or high yielding rice genotypes. The present study was focused to assess the genetic diversity of 30 promising rice genotypes using Mahalanobis $D^2$ statistics.

## MATERIAL AND METHODS

Thirty genetically diverse genotypes (Table 1) across the India collected from IARI, Regional Station, Karnal, Haryana were used for the present study during the *kharif* seasons of 2011 and 2012 at the experimental farm of Post Graduate College Ghazipur, Uttar Pradesh, India. The experiment was arranged in a randomized complete-block design with two replications, using 20 x 20 cm spacing, in six-row plots of 3.2 m row length. The recommended agronomical practices and plant protection measures were followed to ensure a normal crop. Observations were recorded on five randomly selected plants in each replication from the four central rows on various variables (Table 3). The data from the two years were pooled in the analysis. Mahalanobis $D^2$ analysis (Mahalanobis, 1936) was used to estimate genetic divergence among the 30 genotypes. Grouping of genotypes into clusters were carried out following Euclidean²: Cluster Distances: Ward Mean values of the variables, calculated based on measurements on plants from blocks and years for each genotype, were used in the cluster analysis.

## RESULTS AND DISCUSSION

Analysis of variance showed differences among the genotypes for nineteen quantitative characters and high variability (Fig. 1). Based on $D^2$ value, 30 genotypes were grouped into six clusters (Table 1). So, Via Mahalanobs $D^2$ methods, 30 genotypes were grouped into six clusters. Cluster II comprised of 13 genotypes; whereas, cluster III comprised of five genotypes and cluster IV comprised of four genotypes. Clusters V and VI had three genotypes each, whereas cluster I had two genotypes only. Genotypes from different states were grouped in the same cluster, as revealed by clusters I, II, III and VI (Table 1). This suggested that geographical distribution did not necessarily determine genetic divergence; similar finding also reported by Rathore

*et al*. (2001). The possible reason for grouping of genotypes of different states in one cluster could be the free exchange of germplasm among the breeders of different regions, or unidirectional selection practiced by breeder in tailoring the promising cultivars for different regions. On the other hand, our study has also revealed the existence of genetic diversity within the same state, because genotypes from the same state were distributed across clusters. Among the selected genotypes, a rather small level of genetic divergence in yield was detected.

In the present finding, the first three clusters (1-3) having non basmati genotypes, whereas, last three clusters (4-6) having basmati genotypes; except Heera variety in cluster VI (non basmati). The basmati genotypes are more distantly related with the non-basmati type in comparison within both groups. Group 1 having short grains, 2 having long grains, group 4, 5 and 6 having extra long grains, while group 3 having short, medium and long grains varieties (Table 1).

The maximum inter-cluster $D^2$ values were between clusters I and V (915) followed by clusters III and V (862), I and IV (694), III and IV (514). Hybridization between divergent parents is likely to produce wide variability and transgressive segregations with high heterotic effects, similar recommendations were also made by Rao and Gomanthinayagam (1997). The minimum $D^2$ value are obtained between cluster IV and V (214), followed by IV and VI (244), II and VI (283) (Table 2). The smallest inter-cluster

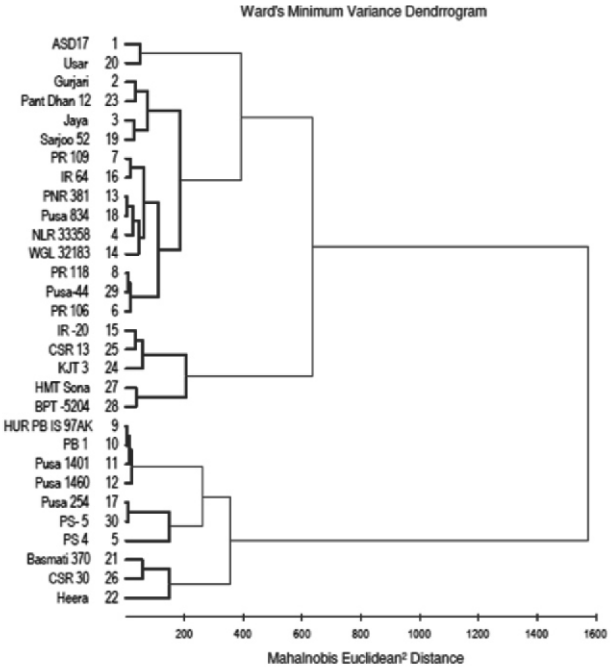


**Fig. 1.** Dendrrogram showing genetic distance between genotypes

distance was observed between clusters IV and V (213) followed by clusters IV and VI (244) indicating wider genetic diversity among the genotypes between these groups (Subudhi *et al*., 2009). The lines belonging minimum $D^2$ value of the clusters were relatively closer to each other, in

**Table 1.** Clustering pattern of 30 promising rice genotypes across the India

| Cluster | Genotypes | Name of entry | Origins | Grain colour | Grain type |
|---|---|---|---|---|---|
| I | 2 | ASD17 | Tamil Nadu | Red | Short Bold |
| | | Usar | Uttar Pradesh | Light Brown | Short Bold |
| II | 13 | Gurjari | Gujarat | Light Brown | Long Bold |
| | | Pant Dhan 12 | Uttar Pradesh | Light Brown | Long Bold |
| | | Jaya | DRR, Hyderabad | Light Brown | Long Bold |
| | | Sarjoo 52 | Uttar Pradesh | Light Brown | Long Bold |
| | | PR 109 | PAU, Ludhiana, Punjab | Light Brown | Long Slender |
| | | IR 64 | IRRI | Light Brown | Long Slender |
| | | PNR 381 | IARI, New Delhi | Light Brown | Long Slender |
| | | Pusa 834 | IARI, New Delhi | Light Brown | Long Slender |
| | | NLR 33358 | Andhra Pradesh | Light Brown | Long Bold |
| | | WGL 32183 | Warangal, Andhra Pradesh | Light Brown | Long Slender |
| | | PR 118 | PAU, Ludhiana, Punjab | Light Brown | Long Bold |
| | | Pusa-44 | IARI, New Delhi | Light Brown | Long Slender |
| | | PR 106 | PAU, Ludhiana, Punjab | Light Brown | Long Slender |
| III | 5 | IR -20 | IRRI | Light Brown | Medium Slender |
| | | CSR 13 | CSSRI, Karnal, Haryana | Light Brown | Long Slender |
| | | KJT 3 | Karjat | Light Brown | Short Bold |
| | | HMT Sona | Maharashtra | Light Brown | Short Slender |
| | | BPT -5204 | Bapatla, Andhra Pradesh | Light Brown | Medium Slender |
| IV | 4 | HURPB97AK | BHU, Varanasi | Light Brown | Extra Long Slender |
| | | PB 1, Pusa 1401, Pusa 1460 | IARI, New Delhi | Light Brown | Extra Long Slender |
| V | 3 | Pusa 254, PS- 5, PS 4 | IARI, New Delhi | Light Brown | Extra Long Slender |
| VI | 3 | Basmati 370 | IARI, New Delhi | Light Brown | Extra Long Slender |
| | | CSR 30 | CSSRI, Karnal, Haryana | Light Brown | Extra Long Slender |
| | | Heera | CRRI, Cuttack, Orissa | Light Brown | Long Slender |

comparison to lines grouped in maximum $D^2$ value of clusters. The largest intra-cluster distance was recorded for cluster VI (202) followed by clusters III (163), V (156), II (100), I (99) and IV (22); the lines included in clusters III, V and VI were relatively more diverse than those in the other clusters (Table 2). Therefore, varieties originating from same place may have different genetic architecture or vice-versa. Statistical distances represent the index of genetic diversity among the clusters. The inter-cluster distances in all of the cases were higher than the intra-cluster distances suggesting wider genetic diversity among the genotypes of different groups (Table 1).

Most of the characters showed distinct differences among the clusters (Table 3). Among the traits studied, cluster mean of days to fifty percent flowering was highest for cluster III (116) and lowest for cluster VI (93). Plant height was highest for cluster I (130) and lowest for cluster III (87).

For penultimate leaf length cluster mean was highest for cluster I (46) and lowest for cluster IV (43). Cluster V (27) had highest cluster mean value of 1000 grains weight whereas, cluster III (17) exhibit lowest value. Cluster III (192) had highest cluster mean value of grains per panicle whereas, cluster VI (99) exhibited lowest value. The highest cluster mean of plot yield was exhibited by cluster I (2.83) and lowest cluster mean value was observed for cluster VI (1.66). Hence, selection within these clusters may be exercised based on the highest areas for the desirable traits, which would be made use of line in improvement through inter-varietal hybridization (Joshi *et al*., 2008).

For quality characters, highest mean value was for the decorticated grain length in cluster V (8.9) and lowest for the cluster I (5.6) whereas, for L/ B ratio of highest cluster mean was shown in cluster IV (4.69) and lowest for cluster I (2.13). The highest cluster mean for elongation ratio was shown by cluster IV (1.77) and lowest value recorded for cluster II (1.56). The cluster IV (6.46) had highest cluster mean value

**Table 2.** Average intra and inter-cluster values of yield and quality characters of 30 genotypes

| | Cluster 1 | Cluster 2 | Cluster 3 | Cluster 4 | Cluster 5 | Cluster 6 |
|---|---|---|---|---|---|---|
| Cluster 1 | 98.923 | 298.479 | 418.573 | 694.255 | 915.152 | 459.649 |
| Cluster 2 | | 100.488 | 287.117 | 312.909 | 408.038 | 282.866 |
| Cluster 3 | | | 163.91 | 514.132 | 861.784 | 483.135 |
| Cluster 4 | | | | 22.063 | 213.594 | 243.578 |
| Cluster 5 | | | | | 156.43 | 379.557 |
| Cluster 6 | | | | | | 202.344 |

**Table 3.** Cluster mean of different yield and yield contributing characters as well as quality characters in 30 rice genotypes

| Characters | Cluster1 | Cluster2 | Cluster3 | Cluster4 | Cluster5 | Cluster6 | Characters mean |
|---|---|---|---|---|---|---|---|
| Penultimate leaf length (cm) | 46.42 | 43.23 | 44.30 | 42.79 | 46.27 | 44.69 | 44.01 |
| Days to 50% flowering | 99.79 | 103.34 | 115.95 | 106.67 | 100.53 | 93.00 | 104.33 |
| Plant height (cm) | 130.44 | 90.81 | 86.95 | 94.14 | 102.06 | 113.67 | 96.66 |
| Panicle length (cm) | 24.14 | 24.94 | 24.00 | 28.18 | 27.89 | 26.02 | 25.56 |
| Effective tillers/ plant | 12.20 | 11.07 | 13.20 | 12.37 | 10.55 | 14.06 | 11.92 |
| Days to maturity | 123.42 | 126.21 | 138.07 | 128.48 | 123.11 | 117.08 | 127.08 |
| Fertile grains/ panicle | 171.94 | 159.42 | 192.08 | 116.46 | 135.50 | 98.68 | 151.50 |
| Spikelet's / panicle | 201.43 | 203.12 | 235.99 | 163.49 | 166.71 | 115.40 | 190.79 |
| 1000 grains weight (gm) | 23.25 | 24.21 | 17.57 | 20.66 | 27.46 | 22.59 | 22.73 |
| Yield (kg/plot) | 2.83 | 2.67 | 2.66 | 1.86 | 2.24 | 1.66 | 2.43 |
| Yield (gm/plant) | 32.53 | 30.54 | 30.60 | 21.18 | 25.73 | 18.99 | 27.80 |
| Grain length (mm) | 7.98 | 9.30 | 8.23 | 10.79 | 11.55 | 9.90 | 9.52 |
| Grain width (mm) | 3.01 | 2.63 | 2.29 | 2.12 | 2.38 | 2.29 | 2.47 |
| Decorticated grain length (mm) | 5.56 | 6.80 | 5.86 | 8.22 | 8.92 | 7.55 | 7.04 |
| Decorticated grain width (mm) | 2.61 | 2.29 | 2.00 | 1.76 | 2.02 | 1.95 | 2.13 |
| Decorticated grain L/B ratio | 2.13 | 2.99 | 2.99 | 4.69 | 4.42 | 3.90 | 3.39 |
| Grain length after cooking (mm) | 9.02 | 10.58 | 9.21 | 14.55 | 15.44 | 11.98 | 11.40 |
| Elongation ratio | 1.63 | 1.56 | 1.58 | 1.77 | 1.73 | 1.59 | 1.62 |
| Gelatinization temperature (ASV 1-7 scale) | 3.21 | 5.18 | 3.12 | 6.46 | 6.41 | 3.23 | 4.81 |

of alkali spreading value whereas, cluster III (3.12) exhibited lowest value.

Contribution of individual characters towards divergence (Fig. 2) in all the combinations of inter-cluster distances in each character was ranked on the basis of inter-cluster distances. Rank 1 was given to the character having highest mean difference and rank p is given to the character having lowest mean difference, where p was the numbers of characters. Percentage contribution of each character was calculated on the basis of occurrence of these ranks. Among the traits, decorticated grain length contributed maximum divergence (34.35%) followed by 1000 grain weight (17.99 %), days to fifty percent flowering (13.08%), alkali spreading value (12.15%) and two characters have equal contribution decorticated grain length/ breadth ratio and grain length after cooking are 7.24% each. The minimum contribution was observed in panicle length, penultimate leaf length contributed for 0.23% each, whereas penultimate leaf length (0.27%), and spikelets / panicle (0.46 %). These characters contributed equal contribution grain breadth, grain yield/plot, grain breadth; decorticated grain breadth of 0.93 % each and fertile grains/panicle (0.94%), plant height having 3.27 %. Other than that some character did not contribution towards genetic divergence which is effective tillers/plant, days to maturity, grain yield/plant, grain length, elongation ratio (Table 4). Similar result were reported by Chaturvedi and Maurya (2005) and Sabesan (2008) that selection of genotypes as parents for hybridization or in crop improvement programme need not necessarily be based on geographical diversity, the genetic diversity may prove sound base for the purpose.

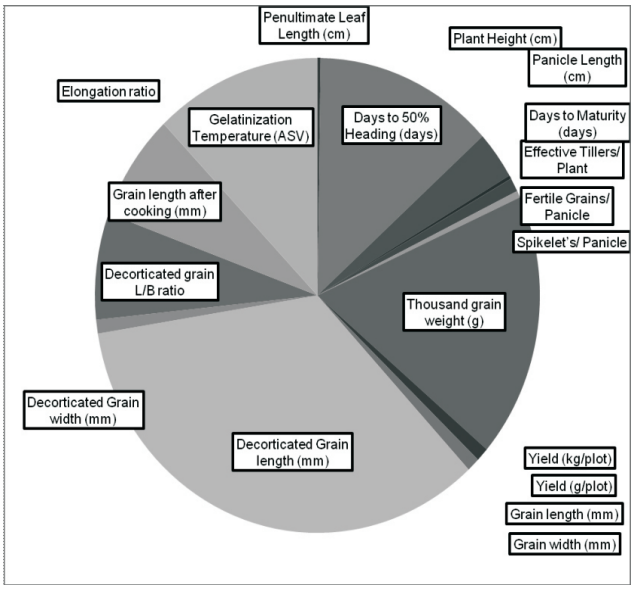


**Fig. 2.** Pie diagram showing per cent divergence

**Table 4.** Percentage of contribution of each character towards total divergence

| Character | Time ranked 1st | Contribution (%) |
|---|---|---|
| Penultimate leaf length (cm) | 1 | 0.23 |
| Days to 50% heading (days) | 56 | 13.08 |
| Plant height (cm) | 14 | 3.27 |
| Panicle length (cm) | 1 | 0.23 |
| Effective tillers/ plant | 0 | 0.00 |
| Days to maturity (days) | 0 | 0.00 |
| Fertile grains/ panicle | 4 | 0.93 |
| Spikelet's/ panicle | 2 | 0.47 |
| Thousand grain weight (g) | 77 | 17.99 |
| Yield (kg/plant) | 4 | 0.93 |
| Yield (g/plot) | 0 | 0.00 |
| Grain length (mm) | 0 | 0.00 |
| Grain width (mm) | 4 | 0.93 |
| Decorticated grain length (mm) | 147 | 34.35 |
| Decorticated grain width (mm) | 4 | 0.93 |
| Decorticated grain L/B ratio | 31 | 7.24 |
| Grain length after cooking (mm) | 31 | 7.24 |
| Elongation ratio | 0 | 0.00 |
| Gelatinization temperature (ASV) | 52 | 12.15 |

In the present finding, first three clusters (1-3) had non-basmati genotypes, whereas, last three clusters (4 -6) had basmati genotypes; except Heera variety in cluster VI (non-basmati). Basmati genotypes are more distantly related with the non-basmati type in comparison to within both groups. Cluster 3 had short & medium slender grains, Cluster 2 had long (slender/bold) grains, whereas, cluster 1 had short bold grains.

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# Genetic Variability, Correlation Coefficient and Path Coefficient Analysis for Yield and Component Traits in Groundnut

**Ashutosh Kushwah, Soma Gupta[1], Sheetal Raj Sharma and K. Pradhan[2]**

*Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhaina-141 004 India*
*[1] Division of Genetics, ICAR-Indian Agricultural Research Institute, New Delhi-110 012, India*
*[2] Department of Plant Breeding and Genetics, Odisha University of Agriculture and Technology, Bhubaneswar-751 003, India*
*E-mail: anshu.kushwah24@gmail.com*

***Abstract:*** Twenty nine breeding lines of groundnut were evaluated to estimate genetic variability, correlation coefficient and direct and indirect effects by path analysis for yield and its components traits. Phenotypic and genotypic coefficient of variation were high for pod yield per plant, kernel yield per plant, number of pods per plant, number of kernels per plant and hundred kernel weight. Pod yield per plant exhibited significant positive correlation with kernel yield per plant, number of kernel per plant, hundred kernel weight, number of pods per plant and harvest index at both genotypic and phenotypic level. Positive and significant association and higher contribution made to pod yield per plant suggested that kernel yield per plant, number of kernel per plant and hundred kernel weight are most important morphological traits that should be given due emphasis while deciding about selection criteria for groundnut.

***Keywords:*** Genetic variability, Correlation coefficient, Path analysis

Groundnut (*Arachis hypogaea* L.) is one of the most important oilseed crops in India, occupying 5.52 m. ha area and contributing 9.67 million tones production of groundnut in shell with productivity of 1750 kg $ha^{-1}$ during 2013-14 (Department of Agriculture and Cooperation, December 2014). Yield potential of groundnut is known only when the crop is harvested as the economic yield is contributed by the pods formed under the ground. It is more or less difficult to expect pod yield based on aerial morphological characters (Weiss, 2000). Therefore, the choice of directly or indirectly yield-related traits is greatly valuable for breeders. Advancement has been made in genetic improvement of the Spanish type groundnut since organized breeding programmes commenced in India. As Spanish type variety contributes above 50 % of the total groundnut production of the country, the genetic improvement achieved in yield potential is really a commendable achievement for the groundnut breeders. The alternation in plant architecture with erect growth habit, reduced height, more number of pods etc., are the main milestones in the Spanish groundnut improvement. A rapid expansion phenophase, a long filling phenophase, a short podding phenophase and a high partitioning of assimilates to pods were considered to be the physiological criteria responsible for higher yields (Mc Cloud *et al.*, 1980).

The correlation coefficient may be confounded with indirect effect due to frequent association inherent in trait interrelationships. The applicability of correlation can be more visibly understood by path analysis, which permits the partitioning of correlation in direct and indirect effects, thus, a valuable tool in breeding programmes (Dewey and Lu, 1959; Gomes and Lopes, 2005). Keeping this fact in view, present study was undertaken to estimate phenotypic and genotypic correlations and path coefficients of significant agronomic traits on pod yield per plant to originate an efficient selection strategy.

## MATERIAL AND METHODS

Materials for the present study included 27 advance breeding lines and 2 high yielding standard varieties of groundnut (Table 1). The field trial was conducted in randomized block design (RBD) with three replications during 2013. Each entry was planted having 3 m row length with a spacing of 30 cm x l0 cm. Twelve characters related to growth, vigour and yield were recorded. Days to 50% flowering was taken on plot basis. For other characters like plant height (cm), number of branches, number of pods $plant^{-1}$, number of kernels $plant^{-1}$, 100 kernel weight, sound mature kernel per cent, shelling per cent, harvest index, kernel yield $plant^{-1}$, haulm yield $plant^{-1}$ and pod yield $plant^{-1}$ observations were recorded on five consecutive plants per genotype in each replication and average data were used in multi-variable statistical analysis. The mean values were used for the statistical analysis. The phenotypic and genotypic correlation coefficients for pair of the characters were worked-out through covariance analysis as per Al-Jibouri *et al.* (1958). The genotypic path coefficient analysis was done as per the method suggested by Dewey and Lu (1959) by using Window Stat software program (version 7.5).

## RESULTS AND DISCUSSION

**Variability, heritability and genetic advance:** Wide range of variation was observed for most of the characters under study. Phenotypic and genotypic coefficient of variation estimates were high for plant height, number of branches plant$^{-1}$, number of pods plant$^{-1}$, number of kernels plant$^{-1}$, hundred kernel weight, harvest index percentage, kernel yield plant$^{-1}$ and pod yield plant$^{-1}$ (Table 2). High genotypic coefficient of variation indicates greater variability for these characters, there by suggesting abundant scope for improvement through selection among these advance breeding lines. High genotypic and phenotypic coefficients of variation were also reported for pod yield and its contributing characters by Shoba *et al.* (2009), John (2005), Meta and Monpara (2010) while moderate estimate for these traits were observed by Sudhir kumar *et al.* (2008).

Low values of genotypic coefficient of variation was observed for days to 50% flowering, sound mature kernel percentage, shelling percentage and haulm yield plant$^{-1}$ (Table 2) indicating need to generate variability either by hybridization or mutation followed by selection. Similarly low estimates were also reported by Pradhan and Patra (2011) for shelling per cent, pod yield and yield component characters.

Present study also demonstrated high heritability and genetic advance for 100 kernel weight, shelling percentage, pod yield plant$^{-1}$, harvest index and number of pods plant$^{-1}$ (Table 2). These results explain additive type of gene action

**Table 1.** List of genotypes included in study and their source of origin

| Name of genotypes | Source of origin | Name of genotypes | Source of origin |
|---|---|---|---|
| DhS-102 | AICRP groundnut, Dharwad | K-1336 | AICRP on Groundnut Kadri |
| Dh-8 | AICRP groundnut, Dharwad | R-8892 | AICRP on Groundnut Raichur |
| Dh-216-1 | AICRP groundnut, Dharwad | R-2001-1 | AICRP on Groundnut Raichur |
| Dh-209 | AICRP groundnut, Dharwad | JNDB-14 | AICRP on Groundnut JAU Junagadh |
| Dh-206 | AICRP groundnut, Dharwad | UG-5 | AICRP on Groundnut Udayapur |
| Dh-204 | AICRP groundnut, Dharwad | DH-107 | AICRP groundnut, Dharwad |
| TCGS-159 | AICRP on Groundnut JAU Junagadh | GG-6 | AICRP on Groundnut JAU Junagadh |
| Dh-108 | AICRP groundnut, Dharwad | GPBD-5 | Genetics and Plant Breeding Department, Dharward |
| CSMG-2014 | AICRP on Groundnut JAU Junagadh | ICGV-9921 | ICRISAT Hyderabad |
| ALG-234 | AICRP on Groundnut Aliyarnagar | Dh-216-2 | AICRP groundnut, Dharwad |
| AG-2006-15 | AICRP on Groundnut Anand | AG-2240 | AICRP on Groundnut Anand |
| ICGV-95401 | ICRISAT Hyderabad | JL-575 | AICRP on Groundnut, Jalgaon |
| DRT-53 | AICRP on Groundnut JAU Junagadh | OG-86-5-2 | AICRP on Groundnut JAU Junagadh |
| KGN-34 | AICRP on Groundnut JAU Junagadh | UG-3 | AICRP on Groundnut Udayapur |
| K-1371 | AICRP on Groundnut Kadri | | |

**Table 2.** Genetic parameters of the morphological characters in groundnut during *rabi* season

| Character | Range (Min-Max) | Mean | PCV (%) | GCV (%) | $h^2$ (%) | GA (% of mean) |
|---|---|---|---|---|---|---|
| Days to 50% flowering | 27.67-37.33 | 32.103 | 10.03 | 7.33 | 53.40 | 9.42 |
| Plant height (cm) | 13.53-26.53 | 21.591 | 17.70 | 11.00 | 38.61 | 12.03 |
| No. of branches plant$^{-1}$ | 3.47-7.00 | 4.653 | 17.11 | 11.37 | 44.19 | 13.31 |
| No. of pods plant$^{-1}$ | 9.07-16.07 | 12.267 | 16.04 | 12.59 | 61.62 | 17.39 |
| Sound mature kernel (%) | 82.98-98.84 | 92.383 | 5.89 | 2.64 | 20.00 | 2.07 |
| 100 kernel weight (g) | 34.87-54.85 | 45.013 | 12.24 | 11.49 | 88.14 | 18.98 |
| No. of kernels plant$^{-1}$ | 15.20-24.27 | 19.131 | 14.81 | 10.66 | 51.79 | 13.50 |
| Kernel yield plant$^{-1}$ (g) | 5.86-10.49 | 8.569 | 18.95 | 11.80 | 38.81 | 12.94 |
| Shelling (%) | 63.67-84.00 | 74.184 | 8.50 | 7.73 | 82.58 | 12.36 |
| Haulm yield plant$^{-1}$ (g) | 19.57-28.87 | 24.489 | 10.90 | 4.56 | 17.47 | 3.35 |
| Harvest index (%) | 25.66-36.65 | 31.710 | 12.46 | 10.60 | 72.37 | 15.87 |
| Pod yield plant$^{-1}$ (g) | 7.54-14.74 | 11.412 | 17.25 | 15.34 | 79.09 | 24.01 |

and indicate phenotypic selection to be effective for traits under study. Similar results were reported by Rao *et al.* (2015), Patil *et al.* (2015), Sudhir Kumar *et al.* (2008), John *et al.* (2009) for yield and its component characters. In contrast, low heritability and genetic advance were reported by Mohan Vishnuwardhan *et al.* (2013) for shelling percentage and harvest index.

Heritability and genetic advance as percent of mean were moderate for days to 50% flowering, number of kernels per plant, number of branches per plant, kernel yield per plant and plant height whereas, it was low for sound mature kernel percent and haulm yield per plant (Table 2). High heritability along with high genetic advance was observed for number of branches per plant by Korat *et al.* (2009), John *et al.* (2009) and Mohan Vishnuwardhan *et al.* (2013). This again indicated prime role of additive gene action and amenability for phenotypic selection of these traits. However, John *et al.* (2012) reported low heritability and moderate genetic advance for the same trait. Such results indicate both additive and non additive gene actions have a role in their inheritance and phenotypic selection would be effective to some amount for these traits. Rathnakumar *et al.* (2010) reported annual increments of 9.4 kg $ha^{-1}$ and 6.2 kg $ha^{-1}$ in pod and kernel yields respectively. The enhanced pod yield has resulted mainly from improvements in number of pods per plant, pod weight and seed weight. Improvement in shelling and sound mature kernel percent was not significant which may be due to low genetic advance along with low heritability estimate for sound mature kernel percent and haulm yield per plant as observed in present study.

**Phenotypic and genotypic correlation among traits:** Out of the 66 correlation coefficients among 12 traits, 24 correlation coefficients were significant at phenotypic level whereas 25 correlation coefficients were significant at genotypic level (Table 3). In general, the values of genotypic correlation were higher than their corresponding phenotypic

**Table 3.** Genotypic ($r_g$) and phenotypic correlation coefficients ($r_p$) among twelve characters in 29 genotypes of groundnut in *rabi* season

| Trait | | DFF | PH | NB | NP | SMK | HKW | NK | KY | SP | HY | HI | PY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DFF | $r_g$ | 1 | 0.18 | 0.282 | 0.123 | -0.191 | 0.222 | 0.13 | 0.306 | -0.122 | 0.538** | 0.094 | 0.235 |
| | $r_p$ | 1 | -0.041 | 0.088 | 0.129 | -0.154 | 0.12 | 0.085 | 0.142 | -0.061 | 0.162 | 0.059 | 0.163 |
| PH | $r_g$ | | 1 | -0.05 | 0.520** | -0.4 | 0.247 | 0.591** | 0.677** | 0.264 | -0.006 | 0.740** | 0.744** |
| | $r_p$ | | 1 | 0.231 | 0.470** | -0.023 | 0.169 | 0.517** | 0.559** | 0.276 | 0.382* | 0.337 | 0.580** |
| NB | $r_g$ | | | 1 | 0.451* | -0.224 | 0.095 | 0.314 | 0.278 | 0.255 | 0.03 | 0.348 | 0.34 |
| | $r_p$ | | | 1 | 0.463* | -0.146 | 0.059 | 0.489** | 0.465* | 0.333 | 0.264 | 0.222 | 0.377* |
| NP | $r_g$ | | | | 1 | -0.599 | -0.294 | 0.860** | 0.371* | 0.185 | 0.188 | 0.386* | 0.435* |
| | $r_p$ | | | | 1 | -0.192 | -0.21 | 0.860** | 0.587** | 0.356 | 0.306 | 0.356 | 0.553** |
| SMK | $r_g$ | | | | | 1 | -0.243 | -0.503** | -0.582** | 0.255 | 0.341 | -0.764** | -0.706** |
| | $r_p$ | | | | | 1 | 0.003 | -0.148 | -0.127 | 0.137 | -0.211 | -0.073 | -0.209 |
| HKW | $r_g$ | | | | | | 1 | -0.232 | 0.778** | 0.09 | -0.06 | 0.713** | 0.681** |
| | $r_p$ | | | | | | 1 | -0.145 | 0.451* | 0.082 | -0.064 | 0.611** | 0.592** |
| NK | $r_g$ | | | | | | | 1 | 0.540** | 0.346 | -0.001 | 0.539** | 0.545** |
| | $r_p$ | | | | | | | 1 | 0.750** | 0.494** | 0.292 | 0.417* | 0.620** |
| KY | $r_g$ | | | | | | | | 1 | 0.358 | -0.217 | 1.129** | 1.060** |
| | $r_p$ | | | | | | | | 1 | 0.493** | 0.28 | 0.677** | 0.882** |
| SP | $r_g$ | | | | | | | | | 1 | 0.382* | 0.169 | 0.279 |
| | $r_p$ | | | | | | | | | 1 | 0.298 | 0.197 | 0.389* |
| HY | $r_g$ | | | | | | | | | | 1 | -0.114 | 0.12 |
| | $r_p$ | | | | | | | | | | 1 | -0.349 | 0.204 |
| HI | $r_g$ | | | | | | | | | | | 1 | 0.972** |
| | $r_p$ | | | | | | | | | | | 1 | 0.841** |
| PY | $r_g$ | | | | | | | | | | | | 1 |
| | $r_p$ | | | | | | | | | | | | 1 |

Abbreviations: DFF- Days to 50% flowering, PH- Plant height (cm), NB- Number of branches $plant^{-1}$, NP-Number of pods/plant, SMK-Sound mature kernel (%), HKW- 100 kernel weight(g), NK- Number of kernels/plant, KY- Kernel yield $plant^{-1}$ (g), SP-Shelling (%), HY- Haulm yield $plant^{-1}$ (g), HI- Harvest index (%), PY- Pod yield $plant^{-1}$ (g)

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

correlation indicating that there was high degree of association between two variables at genotypic level (Table 3). Its phenotypic expression was reduced by the influence of environment, pointing out the possibilities of effective phenotypic selection. Pod yield plant$^{-1}$ exhibited significant positive correlation with number of pods plant$^{-1}$ ($r_g$ = 0.435, $r_p$ = 0.553), plant height ($r_g$ = 0.744, $r_p$ = 0.580), hundred kernel weight ($r_g$ = 0.681, $r_p$ = 0.592), number of kernel plant$^{-1}$ ($r_g$ = 0.545, $r_p$ = 0.620), kernel yield plant$^{-1}$ ($r_g$ = 1.060, $r_p$ = 0.882) and harvest index ($r_g$ = 0.972, $r_p$ = 0.841) at both genotypic and phenotypic level and with number of branches ($r_p$ = 0.377) and shelling per cent ($r_p$ = 0.389) at phenotypic level only. Babariya and Dobariya, (2012) observed similar association of pod yield per plant with other yield contributing characters. Sumathi *et al.* (2007) and Dhaliwal *et al.* (2010) also reported significant positive association for pod yield per plant with kernel yield and 100 seed weight both at genotypic and phenotypic level that supports present findings. Positive and significant association between 100 kernel weight and pod yield plant$^{-1}$ was reported by Korat *et al.* (2010) at phenotypic level.

Sound mature kernel percentage showed significantly negative correlation with pod yield plant$^{-1}$ ($r_g$ = -0.706), number of kernels plant$^{-1}$ ($r_g$ = -0.503), kernel yield plant$^{-1}$ ($r_g$ = -0.582) and harvest index percentage ($r_g$ = -0.764) only at genotypic levels. In contrast to this, days to 50 % flowering did not show any significant correlation with pod yield ($r_p$ = 0.163, $r_g$ = 0.235) and other yield contributing characters (Table 3).

**Path co-efficient analysis:** To know the direct and indirect effects of these traits on pod yield plant$^{-1}$, correlations were further partitioned into direct and indirect effects through path coefficient analysis (Table 4). Harvest index percentage is having highest direct positive effect on pod yield plant$^{-1}$ (0.930) followed by haulm yield plant$^{-1}$ (0.484). Also kernel yield plant$^{-1}$ (0.074), hundred kernel weight (0.018), number of pods plant$^{-1}$ (0.001), number of kernel plant$^{-1}$ (0.019) and plant height (0.027) were observed to be the major indirect contributor towards pod yield through harvest index percentage. Dhaliwal *et al.* (2010) also observed high positive direct contribution of kernel yield plant$^{-1}$ to the pod yield. Bera *et al.* (2010) reported positive direct contribution of harvest index to the seed yield irrespective of location and year effect. Padmaja *et al.* (2015) emphasized number of mature pods plant$^{-1}$, total number of pods plant$^{-1}$, mature seeds plant$^{-1}$ and haulm weight plant$^{-1}$ for selecting high yielding lines in groundnut. Path coefficient analysis showed low residual effect (R=0.089) (Table 4) indicating most of the

**Table 4.** Direct and indirect effects of component traits on pod yield in groundnut

| Characters | Days to 50% flowering | Plant height (cm) | No of branches plant$^{-1}$ | No. of pods plant$^{-1}$ | Sound mature kernel (%) | 100 kernel weight (g) | No. of kernels plant$^{-1}$ | Kernel yield plant$^{-1}$ (g) | Shelling (%) | Haulm yield plant$^{-1}$ (g) | Harvest index (%) | Phenotypic correlation with pod yield plant$^{-1}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days to 50% flowering | 0.015 | -0.001 | -0.002 | 0.000 | 0.005 | 0.002 | 0.002 | 0.010 | -0.001 | 0.078 | 0.055 | 0.163 |
| Plant height(cm) | -0.001 | 0.027 | -0.005 | 0.000 | 0.001 | 0.003 | 0.010 | 0.041 | 0.005 | 0.185 | 0.313 | 0.580** |
| No of branches plant$^{-1}$ | 0.001 | 0.006 | -0.020 | 0.000 | 0.004 | 0.001 | 0.009 | 0.034 | 0.006 | 0.128 | 0.206 | 0.377* |
| No. of pods plant$^{-1}$ | 0.002 | 0.013 | -0.009 | 0.001 | 0.006 | -0.004 | 0.016 | 0.043 | 0.007 | 0.148 | 0.331 | 0.553** |
| Sound mature kernel (%) | -0.002 | -0.001 | 0.003 | 0.000 | -0.029 | 0.000 | -0.003 | -0.009 | 0.003 | -0.102 | -0.068 | -0.209 |
| 100 kernel weight (g) | 0.002 | 0.005 | -0.001 | 0.000 | 0.000 | 0.018 | -0.003 | 0.033 | 0.001 | -0.031 | 0.568 | 0.592** |
| No. of kernels plant$^{-1}$ | 0.001 | 0.014 | -0.010 | 0.001 | 0.004 | -0.003 | 0.019 | 0.055 | 0.009 | 0.141 | 0.388 | 0.620** |
| Kernel yield plant$^{-1}$ (g) | 0.002 | 0.015 | -0.009 | 0.000 | 0.004 | 0.008 | 0.014 | 0.074 | 0.009 | 0.136 | 0.629 | 0.882** |
| Shelling (%) | -0.001 | 0.007 | -0.007 | 0.000 | -0.004 | 0.001 | 0.009 | 0.036 | 0.018 | 0.144 | 0.183 | 0.389* |
| Haulm yield plant$^{-1}$ (g) | 0.002 | 0.010 | -0.005 | 0.000 | 0.006 | -0.001 | 0.006 | 0.021 | 0.005 | 0.484 | -0.325 | 0.204 |
| Harvest index (%) | 0.001 | 0.009 | -0.004 | 0.000 | 0.002 | 0.011 | 0.008 | 0.050 | 0.004 | -0.169 | 0.930 | 0.841** |

Residual effect = 0.089, (*Significance at 5 % level, **Significant at 1 % level)
The bold values in diagonal indicates direct effect

major yield components has been included in the study.

Positive and significant genotypic as well as phenotypic correlations of pod yield plant$^{-1}$ with kernel yield plant$^{-1}$, number of kernel plant$^{-1}$ and hundred kernel weight and the highest direct contribution of same traits to pod yield plant$^{-1}$ and great indirect contribution via harvest index and haulm yield plant$^{-1}$ suggests that pod yield plant$^{-1}$ was dependent on these traits.

## CONCLUSION

Positive and significant association and higher contribution made to pod yield plant$^{-1}$ suggested that kernel yield plant$^{-1}$, number of kernel plant$^{-1}$ and hundred kernel weight are most important morphological traits that should be given due emphasis while selecting genotypes with higher yield.

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# Morpho-Agronomic Characteristics of Farmers Rice Variety "Safri" from Different Regions of Chhattishgarh

**Hemant Sahu, Ritu R. Saxena[1], Satish B. Verulkar[1], V. Pratibha Mohan[1] and R. K. Rao**

*Department of Genetics and Plant Breeding*
*[1]Department of Plant Molecular Biology and Biotechnology, Indira Gandhi Krishi Vishwavidyalaya, Raipur-492012,India*
*E-mail: hemant.sahupant@gmail.com*

***Abstract***: In this study characterization of hundred landraces/farmers varieties of rice (Safri) collected from different part of chhattishgarh was performed using DUS testing protocol. Characterization was done using forty six agro-morphological traits following Distinctiveness, Uniformity and Stability test (DUS) during kharif season of 2014 at the biodiversity park Indira Gandhi Krishi Vishwavidyalaya, Raipur. Among the investigated forty six qualitative and quantitative characters, 10 characters were quantitative and 36 were qualitative in nature. Leaf intensity of green colour, Leaf width of blade, time of heading, flag leaf attitude, 1000 grain weight, Grain length, Grain width, Decorticated Grain length and Width are the essential characters which are used for the grouping of variety according to the DUS guideline and recorded highest variation among accessions. All the accessions were distinct on the basis of thirty five characters. The present work is so much important in respect to the present scenario of agro-biodiversity of this region as well as identification, conservation and documentation of landraces variety for future crop improvement.

***Keywords***: Farmers variety, DUS, Accession, Land races, Biodiversity

Rice is a complicated crop which grown in diverse agro-climatic condition. To utilize its food yield potentiality specific adaptability of rice is most important. So study of agro-morphic characteristic will be very much helpful to the breeder for future crop improvement. Indigenous rice genotypes available in different countries are endowed with tremendous genetic variability and are vital genetic resources for biotic and abiotic stress resistance/ tolerance, reduction of growth duration and improved nutritional characteristics (Deb, 2000; Bhagwat *et al*., 2008; Agnihotri and Palni, 2007). In addition to these, Chhattisgarh is having greatest diversity of rice including aromatic rice (Bisne and Sarawgi, 2008). Some of these genotypes are being gradually eroded from their respective places of origin and are on the verge of becoming extinct due to competition from high yielding varieties (Ram *et al*., 2007; Maxted and Kell, 2009). Despite the richness of genetic resources, only a small proportion of the world rice germplasm collections have been used in breeding programs. Knowledge regarding the amount of genetic variation in germplasm accessions and genetic relationships between genotypes are important considerations for designing effective breeding programme. The process of variety identification includes several steps, were identification of a variety, confirmation, distinctness of the variety from all other in common knowledge, Purity of the variety and Characterization of the variety. The 2

concept of distinctness, uniformity and stability (DUS) are thus fundamental to the characterization of a variety as a unique creation. India has enacted a *sui generis* legislation as Protection of Plant Varieties and Farmers' Rights Act 2001 (PPV&FR) for protection of plant varieties by registration. Under PPV&FR Act DUS (distinctiveness, uniformity, stability) testing procedure will be performed with morphological descriptors (Patra and Chawla 2010). The uniqueness of a particular variety is to be established by the test called DUS. In this context, an attempt was made to characterize a set of Hundred farmer's varieties of rice germplasm for different morphological and agronomic traits and identify the variability available in the collection.

## MATERIAL AND METHODS

Extensive survey was conducted in remote villages of different istricts of Chhattishgarh Hundred indigenous local safri rice (*Oryza sativa* L.) germplasm (Table 1) were grown at R. H. Richharia biodiversity park, IGKV, Raipur during *Kharif* 2014. Each entry was sown in two rows of 2 m length at spacing of 20 cm between rows and 15 cm between plants. Observations were recorded on five randomly selected plants of each genotype per replication for quantitative traits. The qualitative traits were visually assessed according to the National Test Guidelines for DUS test in rice which was developed by Directorate of Rice Research Rajendranagar, Hyderabad (Shobha Rani *et al*., 2006). The observation of various characteristics was recorded at different stages of growth with appropriate procedures as per the DUS test guidelines of PPV & FR Act, 2001. Forty six characteristics of the indigenous rice varieties at different growth stage were

**Table 1.** List of farmer's varieties and place of collection

| S. No. | Entry No. | Acc. No. | Name of the varieties | District | S. No. | Entry No. | Acc. No. | Name of the varieties | District |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 6292 | S:121 | Safri | Durg | 39 | 6369 | S:1223 | Safri | Raigarh |
| 2 | 6293 | S:126 II | Safri | Durg | 40 | 6370 | S:1227 | Safri | Raigarh |
| 3 | 6294 | S:126 II | Safri | Durg | 41 | 6372 | S:1275 | Safri | Raigarh |
| 4 | 6297 | S:164 | Safri | Raipur | 42 | 6373 | S:1307 | Safri | Raipur |
| 5 | 6298 | S: 233 I | Safri | Housangabad | 43 | 6375 | S:1315 | Safri | Bilaspur |
| 6 | 6300 | S:261 | Safri | Durg | 44 | 6376 | S:1316 | Safri | Bilaspur |
| 7 | 6302 | S:263 I | Safri | Durg | 45 | 6377 | S:1336 | Safri | Bilaspur |
| 8 | 6303 | S: 289 I | Safri | Rajnandgaon | 46 | 6379 | S:1360 | Safri | Raipur |
| 9 | 6305 | S:289 I | Safri | Rajnandgaon | 47 | 6380 | S:1388 | Safri | Raipur |
| 10 | 6308 | S:345 | Safri | Durg | 48 | 6382 | S:1392 | Safri | Raigarh |
| 11 | 6310 | S:379 | Safri | Raipur | 49 | 6384 | S:1395 | Safri | Bastar |
| 12 | 6313 | S:484 II | Safri | Raipur | 50 | 6386 | S:1399 | Safri | Bastar |
| 13 | 6314 | S:484 II | Safri | Raipur | 51 | 6387 | S:1456 | Safri | Raipur |
| 14 | 6317 | S:667 | Safri | Durg | 52 | 6388 | S:1462 | Safri | Raipur |
| 15 | 6320 | S:790 | Safri | balaghat | 53 | 6390 | S:1485 | Safri | Raipur |
| 16 | 6323 | S:822 | Safri | Sarguja | 54 | 6391 | S:1491 | Safri | Raipur |
| 17 | 6325 | S:856 I | Safri | Bastar | 55 | 6392 | S:1493 | Safri | Raipur |
| 18 | 6326 | S:858 I | Safri | Bastar | 56 | 6393 | S:1507 | Safri | Raipur |
| 19 | 6327 | S: 858 II | Safri | Bastar | 57 | 6394 | S:1507 | Safri | Raipur |
| 20 | 6329 | S:875 | Safri | Bastar | 58 | 6395 | S:1515 | Safri | Bastar |
| 21 | 6330 | S:879 II | Safri | Bastar | 59 | 6397 | S:1538 | Safri | Bastar |
| 22 | 6334 | S:891 III | Safri | Bastar | 60 | 6398 | S:1544 | Safri | Bastar |
| 23 | 6340 | S:963 II | Safri | Raipur | 61 | 6399 | S:1553 | Safri | Bastar |
| 24 | 6344 | S:1005 I | Safri | Raipur | 62 | 6400 | S:1566 | Safri | Bastar |
| 25 | 6346 | S:1018 | Safri | Raipur | 63 | 6401 | S:1592 | Safri | Bastar |
| 26 | 6347 | S:1022 | Safri | Raipur | 64 | 6402 | S:1605 | Safri | Bastar |
| 27 | 6348 | S:1025 I | Safri | Raipur | 65 | 6403 | S:1616 | Safri | Bastar |
| 28 | 6350 | S:1025 II | Safri | Raipur | 66 | 6404 | S:1618 | Safri | Bastar |
| 29 | 6351 | S:1026 I | Safri | Raipur | 67 | 6405 | S:1618 | Safri | Bastar |
| 30 | 6353 | S:1030 III | Safri | Raipur | 68 | 6406 | S:1638 | Safri | Bastar |
| 31 | 6355 | S:1042 | Safri | Bilaspur | 69 | 6408 | S:1652 | Safri | Bastar |
| 32 | 6356 | S:1074 | Safri | Sarguja | 70 | 6410 | S:1672 | Safri | Bastar |
| 33 | 6359 | S:1107 | Safri | Bastar | 71 | 6411 | S:1674 | Safri | Bastar |
| 34 | 6360 | S:1112 | Safri | Bastar | 72 | 6412 | S:1692 | Safri | Raigarh |
| 35 | 6362 | S:1152 | Safri | Bastar | 73 | 6415 | S:94 II | Safribanko | Bilaspur |
| 36 | 6363 | S:1160 | Safri | Bastar | 74 | 6418 | s:852 | Safribanko | Bastar |
| 37 | 6364 | S:1172 | Safri | Rajnandgaon | 75 | 6420 | s:1595 | Safribanko | Bastar |
| 38 | 6365 | S:1204 | Safri | Raigarh | 76 | 6423 | S:125 | SafriDeshi | Durg |
| 77 | 6424 | S:1462 | SafriDeshi | Raipur | 91 | 6451 | D:196 | DeshiSafri | Raipur |
| 78 | 6427 | S:473 II | SafriDeshi | Rajnandgaon | 92 | 6453 | D:214 | DeshiSafri | Raipur |
| 79 | 6430 | S:671 | SafriDeshi | Durg | 93 | 6456 | D:310 | DeshiSafri | Raipur |
| 80 | 6431 | S:1008 | SafriDeshi | Raipur | 94 | 6457 | D:310 | DeshiSafri | Raipur |
| 81 | 6432 | S:1013 | SafriDeshi | Raipur | 95 | 6460 | D:393 | DeshiSafri | Raipur |
| 82 | 6433 | S:1017 | SafriDeshi | Raipur | 96 | 6470 | D:690 I | DeshiSafri | Rajnandga |
| 83 | 6434 | S:1695 | SafriDeshi | Bastar | 97 | 6472 | D:735 I | DeshiSafri | Raipur |
| 84 | 6436 | S:1228 | SafriDeshi | Rajnandgaon | 98 | 6473 | D:735 II | DeshiSafri | Raipur |
| 85 | 6437 | S:1522 | SafriDeshi | ba | 99 | 6475 | D:764 II | DeshiSafri | Raipur |
| 86 | 6439 | S:1647 | SafriDeshi | Bilaspur | 100 | 6476 | D:764 II | DeshiSafri | Raipur |
| 87 | 6441 | S:969 I | Safri Local | Raipur | 91 | 6451 | D:196 | DeshiSafri | Raipur |
| 88 | 6443 | B:250 | BhathaSafri | Raipur | | | | | |
| 89 | 6445 | C:100 | Cross Safri | Raipur | | | | | |
| 90 | 6450 | D: 149 II | DeshiSafri | Raipur | | | | | |

observed. Among these, 34 were qualitative and 12 characters were quantitative.These parameters provided morphological, agronomic characteristics as well as physiological characteristics of landraces of rice variety.

## RESULTS AND DISCUSSION

**Qualitative characters:** Among the investigated forty six agromorphic characters 36 characters were qualitative. Qualitative characters are important in respect to the identification and the characterization of landraces of rice varieties because it was observed that these characters are less influenced by the various environmental conditions. Polymorphism was found in 24 out of 36 qualitative traits. All the varieties show green coleoptiles (CC), presence of

**Table 2.** Frequency distribution of different traits

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Coleoptile colour | | | 8 | Leaf pubescence on leaf blade | | | 16 | Length of blade | | |
| | 1 | Colourless | 0 | | 1 | Absent | 0 | | 1 | Short | 0 |
| | 2 | Green | 100 | | 2 | Weak | 0 | | 2 | Medium | 5 |
| | 3 | Purple | 0 | | 3 | Medium | 45 | | 3 | Long | 95 |
| 2 | Basal leaf sheath colour | | | | 4 | Strong | 55 | 17 | Width of blade | | |
| | 1 | Green | 97 | | 5 | Very strong | 0 | | 1 | Narrow | 39 |
| | 2 | Purple line | 2 | 9 | Leaf auricle | | | | 2 | Medium | 5 |
| | 3 | Light purple | 1 | | 1 | Absent | 0 | | 3 | Broad | 0 |
| 3 | Leaf intensity of green colour | | | | 2 | Present | 2 | 18 | Culm attitude | | |
| | 1 | Dark | 12 | 10 | Anthocyanine colouration of auricle | | | | 1 | Erect | 34 |
| | 2 | Light green | 87 | | 1 | Colourless | 99 | | 2 | Semi-erect | 62 |
| | 3 | Medium | 1 | | 2 | Light purple | 1 | | 3 | Open | 4 |
| 4 | Leaf anthocyanine colouration | | | 11 | Leaf color | | | | 4 | Spreading | 0 |
| | 1 | Absent | 97 | | 1 | Absent | 0 | 19 | Time of heading (days) | | |
| | 2 | Present | 3 | | 2 | Present | 100 | | 1 | Very early | 0 |
| | | | | 12 | Anthocyanin colouration of auricle | | | | 2 | Early | 0 |
| 5 | Distribution of anthocyanine coloration | | | | 1 | Absent | 99 | | 3 | Medium | 74 |
| | 1 | Tip | 3 | | 2 | Present | 1 | | 4 | Late | 26 |
| | 2 | Margine | 0 | 13 | Leaf ligule | | | | 5 | Very late | 0 |
| | 3 | Both | 0 | | 1 | Absent | 0 | 20 | Flag leaf attitude | | |
| 6 | Leaf sheath anthocyanine colouration | | | | 2 | Present | 100 | | 1 | Erect | 27 |
| | 1 | Absent | 97 | 14 | Leaf shape of ligule | | | | 2 | Semi-erect | 59 |
| | 2 | Present | 3 | | 1 | Truncate | 0 | | 3 | Horizontal | 12 |
| 7 | Anthocyanine intensity in leaf sheath | | | | 2 | Acute | 0 | | 4 | Drooping | 2 |
| | 1 | Very weak | 0 | | 3 | Split | 100 | | | | |
| | 2 | Weak | 1 | 15 | Leaf colour of ligule | | | | | | |
| | 3 | Medium | 2 | | 1 | White | 100 | | | | |
| | 4 | Strong | 0 | | 2 | Light purple | 0 | | | | |
| 21 | Spikelet: density of pubescence of lemma | | | 27 | Stem thickness | | | 33 | Panicle curvature of main axis | | |
| | 1 | Absent | 0 | | 1 | Thin | 26 | | 1 | Straight | 0 |
| | 2 | Weak | 4 | | 2 | Medium | 60 | | 2 | Semi straight | 100 |
| | 3 | Medium | 59 | | 3 | Thick | 14 | | 3 | Deflexed | 0 |
| | 4 | Strong | 37 | 28 | Stem anthoyanin colouration | | | | 4 | Drooping | 0 |
| | 5 | Very strong | 0 | | 1 | Absent | 98 | 34 | Spiklet: colour of tip of lemma | | |
| 22 | Male sterility | | | | 2 | Present | 2 | | 1 | White | 90 |
| | 1 | Absent | 100 | 29 | Intensity of anthocyanine colouration of nodes | | | | 2 | Yellowish | 0 |
| | 2 | Present | 0 | | 1 | Weak | 1 | | 3 | Brown | 6 |
| 23 | Lemma anthocyanin colouration | | | | 2 | Medium | 0 | | 4 | Red | 1 |
| | 1 | Absent | 100 | | 3 | Strong | 0 | | 5 | Purple | 3 |
| | 2 | Weak | 0 | 30 | Stem anthocyanin colouration of internode | | | 35 | Lemma palea colour | | |
| | 3 | Medium | 0 | | 1 | Absent | 98 | | 1 | Straw | 8 |
| | 4 | Strong | 0 | | 2 | Present | 2 | | 2 | Gold and gold furrow on straw | 92 |
| | 5 | Very strong | 0 | 31 | Panicle length of main axis | | | | 3 | Brown spots on straw | 0 |
| 24 | Lemma anthocyanin colouration area below apex | | | | 1 | Very short | 0 | | 4 | Brown furrow on straw | 0 |
| | 1 | Absent | 100 | | 2 | Short | 0 | | 5 | Brown | 0 |
| | 2 | Present | 0 | | 3 | Medium | 96 | | 6 | Reddish to light purple | 0 |
| 25 | Lemma anthocyanin colouration of apex | | | | 4 | Long | 4 | | 7 | Purple spots/furrow on straw | 0 |
| | 1 | Absent | 100 | | 5 | Very long | 0 | | 8 | Purple | 0 |
| | 2 | Present | 0 | 32 | Flag leaf atitude of blade | | | | 9 | Black | 0 |
| 26 | Spikelet colour of stigma | | | | 1 | Erect | 0 | 36 | Panicle awn | | |
| | 1 | White | 94 | | 2 | Semi erect | 100 | | 1 | Absent | 89 |
| | 2 | Light green | 6 | | 3 | Horizontal | 0 | | 2 | Present | 11 |
| | 3 | Yellow | 0 | | 3 | Horizontal | 0 | | | | |
| | 4 | Light purple | 0 | | | | | | | | |

Cont....

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 37 | Panicle colouration of awn | | | 42 | Grain length (mm) | | |
| | 1 | Yellowish white | 11 | | 1 | Very short (<6) | 0 |
| | 2 | Yellowish brown | 0 | | 2 | Short (6.1-8.5) | 34 |
| | 3 | Brown | 0 | | 3 | Medium (8.6-10.5) | 66 |
| 38 | Panicle length of longest arm | | | | 4 | Long(10.6-12.5) | 0 |
| | 1 | Very short | 6 | | 5 | Very long (>12.5) | 0 |
| | 2 | Short | 3 | 43 | Grain width | | |
| | 3 | Medium | 2 | | 1 | Very narrow (<2) | 1 |
| | 4 | Long | 0 | | 2 | Narrow (2.1-2.5) | 75 |
| | 5 | Very long | 0 | | 3 | Medium (2.6-3) | 24 |
| | | | | 44 | Decorticated grain lengh | | |
| 39 | Distribution of awn | | | | 1 | Short | 2 |
| | 1 | Ti only | 7 | | 2 | Medium | 1 |
| | 2 | Upper half only | 4 | | 3 | Long | 97 |
| | 3 | Whole length | 0 | 45 | Decorticated grain width | | |
| 40 | Sterile lemma colour | | | | 1 | Narrow (<2) | 44 |
| | 1 | Straw | 8 | | 2 | Medium (2.0-2.5) | 56 |
| | 2 | Golden | 92 | | 3 | Broad (>2.5) | 0 |
| | 3 | Red | 0 | 46 | Decorticated grain width | | |
| 41 | Weight of 1000 fully developed grain (g) | | | | 1 | Short slender | 1 |
| | 1 | Very low(<15) | 0 | | 2 | Short bold | 0 |
| | 2 | Low (15-20) | 4 | | 3 | Medium slender | 1 |
| | 3 | Medium (21-25) | 80 | | 4 | Long bold | 3 |
| | 4 | High (26-30) | 14 | | 5 | Long slender | 95 |
| | 5 | Very high(>30) | 2 | | 6 | Extra-long slender | 0 |

**Table 4.** Extent of variability on quantitative traits

| Characters | Mean | Minimum | Maximum | Std. deviation |
|---|---|---|---|---|
| Length of blade | 47.92 | 38 | 55.8 | 2.81 |
| Width of blade | 1.20 | 0.5 | 1.8 | 0.51 |
| Time of heading | 109.95 | 104 | 118 | 2.68 |
| Stem thickness | 0.46 | 0.30 | 0.7 | 0.09 |
| Panicle length of main axis | 23.39 | 21.0 | 28.0 | 1.35 |
| 1000 grain weight | 23.72 | 18.8 | 31.9 | 2.30 |
| Grain length | 8.69 | 7.9 | 9.6 | 0.37 |
| Grain width | 2.39 | 2.0 | 2.9 | 0.2 |
| Decorticated grain length | 6.53 | 5.9 | 7.1 | 0.21 |
| Decorticated grain width | 1.95 | 1.0 | 2.2 | 0.16 |

auricles, leaf collar, leaf ligule, splitted shape of leaf ligule, white colour of ligule, absence of male sterility, lemma anthocyanine colouration, absence of lemma anthocyanine colouration below apex and apex apex, semi erect habit of flag leaf attitude of blade and semi straight curvature of panicle main axis. The basal leaf sheath colour was green in 97% varieties Leaf intensity of green colour shows great variability, where 87% varieties shows light green colour, and 12 % dark green colour.

Ninety Seven per cent of varieties exhibited absence of leaf anthocyanine and leaf sheath anthocyanine colouration and remaining 3% anthocyaniine colouration is distributed in tip portion only. 45% varieties exhibited medium pubescence and 55% varieties exhibited strong pubescence. Only 1% varieties exhibit light purple kind of auricle and presence of anthocyanine in collar. 62% varieties exhibited semierect kind of culm attitude, whereas 34% exhibited erect attitude. Regarding flag leaf attitude showing higher variability, where 27% varieties were erect, 59% were semierect , 12% horizontal and 2% were of drooping type. The pubescence density of lemma showing higher variability where 59% medium, 4% weak and 37% were strongly pubescence. For the character spikelet colour of stigma, stem anthocyanine colouration, colouration at internode, lemma palea colour, awns in panicle, distribution of awns and sterile lemma colour two alternative forms of characters were observed. 92% of the varieties consist golden colour of lemma palea and 8% varieties had straw colour lemma, panicle awn presence 11% and absence in 91% of varieties; 70% awns are distributed on tip only and 40% were on upper half only. 60% longest awns are very short, 40% short and 20% are medium in length. Sterile lemma colour also had 8% straw colour and 92% golden colour. 90% varieties had white tip of lemma. All awns were yellowish white. 98% decorticated grains varieties are

long slender and 2% short slender type.

**Quantitative characters:** Among the investigated forty six agromorphic characters 10 characters were quantitative and are represented into the Table 3. Among the quantitative characters of these landraces varieties, length of blade was ranged in between 38 cm to the 55.8 cm. Width of blade was ranged from 0.5 cm to 1.8 cm. Average time of heading was reported 109.95 days, which was ranged from 104 to 119.8 days. A large variation was found in stem thickness, 26% are thin, 60% medium and 14% are of thick stem in nature. Stem thickness varies from 0.3cm to 0.7 cm. Panicle length of main axis was ranged from 21 cm to 28 cm with an average length of 23.39 cm. But almost all (96%) varieties fall under medium length. 1000 grains weight, grain length, grain width, decorticated grain length, breadth and length breadth ratios are important yield attribute characters. A large variation was reported in 1000 grain weight, ranges from 18.8 to 31.9 gm. 73% varieties are of medium, 22% high, 3% low and 2% are of very high in 1000 grain weight. Based on our study we can classified 100 varieties into medium grain length (67%) and short grain length (33%). we have reported three categories of grain width viz., very narrow (1%), narrow (75%) and medium (24%). None of the variety was broad grain type. For the decorticated grain length 53 cultivars shown medium length, 45 were of long and only 2 cultivars were shown short in length. Medium decorticated grain width (2-2.5 mm) was observed for 56 cultivars 44 were of narrow (<2 mm) in width. Among the investigated forty six qualitative and quantitative characters. 10 characters are quantitative and 36 are qualitative in nature. Leaf intensity of green colour, Leaf width of blade, Time of heading, Flag leaf attitude, 1000 grain weight, Grain length, Grain width, Decorticated Grain length and Width are the essential characters which are used for the grouping of variety according to the DUS guideline. Subbarao et.al. (2013), Sinha and Mishra (2012, 2013), Agnihotri (2001), Patra (2000) and Singh and Singh (1997) studied the local rice varieties. The present study adds a new dimension confining itself to Chhattishgarh. Importance of these varieties are immense keeping their gene pool in mind. In present era when much stress is being laid on conservation of landraces, we cannot afford to lose landraces of rice varieties. Beyond any doubt, local varieties which have sustained in particular climatic condition since thousands of years back are better suited as compared to high yielding varieties. So, proper solution of climate change vis-a-vis agriculture is in conserving landraces of rice varieties. The present work is so much important in respect to the present scenario of agro-biodiversity of this region as well as identification, conservation and documentation of landraces variety for future crop improvement.

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# Effect of Hand and Chemical Thinning on Growth and Production of Nectarine cv. Snow Queen

**Rajiv Kumar, N. Sharma, Rimpika* and D.P. Sharma**

*Department of Fruit Science, Dr. Y S Parmar University of Horticulture and Forestry, Nauni-173 230 ,India*
*E-mail:rimpikathakur@yahoo.in*

***Abstract:*** The present investigation was carried out on six-year old nectarine trees, established on seedling rootstock at 2×3 meter spacing and trained as open centre, at the experimental orchard Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, during the years 2012 and 2013. Experimental trees were subjected to different treatments viz. retention of 3, 4 and 5 fruits per fruiting shoot manually, foliar application of Ethrel at 200 and 300 ppm, NAA at 20 and 40 ppm, TDZ at 20 and 40 ppm, Ethrel at 200 ppm + NAA at 20 ppm, Ethrel at 200 ppm + TDZ at 20 ppm and control (water spray) two weeks after petal fall. Hand thinning to retain 3 fruits shoot$^{-1}$ registered highest thinning percentage, vegetative growth and production of superior grade fruits.

***Keywords:*** Thinning, Growth, Production, Nectarine

Snow Queen is the most important cultivar of nectarine grown in the state. Its fruit is mid-season maturing, attractive bright red coloured on cream white background, white fleshed, small to medium sized, cling stone and possessing excellent flavour. This cultivar however, invariably bears copiously under congenial agro climatic conditions with small to medium sized fruits and consequently fetches low prices in the market. However, for profitable nectarine production, some quality parameters are very important and foremost is large and uniform sized fruit, which has strong market demand.

The nectarineis one of the important and emerging potential stone fruit crops of Himachal Pradesh, where it can be successfully cultivated up to an elevation of 2000 m a.m.s.l. In the recent years, its commercial cultivation is catching up in mid-hill areas comprising districts of Kullu and Sirmour, due its attractive appearance and better remuneration in comparison to peaches. However, its cultivation can also be extended to the other sub humid mid-hill areas in Chamba, Mandi, Solan, Shimla and Kangra districts of Himachal Pradesh due to the prevalence of congenial agro climatic conditions for its successful cultivation and can contribute towards improvement in socio-economic conditions of farmers.

Heavy crop load results in small and poor quality fruits, breakage of limbs, exhaustion of tree reserves (Dennis, 2000).Thinning is one of the important agro techniques required for the improvement of fruit size, colour and quality, besides reducing limb breakage and promoting general tree vigour. Thinning lessens the demand on the tree's resources so that it is able to make good growth and develop fruit buds for the following year and thus avoiding the risk of biennial bearing. It allows sunlight and air to penetrate the branches, so improving evenness of ripening. Traditionally, thinning of blossoms or fruit-lets had been carried out manually and still is in practice. However, through this practice only a small portion of an orchard may be best thinned at the optimum time. Since, the manual thinning is a time consuming, labour intensive and expensive, therefore, the trend has shifted towards chemical thinning using chemicals. Chemical thinning can be accomplished at pre-bloom, bloom and post-bloom stages; thinning at the earlier two stages is based on the crop potential, whereas the thinning at later stage is done only after assessing the actual crop load and is a better practice under Indian agro-climatic conditions. Plant growth regulators like NAA and Ethrel have been reported to give best results in different fruit crops when sprayed at post bloom stage (Rimpika *et al*., 2016). Keeping in view of these points, the present studies were undertaken to study the effect of hand and chemical thinning on fruit thinning on growth and graded yield in Snow Queen.

## MATERIAL AND METHODS

The experiment was carried out on six-year old trees of nectarine cultivar Snow Queen raised on seedling rootstocks at 2×3 meter spacing and trained as open centre out at the experimental orchard of Department of Fruit Science, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, during the years 2012 and 2013 in a randomized block design with twelve treatments and three replications (Table 1). For the present study, 36 trees of uniform vigour were selected and were kept under uniform

cultural practices. Hand and chemical thinning treatments were carried out two weeks after petal fall, when fruitlets were approximately of pea size. Per cent fruit thinning per treatment were calculated by using the following formula

Per cent fruit thinning per treatment were calculated by using the following formula

$$\text{Thinning percentage} = \frac{\text{Initial fruit set - Final fruit set}}{\text{Initial fruit set}} \times 100$$

The length of these shoots was measured at the end of growing period. Trunk girth of each tree was measured before the commencement of experiment during January 2012 and measurements were again taken at the end of growing season. The difference generated was computed as per cent increase in tree girth. The tree height was measured in meter (m) with the help of graduated flag staff from the soil surface to the top of a tree, once before the start of the experiment in January and again after the end of growing season. The tree spread was measured in meter (m) in two directions (East-West and North-South) once before the commencement of the experiment and again after the end of growing season with the help of graduated flag staff at the height where the canopy spread was maximum. The Leaf area was measured with the help of Automatic Leaf Area Meter (Licor Model 3100). Leaf/fruit ratio was worked out by dividing the total number of leaves with total number of fruits. The rate of photosynthesis was taken with the help of LCA4 portable photosynthesis system (ADC.UK) in mid- June (Hunter and Proctor, 3).

$$\text{Fruit drop (\%)} = \frac{\text{No. of fruits at final fruit set - Number of fruit retained}}{\text{No. of fruits at final fruit set}} \times 100$$

Fruits were graded into three different grades as “A grade”, “B grade” and “C grade” with diameter of 50 mm or above 45 to 49 mm were selected “B” grade fruit and less than 45 mm were selected “C” grade fruit and the yield of “A” “B” and “C grade fruit was expressed as percentage of total yield.

## RESULTS AND DISCUSSION

The hand thinning treatment involving retention of three fruits per shoot gave highest fruit thinning percentage, followed by the hand thinning treatments of retaining four and five fruits per shoot, in the decreasing order. These results are on the expectation line and in agreement with the earlier findings (Sharma *et al*., 2001) that fruit thinning percentage increased with the increase in the severity of thinning in peaches. The detachment of fruits encompasses the formation of anatomically distinct separation layer which facilitate abscission by cell wall changes due to hydrolysis or dissolution of middle lamella which causes the loss of cementing effectiveness between adjacent cell wall (Ouma, 2010). Earlier studies also demonstrated that post bloom application of ethephon induced fruit thinning in peaches (Sharma *et al.,* 2003).

All the hand thinning and thidiazuron treatments and NAA applied at 40 ppm have increased leaf area significantly

**Table 1.** Effect of manual and chemical thinning on pooled data offruit thinning, leaf area and leaf to fruit ratioin nectarine cv. Snow Queen

| Treatments | Fruit thinning (%) | Leaf area ( $cm^2$ ) | Leaf / fruit ratio |
|---|---|---|---|
| $T_1$ : Retention of 3 fruits $shoot^{-1}$ | 53.54(47.02) | 48 | 49.43 |
| $T_2$ : Retention of 4 fruits $shoot^{-1}$ | 48.93(44.37) | 43.85 | 45.37 |
| $T_3$ : Retention of 5 fruits $shoot^{-1}$ | 46.86(43.19) | 42.81 | 43.08 |
| $T_4$ : Ethrel 200 ppm | 30.45(33.46) | 37.62 | 31.81 |
| $T_5$ : Ethrel 300 ppm | 33.64(35.34) | 36.64 | 36.04 |
| $T_6$ : NAA 20 ppm | 29.51(32.08) | 38.25 | 30.41 |
| $T_7$ : NAA 40 ppm | 34.40(35.90) | 42.2 | 34.69 |
| $T_8$ : TDZ 20 ppm | 28.23(32.08) | 43.5 | 29.74 |
| $T_9$ : TDZ 40 ppm | 30.92(33.77) | 40.89 | 32.48 |
| $T_{10}$ : Ethrel 200 ppm + NAA 20 ppm | 33.90(35.59 | 38.78 | 33.25 |
| $T_{11}$ : Ethrel 200 ppm + TDZ 20 ppm | 34.77(36.12) | 40.38 | 35.75 |
| $T_{12}$ : Control (No thinning) | 23.28(28.82) | 31.88 | 22.61 |
| CD (p=0.05) | -1.6 | -5.8 | -1.6 |

Figures in the parentheses are angular transformed values

over the control. The different TDZ treatments also significantly increased the photosynthetic rate, transpiration rate and stomatal conductance. The results are in accordance with the earlier findings that reduction in crop load with hand thinning increased the leaf area in peaches (Sharma *et al.,* 2003; El-Boray *et al.* 2012). Similarly, foliar application of NAA to induce fruit thinning resulted in significant increase in the leaf area in pomegranate cultivar Shisheh Cup (Rahemi and Atahosseini, 2004). The hand thinning to retain 3 fruits shoot$^{-1}$gave highest leaf/fruit ratio) and conversely, the values of this parameter was found significantly least in un-thinned control. Since, the leaf to fruit ratio increased in equivalence with the increase in fruit thinning percentages under different thinning treatments, the resultant effect on this attribute seems to be clearly understandable. The present results are in accordance with the earlier findings that leaf to fruit ratio increased with hand thinning and thinning with NAA and Ethrel in peaches (Sharma *et al*., 2003).

The maximum increase in shoot growth and tree height and spread was observed with heaviest manual fruit thinning level involving the retention of three fruits per shoot, which gradually decreased with the increase in the number of fruits per shoot Reduction in fruit load following hand thinning has a bearing on promoting general tree vigour (Rimpika *et al*., 2016). Similarly, increase in vegetative growth with the increase in the intensity of fruit thinning has been reported in peaches (Saini *et al*., 2001; Myers *et al*., 2002) and in apples (Ashour, 2003). In this study, the increase in the shoot growth and tree height and spread under the above treatments can be attributed to more availability of nutrients and photosynthates for vegetative growth, consequent upon increase in the sink strength of shoot, after selective removal of the competing fruits.

The application of NAA at 40 ppm had caused significant increase in shoot growth, tree height and spread and trunk girth of nectarine as compared to control. Adequate fruit thinning as achieved with NAA might have favoured the growth of nectarine trees in the present study. These findings are in consistent with (Rahemi and Atahosseini, 2004) that reduced crop load with NAA application increased the general tree vigour in different fruit crops.

A large increment in the annual trunk girth over a growing season was observed by treatments with NAA at 20 ppm and TDZ at 40 ppm.

Increased photosynthetic rate following the treatments with TDZ is difficult to explain, as work on this aspect is lacking. However, these responses may be related to TDZ induced modification in cell membrane, energy levels, nutrient absorption, transport and assimilation, etc. (Guo *et al.,* 2011).

However, when yield of graded fruits was taken into account, the production of superior grade fruits was found to be significantly higher under different thinning treatments in comparison to control. Trees under hand thinning treatment implying retaining of 3 fruits shoot$^{-1}$ and chemical thinning with NAA at 40 ppm and Ethrel at 300 ppm produced higher percentage of “A" and “B" grade fruits, and lowest percentage of “C” grade fruits, whereas, trees under control produced only fractional quantity of marketable grade fruits

**Table 2.** Effect of manual and chemical thinning on pooled data of shoot growth, increase in trunk girth, increase in tree height, increase in tree spread and photosynthetic rateof nectarine cv. Snow Queen

| Treatments | Shoot growth (cm) | Trunk girth (% increase) | % Increase in tree height | % Increase in tree spread | Photosynthetic rate (µ mole m-2 s-1 ) |
|---|---|---|---|---|---|
| $T_1$ | 75.9 | 11.39(3.50) | 45.9 (42.60) | 58.1(49.71) | 3.55 |
| $T_2$ | 59.1 | 11.64(3.53) | 45.7(42.52) | 54.6 (47.67) | 2.54 |
| $T_3$ | 56.3 | 10.34(3.31) | 40.5(39.46) | 43.8 (41.33) | 3.33 |
| $T_4$ | 48.5 | 09.67(3.26) | 21.9 (27.81) | 24.2 ( 29.39) | 4.72 |
| $T_5$ | 46.4 | 10.66(3.41) | 23.1(28.70) | 26.6 (30.93) | 5.09 |
| $T_6$ | 68 | 13.78(3.83) | 23.8 (29.12) | 28.9 (32.45) | 4.2 |
| $T_7$ | 59.6 | 12.57(3.64) | 27.8 (31.54) | 29.8 (32.98) | 3.72 |
| $T_8$ | 56.3 | 08.09(3.00) | 20.8 (27.11) | 18.5 (25.46) | 4.65 |
| $T_9$ | 51.7 | 13.47(3.80) | 22.6 (28.27) | 21.8 (27.68) | 6.44 |
| $T_{10}$ | 46.2 | 13.37(3.73) | 18.6 (25.45) | 19.8 (26.39) | 5.34 |
| $T_{11}$ | 52.8 | 11.25(3.50) | 20.8 (26.92) | 20.4 (26.51) | 5.23 |
| $T_{12}$ | 44.6 | 08.01(3.00) | 15.2 (22.88) | 16.3 (23.78) | 1.93 |
| CD ( p=0.05) | -8.47 | -0.52 | -5.14 | -5.8 | -1.4 |

Figures in the parentheses are angular transformed values; treatment details are given in table 1

**Table 3.** Effect of manual and chemical thinning on pooled data of graded yield in nectarine cv. Snow Queen

| Treatments | A grade fruits (%) | B grade fruits (%) | C grade fruits (%) |
|---|---|---|---|
| $T_1$ | 46.89(43.19) | 37.29(37.62) | 15.83(23.43) |
| $T_2$ | 33.89(35.59) | 34.93(36.21) | 31.18(33.93) |
| $T_3$ | 31.65(34.21) | 36.36(37.07) | 31.99(34.43) |
| $T_4$ | 38.20(38.16) | 36.27(37.01) | 25.55(30.34) |
| $T_5$ | 41.99(40.37) | 35.29(36.42) | 22.73(28.46) |
| $T_6$ | 37.90(37.98) | 35.29(36.43) | 26.81(31.17) |
| $T_7$ | 40.63(39.58) | 39.26(38.78) | 20.11(26.63) |
| $T_8$ | 27.41(31.55) | 29.61(32.95) | 42.98(40.95) |
| $T_9$ | 27.09(31.55) | 31.81(34.31) | 41.11(39.86) |
| $T_{10}$ | 34.32 (35.84) | 35.57(36.59) | 30.11(33.26) |
| $T_{11}$ | 38.41 (38.28) | 35.18(36.36) | 26.41(30.91) |
| $T_{12}$ | 5.41(13.44) | 9.15 (17.59) | 85.44(67.55) |
| CD (p=0.05) | -0.92 | -0.94 | -0.83 |

Figures in the parentheses are angular transformed values; check table 1 for treatment details

and larger proportion of inferior grade fruits. In the study, reduction in total fruit yield may be the direct result of reduction in crop load because of the removal of fruits in the thinning operation. Total fruit yield in peach cv. Floridaprince decreased significantly in comparison to control, when the blossoms were spaced at 20 cm on shoots by hand thinning (Mohsen, 2010; El-Boray*et al.,* 2012). The results are in conformity with the earlier findings that fruit thinning with NAA lead to a decrease in average yield and increase in the production of marketable fruits in peach (Sharma *et al.,* 2003) and apple (Afshari *et al.,*2003). Furthermore, Sharma *et al.* (2003) observed significantly higher thinning percentage and enhancement in the production of superior grade fruits with the application of Ethrel at 200 and 300 ppm, at pea's stage in peach cv. Redhaven.

The results obtained in the present investigation demonstrated that hand thinning treatment of retaining 3 fruits shoot$^{-1}$ and thinning treatments with NAA at 40 ppm and Ethrel 300 ppm applied two weeks after petal fall significantly influenced the various fruit production parameters. However among these, the foliar application of NAA at 40 ppm judiciously thinned the young fruitlets, besides maintaining optimum vegetative growth in “Snow Queen” nectarine trees.

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# Principal Components Analysis for Yield and Yield Attributing Traits in Sesame

**Ajay Tanwar and Rajani Bisen***

*Jawaharlal Nehru KrishiVishwa Vidyalaya, Jabalpur-482 004, India*
**E-mail: rajanitomar20@gmail.com*

***Abstract*:** The present research was conducted to identify the minimum number of components, which can explain maximum variability out of the total variability and also to rank 96 sesame germplasm on the basis of PC scores using Principal Component Analysis (PCA). Out of ten, only nine principal components (PCs) exhibited more than 0.5 eigen value and showed 95.19% total variability among the characters. These nine PCs were given due importance for further explanation. Rotated component matrix revealed that the PC1, which accounted for the highest variability was mostly related to yield related traits like plant height, number of capsules plant$^{-1}$, number of primary branches plant$^{-1}$ and seed yield plant$^{-1}$. PC2 was also dominated by yield related traits like number of secondary branches plant$^{-1}$, 1000 seed weight and capsule length. PC3 was dominated by physiological and quality related traits like days to maturity and oil content. While, PC4 was more related to physiological traits like days to 50% flowering. On the basis of Principal Component Analysis, the germplasm ES-334962, EC-334992-1, ES-424, S-0069, ES-173, G-19 and GRT-8392 were selected with highest PC values for characters plant height, number of capsules, number of primary branches plant$^{-1}$, oil content, days to maturity and seed yield plant$^{-1}$.

***Keywords:*** Sesame, Physiological traits, Variability, Principal component analysis

Sesame (*Sesamum indicum* L.) is a self-pollinating crop with varying degrees of cross pollination (5 to 60%) depending on insect activity, environmental conditions and availability of other vegetation. Despite its low ranking in area and production among oilseeds in the country, sesame has upsurged as a silver line in the export with its contribution to the export earnings among the edible oilseeds of the country. Sesame being drought tolerant in nature, crop grows well in well drained soils of various agro-climatic regions during *kharif*, spring/summer seasons in North India and in all seasons in South India. Sesame has also been called a survivor crop having varieties well adapted to many soil types. It thrives best on well-drained, fertile soils of medium texture and neutral pH.

Seed yield is a complex trait and is reportedly associated with a number of component traits. These traits are themselves inter-related. Selection for seed yield can only be effective if the desired genetic variability is present in a genetic stock. However, the development of improved plant cultivars is restricted mainly due to narrow genetic pool, which results into limited possibility to restructure the sesame crop. Owing to lack of knowledge regarding relative importance and usefulness of variables, the investigator tries to include all the possible variables and makes the data matrix perceivably large, complicated and beyond comprehension. Therefore, a technique is required for systematic reduction and summarization of data sets. Principal Component Analysis (PCA) analyzes the data in which observations are described by several inter-correlated quantitative dependent variables (Abdi and Williams, 2010). PCA is a well-known method to identify the minimum number of components, which can explain maximum variability out of the total variability and also to rank germplasm on the basis of PC scores. The present designed with an objective to identify the minimum number of components, which can explain maximum variability out of the total variability and also to rank 96 sesame germplasm on the basis of PC scores.

## MATERIAL AND METHODS

The experiment was conducted at JNKVV, Jabalpur, India during *kharif* 2013 on medium black with uniform topography and free from water logged conditions. The region has sub-tropical, semi-arid conditions with hot and dry summer and cold winter with occasional showers. The average rainfall is about 1200 mm. The minimum and maximum temperatures range between 22°C to 35°C, respectively during the *kharif* season. The experimental material comprised of 96 germplasm of sesame with one check in randomized complete block design with two replications with net plot size of 7.2 m$^2$. Principal component analysis (PCA) is a standard tool in modern data analysis because it is a simple, non-parametric method for extracting relevant information from confusing data sets (Massay, 1965 and Jolliffie, 1986). It transforms a number of possibly correlated variables into a smaller number of uncorrelated variables called principal components.

## RESULTS AND DISCUSSION

PCA was preformed for phenological and yield component traits in germplasm lines of sesame. Out of ten, only nine principal components (PCs) exhibited more than 0.5 eigen value and showed about 95.19% total variability among the characters. Nine PCs were given due importance for further explanation. The per cent variability in PC1 was 20.33% while, in rest it varied from 6.05-15.38% for the traits under study (Table 1).

Rotated component matrix revealed that each principal component was separately loaded with various yield attributing traits under study. The PC1 was more related to the physiological and yield attributing traits *viz*., plant height, number of capsules plant$^{-1}$, number of primary branches plant$^{-1}$and seed yield plant$^{-1}$. Thus, PC1 allows for simultaneous selection of physiological and yield related traits and can be regarded as yield factor. PC2 exhibited positive effect for number of secondary branches plant$^{-1}$, capsule length and 1000 seed weight. The third principal component was more related to quality traits - oil content (%) and negatively related with days to maturity thus, applicable for shortening maturity and fourth component was more related to physiological traits like days to 50% flowering (Table 2). Similar results were reported by Kangbo *et al.* (2009) for plant height and 1000-seed weight, Saha *et al.* (2012) for days to flowering, days to maturity, plant height, number of branches plant$^{-1}$, number of capsules plant$^{-1}$, seed yield plant$^{-1}$ and 1000 seed weight, Iqbal *et al.* (2008) for seed yield plant$^{-1}$ and days to maturity and Badkul *et al.* (2014) for seed yield plant$^{-1}$ in soybean. On the basis of communalities, the days to 50% flowering were more promising for the selection among traits that were investigated. Many of the other traits like plant height (cm), number of primary branches plant$^{-1}$, number of secondary branches plant$^{-1}$, number of capsules plant$^{-1}$, capsule length (cm), days to maturity, 1000 seed weight (g), seed yield plant$^{-1}$ (g), oil content (%) may also be promising in breeding programmes. In future, above traits may be considered for the development of high yielding sesame varieties with good quality (Table 1 and 2).

Scree plot explained the percentage of variance associated with each principal component obtained by drawing a graph between eigen values and principal component numbers. PC1 showed 20.33% variability with eigen value 2.03, which then declined gradually. Semi-curve line is obtained which after eight PC tended to become straight with little variance observed in each PC. The maximum variation was observed in PC1 in comparison to other seven PCs. So, selection of lines from this PC will be useful (Fig. 1 and 2).

**PC scores of germplasm:** The PC scores of the each component (PC1, PC2, PC3, and PC4) had positive and negative values. In PC1, the positive scores ranged from 2.58 (ES-139-284) to 0.501 (G-19), while negative value ranged from -2.57 (IS-607-2-04) to -0.03 (NIC-6059). In PC2, the positive value of the component ranged from 1.96 (S-0627) to 0.56 (IS-424) and negative value ranged from -

**Table 1.** Eigen values, variance, cumulative eigen and extaction values of sesame germplasm

| Characteristics | Extraction | Principal component | Eigen values | Variations (% ) | Cumulative (%) |
|---|---|---|---|---|---|
| Days to 50% flowering | 0.843 | PC1 | 2.033 | 20.328 | 20.328 |
| Days to maturity | 0.604 | PC2 | 1.538 | 15.375 | 35.703 |
| Plant height | 0.536 | PC3 | 1.328 | 13.281 | 48.984 |
| No. of capsules plant$^{-1}$ | 0.687 | PC4 | 1.051 | 10.508 | 59.492 |
| No. of primary branches plant$^{-1}$ | 0.647 | PC5 | 0.897 | 8.968 | 68.459 |
| No. of secondary branches plant$^{-1}$ | 0.378 | PC6 | 0.848 | 8.483 | 76.942 |
| Capsule length | 0.557 | PC7 | 0.682 | 6.823 | 83.766 |
| 1000 seed weight | 0.444 | PC8 | 0.605 | 6.051 | 89.817 |
| Oil content (%) | 0.638 | PC9 | 0.538 | 5.381 | 95.198 |
| Seed yield plant$^{-1}$ | 0.614 | PC10 | 0.480 | 4.802 | 100.000 |

**Table 2.** Interpretation of rotated component matrix for the traits having values >±0.5 in each PC

| PC1 | PC2 | PC3 | PC4 |
|---|---|---|---|
| Plant height | No. of secondary branches plant$^{-1}$ | Days to maturity | Days to 50% flowering |
| No. of capsules plant$^{-1}$ | Capsule length | Oil content (%) | - |
| No. of primary branches plant$^{-1}$ | 1000 seed weight | - | - |
| Seed yield plant$^{-1}$ | - | - | - |

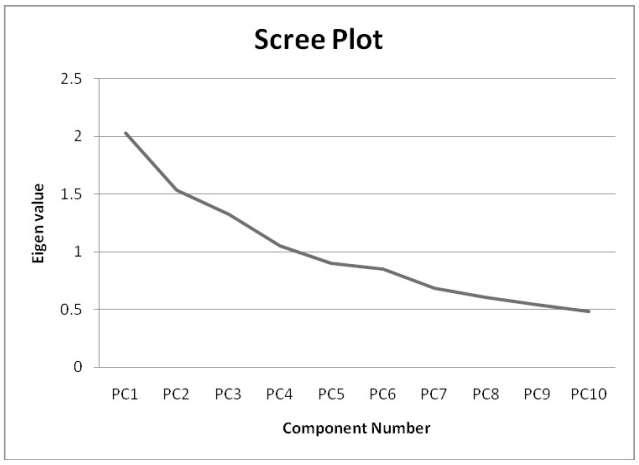


**Fig. 1.** Scree plot

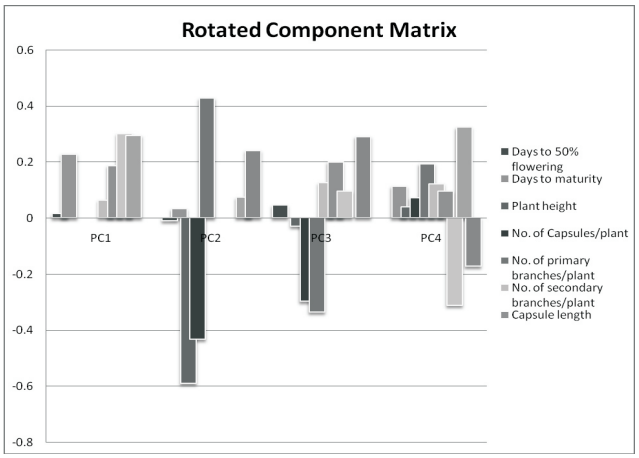


**Fig. 2.** Rotated component matrix

2.71 (IS-132295) to -0.54 (IS-77). In PC3, the positive value of the components ranged from 2.65 (EC-334967) to 0.51 (EC-173) and negative value ranged from -2.26 (GRT-8327) to -0.57 (IC- 152458). In PC4, the positive value of the components ranged from 2.35 (ES-334962) to 0.42 (RJS-Bo), while negative value ranged from -1.64 (ES-370) to -0.67 (KJS-21). Germplasm lines showing maximum positive PC scores and common in PC1, PC3 and PC4 are ES-334962 and EC-334992-1; IS-424 common in PC1, PC2, and PC3 and S-0069, ES-173, G-19 and GRT-8392, which are common in PC1 and PC3 accounts for maximum yield and quality traits. Thus, selection of these lines can help in further development of new high yielding quality varieties. While, lines NIC-7982 and S-0629 were common in PC1, PC2 and PC4 accounting for maximum yield traits. Maximum negative values were recorded in KJS-21, NIC-8055-1 and 78-20, which is common in PC1, PC2 and PC3; G-8 common in PC1, PC2, PC3 and PC4 and IS- 641-2-84 common in PC1, PC2 and PC4 (Table 3). Maximum negative values were recorded in KJS-21 (-2.01), 78-20 (-1.51) and NIC-8055-1 (-1.12), which was common in PC1, PC2 and PC3, G-8 (-1.31) was common in PC1, PC2, PC3 and PC4. Similarly, IS- 641-2-84 (-1.16) was common in PC1, PC2 and PC4 (Table 4).

## CONCLUSION

The germplasm ES-334962, EC-334992-1, ES-424, S-0069, ES-173, G-19 and GRT-8392 had highest PC values for plant height, number of capsules, number of primary branches plant$^{-1}$, oil content, days to maturity and seed yield plant$^{-1}$. Thus, these germplasm lines can be considered as an

**Table 3.** Germplasm selected on the basis of PC score in each component having positive values

| PC1 | PC2 | PC3 | PC4 |
|---|---|---|---|
| S-0627 (1.022) | S-0627 (1.95) | IS-436-3-84 (0.61) | S-0627 (1.28) |
| EC-334967 (0.98) | IS-436-3-84 (1.00) | EC-334967 (2.645) | IS-436-3-84 (0.51) |
| IS-387-2 (0.69) | IS-387-2 (0.76) | IS-387-2 (1.73) | EC-334967 (1.12) |
| NIC-7982 (1.21) | NIC-7982 (1.54) | EC-334992-1 (1.01) | NIC-7982 (1.46) |
| EC-334992-1 (1.38) | I-68 (0.64) | I-68 (2.22) | EC-334992-1 (0.54) |
| IS-424 (1.22) | S-0281 (1.85) | S-0281 (1.16) | I-68 (0.90) |
| ES-334962 (1.76) | IS-424 (0.56) | IS-424 (0.91) | S-0281 (1.43) |
| BS-10 (0.57) | BS-10 (1.53) | ES-334962 (1.26) | ES-334962 (2.34) |
| GT-10 (1.02) | GT-10 (0.83) | BS-10 (1.17) | GT-10 (1.92) |
| EC-131-1-84 (1.89) | ES-131-1-84 (0.69) | S-0069 (1.41) | RJS-Bo (0.41) |
| S-0069 (1.72) | ES-120-1-84-B (0.53) | ES-173 (0.51) | EC-334987 (1.28) |
| RJS-Bo (1.54) | - | G-19 (1.39) | WLR/92/NO/217Shal (0.83) |
| ES-120-1-84-B (0.964) | - | GRT-8392 (1.83) | - |

**Table 4.** Germplasm selected on the basis of PC score in each component having negative values

| PC1 | PC2 | PC3 | PC4 |
|---|---|---|---|
| NICC-8282 (-0.63) | NICC-8282 (-1.51) | G-8 (-0.80) | NICC-8282 (-1.17) |
| G-8 (-1.31) | G-8 (-1.66) | EC-35000 (-1.18) | G-8 (-1.22) |
| NIC-8055-1 (-1.12) | EC-35000 (-1.57) | GRT-8327 (-2.27) | EC-35000 (-0.85) |
| IS-641-2-84 (-1.16) | NIC-8055-1 (-0.82) | NIC-8055-1 (-1.19) | IS-641-2-84 (-0.64) |
| GRT-83128 (-1.31) | IS-641-2-84 (-0.99) | KJS-21 (-0.67) | GRT-8359 (-0.54) |
| KJS-21 (-2.01) | KJS-21 (-1.11) | IS-302 (-1.35) | IS-320 (-0.69) |
| 78-20 (-1.51) | IS-302 (-0.66) | IS-387 (-2.18) | 78-20 (-1.39) |
| NIC-6059 (-0.03) | 78-20 (-0.66) | NIC-9835 (-1.62) | NIC-6059 (-1.25) |
| IS-387 (-0.85) | NIC-6059 (-0.72) | G-40 (-1.29) | NIC-8062 (-1.22) |
| NIC-8062 (-0.54) | SI-3114 (-0.98) | NIC-8210 (-0.90) | IS-156-3-84 (-1.00) |
| NIC-9835(-1.15) | EC-334969 (-2.31) | - | NIC-8343 (-0.86 |
| IS-156-3-84 (-0.55) | IC-30884 (-0.73) | - | SI-3315-16 (-1.17) |
| G-40 (-0.67) | RJS-61 (-0.63) | - | Coredbose (-0.89) |

ideotype breeding material for selection and development of new varieties of sesame and for further utilization in future breeding programmes.

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# Effect of Post Harvest Treatments on Quality of Pomegranate in Zero Energy Cool Chamber and Ambient Conditions

**V.P. Kad and J.K. Dhemre**

*Post Harvest Technology Centre, Mahatma Phule Krishi Vidyapeeth, Rahuri-413 722, India*
*E-mail:vikramkad2014@gmail.com*

**Abstract:** Freshly harvested pomegranate 'Bhagwa' fruits were subjected to treatments of three types of lac based wax (SH-01, SH-02 & SH-03), five concentrations of lac based wax (0%,6%,12%,18%,20%) were kept at room temperature (19.7 to 26.9° C and 41.0 to 70.2 % RH ) and zero energy cool chamber (14.60 to 20.30°C and 83.59 to 91.90 % RH). There was an increase **in** total soluble solids, pH, sugars, physiological loss in weight, rotting percentage with corresponding decrease in aril percentage, rind percentage, juice percentage, acidity, anthocyanin and firmness irrespective of post harvest treatments. The physico-chemical changes were slower in zero energy cool chamber as compared to room temperature storage. The shelf life of pomegranate fruits Cv. Bhagwa treated with SH-03 (20%) lac based wax could be extended upto 32 days in zero energy cool chamber as compared to 12 days at room temperature storage with high overall acceptability and organoleptic score of 8.30 and 7.86 in zero energy cool chamber and ambient condition, respectively.

***Keywords***: Ambient storage, Pomegranate, Quality, shelf life, Wax, Zero energy cool chamber

In India, pomegranate is grown over an area of 131 lakh hectares with the production of 1346 lakh MT and the productivity is about 10.3 MT $ha^{-1}$. In Maharashtra, it is grown over an area of 90,000 hectares with the production of 945 Million Ton and the productivity is 10.5 MT $ha^{-1}$ (Anonymous, 2015). India's share in world export of pomegranate is 4.1 per cent, Spain (45% share) and Iran (15 % share) are major competitors to India in International market (Anonymous, 2012). Owing to lack of information on appropriate post-harvest treatments and storage, the fruits not only lose their quality, but also encounter a substantial post- harvest loss. The research efforts have helped to increase the production of pomegranate fruit but the purpose of obtaining maximum profit will be served only if the increased production is supplemented with the similar efforts to minimize the post harvest losses and enhance the shelf life. Zero energy cool chamber plays a vital role in maintaining quality soon after harvest for domestic marketing. Lac based wax coating is used for extending the shelf life of many fruit in addition of packaging and storage as it is bio-degradable, non- toxic, tasteless, ecofriendly and self-sustaining nature (Sarkar, 2003). Therefore, a study was conducted with the objective to retain quality and to extend the shelf life of pomegranate fruit under zero energy cool chamber.

## MATERIAL AND METHODS

Pomegranate fruit 'Bhagwa' were obtained from the orchards of progressive farmers of Rahuri Tahsil, Dist. Ahmednagar. The fruits were sorted out to eliminate bruised, punctured and damaged ones during transport. Soon after sorting, the fruits were washed thoroughly in running water, drained and then the fruits were subjected to the treatments of three types of lac based wax (SH-01, SH-02 & SH-03) with five concentrations (0, 6, 12, 18 and 20%) (Table 1).Treated and untreated (control) fruits of uniform size (15 numbers) were packed in export quality corrugated fibre board (CFB) box. Two lots of such packed materials were prepared and one lot of these was stored at room temperature (19.7 to 26.9°C and 41.0 to 70.2 %RH) and zero energy cool chamber (14.60 to 20.30°C and 83.59 to 91.90 % RH) with three replications in Completely Randomized Design during the year 2013-2015.

**Physico-chemical parameters:** The physical observations on aril (%), juice (%), rind (%), physiological loss in weight (%), and rotting (%) was recorded. The chemical parameters such as total soluble solids was determined by hand refractometer in terms of °Brix (A.O.A.C., 2005) and the acidity was determined in terms of per cent anhydrous citric acid by the method given by Ranganna (1986). The total sugars was determined by method given by Lane and Eynon (1960).The anthocyanin content (mg/100 ml) pigments were measured by the method reported by Khurdiya and Roy (1984). Firmness of pomegranate fruits was measured by using Texture Analyser (M/s Brookfield Engineering labs, USA make).

**Organoleptic evaluation:** The organoleptic evaluation for assessing the colour, flavour, taste and overall acceptability was worked out by judges using nine point Hedonic scale (Amerine *et al*., 1965).

**Table 1.** Treatment combinations

| Room temperature (RT) | | Zero energy cool chamber (ZECC) | |
|---|---|---|---|
| Sr. No. | Combination | Sr. No. | Combination |
| $T_1$ | $S_1W_1C_1$ | $T_1$ | $S_2W_1C_1$ |
| $T_2$ | $S_1W_1C_2$ | $T_2$ | $S_2W_1C_2$ |
| $T_3$ | $S_1W_1C_3$ | $T_3$ | $S_2W_1C_3$ |
| $T_4$ | $S_1W_1C_4$ | $T_4$ | $S_2W_1C_4$ |
| $T_5$ | $S_1W_1C_5$ | $T_5$ | $S_2W_1C_5$ |
| $T_6$ | $S_1W_2C_1$ | $T_6$ | $S_2W_2C_1$ |
| $T_7$ | $S_1W_2C_2$ | $T_7$ | $S_2W_2C_2$ |
| $T_8$ | $S_1W_2C_3$ | $T_8$ | $S_2W_2C_3$ |
| $T_9$ | $S1W_2C_4$ | $T_9$ | $S2W_2C_4$ |
| $T_{10}$ | $S_1W_2C_5$ | $T_{10}$ | $S_2W_2C_5$ |
| $T_{11}$ | $S_1W_3C_1$ | $T_{11}$ | $S_2W_3C_1$ |
| $T_{12}$ | $S_1W_3C_2$ | $T_{12}$ | $S_2W_3C_2$ |
| $T_{13}$ | $S_1W_3C_3$ | $T_{13}$ | $S_2W_3C_3$ |
| $T_{14}$ | $S_1W_3C_4$ | $T_{14}$ | $S_2W_3C_4$ |
| $T_{15}$ | $S_1W_3C_5$ | $T_{15}$ | $S_2W_3C_5$ |

A. Storage conditions: $S_1$ : Room temperature (RT); $S_2$ : Zero energy cool chamber (ZECC): B. Lac based wax:$W_1$-SH-01; $W_2$ - SH-02; $W_3$- SH-03 ; C. Concentrations of lac based wax: $C_1$ : 0 % (control); $C_2$ : 6 %; $C_3$ : 12 %; $C_4$ : 18 %; $C_5$ : 20 %

## RESULTS AND DISCUSSION

**Aril:** The aril per cent decreased with the increase in storage period in all the treatment combinations (Table 2). The rate of decrease was faster at RT than in ZECC might be due to temperature or respiration. Initially, the aril per cent of fruit was 63.10 per cent. At the end of 12$^{th}$ day of storage period at RT, $T_{15}$ and $T_{14}$ recorded the highest aril per cent (54.12 and 54.08 per cent, respectively) while the lowest aril per cent was in $T_1$ (53.80 %). At the end of 32 days of storage in ZECC, treatment $T_{15}$ and treatment $T_{14}$ recorded the highest aril per cent (56.85 and 56.84 %), respectively, while the lowest aril per cent was in treatment $T_1$ (56.62%). The arils per cent were non-significant in ZECC. These results are comparable to the result reported by Navale *et al*. (2010), Caleb *et al*. (2013) and Aindongo *et al*. (2014) in pomegranate fruit.

**Juice:** The juice per cent decreased with the increase in storage period in all the treatment combinations. The rate of decrease was faster at RT than in ZECC due to loss of moisture. Initially, the juice per cent of fruit was 38.11 per cent. At the end of 12$^{th}$ day of storage period at RT, $T_{15}$ and $T_{14}$ recorded the highest juice per cent (27.42 and 27.40 %, respectively), while the lowest juice per cent was in $T_1$ (27.05 %) and differences were significant. At the end of 32 days in ZECC, $T_{15}$ and $T_{14}$ recorded the highest juice per cent (28.67 and 28.65 %, respectively) while the lowest juice per cent was recorded in $T_1$ (28.40 %). The juice per cent was non-significant in ZECC. These results are comparable to the result reported by Waskar (2011) in pomegranate.

**Rind:** The rind per cent of fresh fruit was 36.90 and decreased significantly with the increase in storage period in all the treatment combinations. The rate of decrease of rind per cent was faster at RT as compared to ZECC. At the end of 12$^{th}$ day of storage period at RT, $T_{15}$ and $T_{14}$ recorded the highest rind per cent (30.90 and 30.86 %, respectively) . At the end of 32 days of storage in ZECC, $T_{15}$ and $T_{14}$ recorded the highest rind per cent (28.65 and 28.60 %, respectively) while the lowest rind per cent was recorded in $T_1$ (24.66%). This might be due to temperature or respiration. These results are comparable to the result reported by Nanda *et al.* (2001) and Navale *et al*. (2010) in pomegranate fruit.

**Firmness:** Initially, the firmness (N) of fruit was 27.67 and decreased significantly with the increase in storage period in all the treatment combinations. The fruit stored under ZECC showed slow decrease in firmness than RT. At the end of 12$^{th}$ day of storage period at RT, $T_{15}$ and $T_{14}$ recorded the highest firmness (21.97 and 21.75, respectively) while the lowest firmness was recorded in $T_1$ (18.21). Similar trend was observed at the end of 32 days of storage in ZECC, The post-harvest storage of pomegranate fruit is accompanied by loss of cell-wall integrity due to breakdown of pectic substances leading to an increase in soluble pectin and decrease in fruit firmness. Similar results were reported by Kalyan Barman *et al.* (2011); Bhatia *et al*. (2013); Kumar *et al*. (2013) and Tabtabaekoloor and Ebrahimpor (2013) .

**Total soluble solids:** The TSS was increased significantly with the increase in storage period in all the treatment combinations (Table 2) and the rate of increase was e faster at RT than in ZECC storage. The TSS of fresh fruit was 16.55$^0$Brix. At the end of 12$^{th}$ day of storage period at RT, $T_{15}$ and $T_{14}$ recorded the lowest TSS (19.05 and 19.14$^0$Brix, respectively) while the highest TSS was recorded in $T_1$ (19.60$^0$Brix). Similar trend was observed at the end of 32 days of storage in ZECC . The slower rate of increase in TSS in ZECC was attributed to lower temperature and higher relative humidity which resulted in lower utilization of soluble solids. The TSS might be increased due to hydrolysis of starch and other insoluble carbohydrates into soluble sugars or might be due to decrease in moisture content. Similar results were also reported by Chandra *et al.* (2013) in pomegranate.

**Acidity:** Initially, the acidity of fruit was 0.410 per cent and was decreased with non-significant differences with the increase in storage period in all the treatment combinations (Table 2). The decline rate was faster at RT than in ZECC storage. At the end of 12$^{th}$ and 32 days of storage period at

**Table 2.** Effect of various post harvest treatments on physico- chemical changes of pomegranate fruits during storage under various storage conditions

| Particulars | Storage Period (days) | Treatments | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | $T_1$ | $T_2$ | $T_3$ | $T_4$ | $T_5$ | $T_6$ | $T_7$ | $T_8$ | $T_9$ | $T_{10}$ | $T_{11}$ | $T_{12}$ | $T_{13}$ | $T_{14}$ | $T_{15}$ | SE | CD |
| Aril (%) | | | | | | | | | | | | | | | | | | |
| Initial | 0 day | 63.10 | 63.10 | 63.10 | 63.10 | 63.10 | 63.10 | 63.10 | 63.10 | 63.10 | 63.10 | 63.10 | 63.10 | 63.10 | 63.10 | 63.10 | - | - |
| RT | 12th day | 53.80 | 53.86 | 53.92 | 54.01 | 54.06 | 53.80 | 53.84 | 53.90 | 53.98 | 54.04 | 53.80 | 53.88 | 53.95 | 54.08 | 54.12 | 0.09 | 0.025 |
| ZECC | 32nd day | 56.62 | 56.68 | 56.72 | 56.78 | 56.82 | 56.62 | 56.67 | 56.71 | 56.77 | 56.80 | 56.62 | 56.69 | 56.74 | 56.84 | 56.85 | 0.09 | NS |
| Juice (%) | | | | | | | | | | | | | | | | | | |
| Initial | 0 day | 38.11 | 38.11 | 38.11 | 38.11 | 38.11 | 38.11 | 38.11 | 38.11 | 38.11 | 38.11 | 38.11 | 38.11 | 38.11 | 38.11 | 38.11 | - | - |
| RT | 12th day | 27.05 | 27.12 | 27.21 | 27.30 | 27.37 | 27.05 | 27.10 | 27.19 | 27.27 | 27.33 | 27.05 | 27.15 | 27.24 | 27.40 | 27.42 | 0.09 | 0.025 |
| ZECC | 32nd day | 28.40 | 28.48 | 28.51 | 28.58 | 28.62 | 28.40 | 28.43 | 28.50 | 28.56 | 28.60 | 28.40 | 28.48 | 28.53 | 28.65 | 28.67 | 0.011 | NS |
| Rind (%) | | | | | | | | | | | | | | | | | | |
| Initial | 0 day | 36.90 | 36.90 | 36.90 | 36.90 | 36.90 | 36.90 | 36.90 | 36.90 | 36.90 | 36.90 | 36.90 | 36.90 | 36.90 | 36.90 | 36.90 | - | - |
| RT | 12th day | 26.19 | 28.59 | 29.38 | 30.10 | 30.74 | 26.19 | 27.75 | 29.16 | 29.97 | 30.38 | 26.19 | 29.02 | 29.69 | 30.86 | 30.90 | 0.09 | 0.025 |
| ZECC | 32nd day | 24.66 | 26.74 | 27.58 | 28.46 | 28.54 | 24.66 | 26.11 | 27.24 | 28.10 | 28.25 | 24.66 | 27.10 | 28.00 | 28.60 | 28.65 | 0.011 | 0.030 |
| Firmness (N) | | | | | | | | | | | | | | | | | | |
| Initial | 0 day | 27.67 | 27.67 | 27.67 | 27.67 | 27.67 | 27.67 | 27.67 | 27.67 | 27.67 | 27.67 | 27.67 | 27.67 | 27.67 | 27.67 | 27.67 | - | - |
| RT | 12th day | 18.21 | 18.68 | 19.78 | 20.78 | 21.31 | 18.21 | 18.45 | 19.54 | 20.31 | 21.05 | 18.21 | 19.21 | 20.10 | 21.75 | 21.97 | 0.009 | 0.025 |
| ZECC | 32nd day | 19.23 | 19.78 | 21.24 | 22.45 | 23.35 | 19.23 | 19.45 | 20.78 | 22.08 | 23.03 | 19.23 | 20.23 | 21.69 | 23.86 | 24.25 | 0.011 | 0.030 |
| Total soluble solids ( $^0$Brix) | | | | | | | | | | | | | | | | | | |
| Initial | 0 day | 16.55 | 16.55 | 16.55 | 16.55 | 16.55 | 16.55 | 16.55 | 16.55 | 16.55 | 16.55 | 16.55 | 16.55 | 16.55 | 16.55 | 16.55 | - | - |
| RT | 12th day | 19.60 | 19.54 | 19.38 | 19.26 | 19.17 | 19.60 | 19.57 | 19.43 | 19.28 | 19.22 | 19.60 | 19.50 | 19.33 | 19.14 | 19.05 | 0.008 | 0.023 |
| ZECC | 32nd day | 19.39 | 19.31 | 19.18 | 18.99 | 18.91 | 19.39 | 19.35 | 19.25 | 19.05 | 18.95 | 19.39 | 19.28 | 19.13 | 18.88 | 18.82 | 0.011 | 0.030 |
| Acidity (%) | | | | | | | | | | | | | | | | | | |
| Initial | 0 day | 0.410 | 0.410 | 0.410 | 0.410 | 0.410 | 0.410 | 0.410 | 0.410 | 0.410 | 0.410 | 0.410 | 0.410 | 0.410 | 0.410 | 0.410 | - | - |
| RT | 12th day | 0.250 | 0.253 | 0.256 | 0.258 | 0.259 | 0.250 | 0.252 | 0.255 | 0.258 | 0.259 | 0.250 | 0.253 | 0.256 | 0.260 | 0.262 | 0.001 | NS |
| ZECC | 32nd day | 0.255 | 0.258 | 0.259 | 0.261 | 0.263 | 0.255 | 0.257 | 0.259 | 0.261 | 0.263 | 0.255 | 0.258 | 0.260 | 0.265 | 0.266 | 0.001 | NS |
| Total sugars (%) | | | | | | | | | | | | | | | | | | |
| Initial | 0 day | 15.95 | 15.95 | 15.95 | 15.95 | 15.95 | 15.95 | 15.95 | 15.95 | 15.95 | 15.95 | 15.95 | 15.95 | 15.95 | 15.95 | 15.95 | - | - |
| RT | 12th day | 18.59 | 18.57 | 18.55 | 18.32 | 18.49 | 18.59 | 18.58 | 18.56 | 18.53 | 18.50 | 18.59 | 18.57 | 18.54 | 18.48 | 18.47 | 0.009 | 0.025 |
| ZECC | 32nd day | 19.25 | 19.12 | 18.97 | 18.87 | 18.76 | 19.25 | 19.18 | 19.01 | 18.89 | 18.83 | 19.25 | 19.09 | 18.95 | 18.72 | 18.67 | 0.011 | NS |
| Anthocyanin content(mg/100 ml) | | | | | | | | | | | | | | | | | | |
| Initial | 0 day | 85.39 | 85.39 | 85.39 | 85.39 | 85.39 | 85.39 | 85.39 | 85.39 | 85.39 | 85.39 | 85.39 | 85.39 | 85.39 | 85.39 | 85.39 | - | - |
| RT | 12th day | 64.06 | 64.73 | 65.51 | 66.13 | 66.76 | 64.06 | 64.52 | 65.34 | 65.96 | 66.44 | 64.06 | 65.01 | 65.68 | 67.05 | 67.38 | 0.09 | 0.025 |
| ZECC | 32nd day | 71.19 | 71.22 | 71.28 | 71.33 | 71.37 | 71.19 | 71.21 | 71.26 | 71.31 | 71.36 | 71.19 | 71.24 | 71.30 | 71.39 | 71.41 | 0.011 | NS |
| Physiological loss in weight (%) | | | | | | | | | | | | | | | | | | |
| Initial | 0 day | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | - | - |
| RT | 12th day | 15.86 | 13.46 | 12.67 | 11.95 | 11.31 | 15.86 | 14.30 | 12.89 | 12.08 | 11.67 | 15.86 | 13.03 | 12.36 | 11.19 | 11.09 | 0.011 | 0.030 |
| ZECC | 32nd day | 14.47 | 12.39 | 11.55 | 10.67 | 10.59 | 14.47 | 13.02 | 11.89 | 11.03 | 10.88 | 14.47 | 12.03 | 11.13 | 10.53 | 10.48 | 0.011 | 0.030 |

RT: Room Temperature; ZECC: Zero Energy Cool Chamber

RT, $T_{15}$ and $T_{14}$ recorded the highest acidity while the lowest acidity per cent was recorded in $T_1$. Decline in acidity was faster at RT could be attributed to higher rate of respiration at RT storage as reported by Khedkar (1997); Waskar (2011); Fawole and Opara (2013) and Kumar *et al.* (2013) in pomegranate.

**Total sugars:** Initially, the total sugar content of fruit was 15.95 per cent and increased with the increase in storage period in all the treatment combinations (Table 2). At the end of 12th and 32 days of storage period at RT, $T_{15}$ and $T_{14}$ recorded the lowest total sugar content while the highest total sugar content was recorded in $T_1$ and differences were significant. The slower rate of increase in total sugar in ZECC was attributed to lower temperature and higher relative humidity which resulted in slower rate of respiration, lower enzymatic activities which helps in slow build up of sugars with reduced utilization in respiration or might be due to the fact that the high temperature and low humidity during RT storage resulted in faster hydrolysis of starch and other insoluble carbohydrates into soluble sugars. Similar results were reported by Dhemre (2001) in mango; Ahire (2007) and Bhatia *et al*. (2013) in pomegranate.

**Total anthocyanin content:** The anthocyanin content decreased with the increase in storage period in all the treatment combinations. Fruit stored under ZECC showed slow decrease in anthocyanin content than RT. Initially, the anthocyanin content of fruit was 85.39 mg/100 ml. At the end of 12th and 32 days of storage period at RT, $T_{15}$ and $T_{14}$ recorded the highest anthocyanin content and differences were significant in various treatments. This might be due to degraded coloured pigments because of increased polyphenoloxidase (PPO) activity, chalcone formation and slower breakdown of protective 3,5-diglucoside and 3-glucoside linkage at a temperature more than 5°C, slow biosynthesis of coloured pigments and/ or *de novo synthesis* of anthocyanins at low temperature and, stabilizing effect of glycolisation (Ahire, 2007; Mangave, 2010; Dhumal, 2012).

**Physiological loss in weight:** At the end of 12th day of storage period at RT, $T_{15}$ and $T_{14}$ recorded the lowest physiological loss in weight per cent (11.09 and 11.19 %, respectively) while the highest physiological loss in weight was recorded in $T_1$ (15.86%). At the end of 32 days of storage in ZECC, $T_{15}$ and $T_{14}$ recorded the lowest physiological loss in weight per cent (10.48 and 10.53 %, respectively) while the highest physiological loss in weight was recorded in $T_1$ (14.47%). The rate of increase in physiological loss in weight was found to be significantly faster at RT storage as compared to ZECC storage might be due to temperature or rate of respiration. Results are in accordance with the findings reported by Dhemre (2001) for mango; Waskar (2011) and Kumar *et al*. (2013) for pomegranate fruit.

**Organoleptic evaluation:** The decrease in organoleptic

**Table 3.** Effect of various post harvest treatments on organoleptic score of pomegranate Cv. Bhagwa under different storage conditions

| Treatments | Organoleptic score | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 12th day at RT | | | | 32nd day in ZECC | | | |
| | Color | Flavour | Texture | Overall | Color | Flavour | Texture | Overall |
| $T_1$ | 4.65 | 4.93 | 4.93 | 4.70 | 5.03 | 5.14 | 5.46 | 5.21 |
| $T_2$ | 4.94 | 5.32 | 5.06 | 5.10 | 5.53 | 5.64 | 5.96 | 5.71 |
| $T_3$ | 5.84 | 6.19 | 6.22 | 6.08 | 6.46 | 6.73 | 6.34 | 6.51 |
| $T_4$ | 6.52 | 6.94 | 6.68 | 6.71 | 7.56 | 7.28 | 7.22 | 7.35 |
| $T_5$ | 73.33 | 7.08 | 7.40 | 7.27 | 7.24 | 7.91 | 8.05 | 7.86 |
| $T_6$ | 4.65 | 4.93 | 4.93 | 4.70 | 5.03 | 5.14 | 5.46 | 5.21 |
| $T_7$ | 4.86 | 4.92 | 5.24 | 5.00 | 5.26 | 5.61 | 5.34 | 5.4 |
| $T_8$ | 5.64 | 5.92 | 5.54 | 5.70 | 6.43 | 6.08 | 6.11 | 6.2 |
| $T_9$ | 6.48 | 6.38 | 6.74 | 6.53 | 6.84 | 7.26 | 6.93 | 7.01 |
| $T_{10}$ | 6.82 | 7.26 | 6.95 | 7.01 | 7.32 | 7.74 | 7.44 | 7.5 |
| $T_{11}$ | 4.65 | 4.93 | 4.93 | 4.70 | 5.03 | 5.14 | 5.46 | 5.21 |
| $T_{12}$ | 5.38 | 5.20 | 5.63 | 5.40 | 6.22 | 5.97 | 5.84 | 6.01 |
| $T_{13}$ | 3.13 | 6.46 | 6.08 | 6.22 | 6.93 | 6.84 | 6.58 | 6.78 |
| $T_{14}$ | 7.42 | 7.73 | 7.36 | 7.50 | 8.32 | 7.96 | 8.08 | 8.12 |
| $T_{15}$ | 7.70 | 8.00 | 7.90 | 7.86 | 8.26 | 8.54 | 8.11 | 8.30 |

RT: Room Temperature; ZECC: Zero Energy Cool Chamber

score for colour, flavor, texture and overall acceptability was rapid at RT storage as compared to ZECC (Table 3). At the end of storage period i.e.12$^{th}$ day at RT, the highest score 7.86 was obtained by $T_{15}$ followed by $T_{14}$ (7.50). At the end of storage period i.e. 32$^{nd}$ day similar trend was observed. Similar finding were reported by Kumar *et al*. (2013) in pomegranate.

The present study made it clear that Zero energy cool chamber played a vital role in maintaining the quality of pomegranate fruits soon after harvest. Therefore, it is concluded that the pomegranate fruits coated with SH-03 (20%) lac based wax had a great significance in retaining the physico-chemical characteristics and maintaining the quality during storage. The shelf life of pomegranate fruit was extended upto 32 days in ZECC and 12 days in RT and was also found to be beneficial in extending the shelf life of pomegranate fruit.

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# Evaporation Estimation by Multilayer perceptron Based Artificial Neural Network and Multiple Linear Regression Techniques

**Bhagwat Saran, P.S. Kashyap and Pankaj Kumar**

*Department of Soil and Water Conservation Engineering,*
*G.B. Pant University of Agriculture and Technology, Pantnagar-263 145, India*
*E-mail: saran.bhagwat007@gmail.com*

***Abstract***: In the present study an attempt has been develop artificial neural network (ANN) and multiple linear regressions (MLR) for estimation of weekly evaporation (Ep) for Pantnagar, Uttarakhand, India. The weeklydata of temperature (T), relative humidity (Rh), wind velocity (W), sunshine hours (S) and evaporation (Ep) data of years 1976-2005 were used to train the models and remaining data of years 2006-2014 were used for test the models for ANN and MLR. The performance of the ANN with four input parameters were better than the MLR (for the test data set, $R^2$for ANN with DBD and L-M learning rule varies from 0.9046 to 0.8975, CE varies from 0.9603 to 96.25and RMSE varies from 1.0322 to 1.0062 by trial and error methods.

***Keywords:*** Activation functions, Artificial neural network (ANN), Learning algorithm, Meteorological parameters, Multiple-linear regression (MLR)

The prediction of evaporation amount is of crucial importance in the management of water resources, irrigation, soil conservations and water balance. Accurate estimation of evaporation is essential for the balancing of irrigation water use in arid and semiarid regions, highly conditioned by water shortages, where responsible irrigation engineering and watershed management is mandatory. Estimation of the water loss is primary importance for monitoring, survey and management of water resources, design of irrigation and drainage systems and irrigation scheduling (Molina Martinez *et al*., 2005; Gundekar *et al*., 2008). It is a key factor for irrigation system design and management, crop production, environmental assessment water resources management and planning. Water resource managers are confronted with the great challenge of scarcity. Scarcity is increasingly becoming the most important environmental constraints limiting plant growth in many regions. Over thirty arid and semi-arid countries are likely to have water scarcity in 2025. This will consequently affect the development, threaten food supplies, and aggravate rural poverty. In areas with little rainfall, evaporation losses can represent a significant part of the water budget for a lake or reservoir and may contribute significantly to the lowering of the water surface elevation.

Estimation of evaporation for remote rural areas where no evaporation data are available is of great attention to the hydrologists and meteorologists (Kisi, 2006). Sudheer *et al*. (2002) showed that the neural computing technique could be employed successfully in modelling the evaporation process from the available climatic data set. However, an analysis of the residuals from the ANN models developed revealed that the models showed significant error in predictions during the validation, implying loss of generalization of ANN models unless trained carefully. In the last decades, artificial neural networks (ANNs) have been successfully applied in water resources management. Recent experiment have reported that ANN may offer a promising alternative in the hydrological context (Kisi, 2006, 2009; Tan *et al.,* 2007; Kekin and Terzi, 2006) developed feed forward ANN models for modelling daily evaporation and the ANN model performed better the conventional method. Enough research has been carried out on evaporation using ANN with few years' climatic data but this research has been carried out using long term climatic data. An attempt has been made to develop models for computation of evaporation by the available whether data of Pantnagar.

## MATERIAL AND METHODS

This study was conducted at Pantnagar; situated in sub-humid and subtropical climatic zone in Tarai belt of Shivalik range, of foot hills of Himalayas. Geographically it is located at 29˚N latitude and 79.29˚E longitude, at 243.84m elevation above mean sea level. Geographical area of Pantnagar is 10,016.29 acres. Maximum rain is received from south-west monsoon during four months rainy season from June to September is 1364 mm. The temperature variation is very large, as summer holding temperature maxima of around 42 to 45 ºC while in winter, it falls heavily to 2 to 4 ºC. The mean relative humidity remains almost 80-90 per cent from mid-June to February end. The average pH value of the soil is 7.2 to 7.4; the soil of this region is good for agriculture and holds enough moisture to produce good crops.The weekly weather data of maximum and minimum temperature, wind velocity, relative humidity ($Rh_1$ was recorded in morning at 7 am and relative humidity ($Rh_2$) was recorded in afternoon at 2 pm at

Indian Standard Time, sunshine hour and evaporation of 39 years (468 months) for the year 1976 to 2014 were collected from Meteorological Observatory at Crop Research Centre (CRC) of G.B. Pant University of Agriculture and Technology, Pantnagar.

**Development of models for study area:** For study area, the dataset formulation was taken as standard meteorological weather data of; mean of maximum and minimum temperature, mean of relative humidity, sunshine hours and wind velocity as input and remaining evaporation data was used for output. **T**otal number of data for each year's period comes out to be 52. Then the whole numbers of data of 39 year are 2028. Data of years 1976 to 2005 (1560) were used for training of the models and remaining data 2006 to 2014 (468) were used for testing of the models.

**Artificial Neural Networks (ANNs):** In the present study, the two different algorithms (i.e. Levenberg–Marquardt, Delta-Bar-Delta) were applied with multiple linear regressions, in order to identify the one which best train the network. The best learning algorithm, activation function and architecture of the network (the number of hidden layers and neurons in hidden layers) were determined by trial and error. In this study, an adaptive technique; Delta-bar-Delta and Levenberg–Marquardt based on the generalized delta rule was adopted.

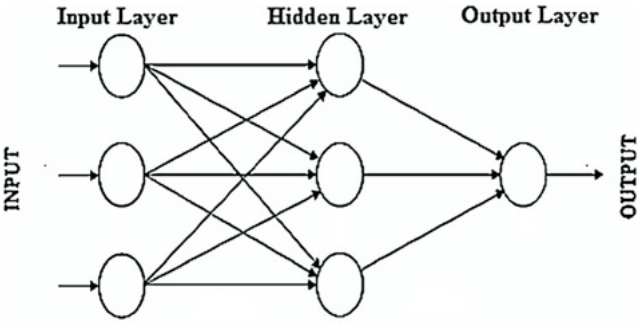


**Fig. 1.** Architecture of multilayer feed forward neural network

Let $x_i (i = 1,2, \ldots n)$ are inputs and $w_i (i = 1,2, \ldots n)$ are respective weights. The net input to the node can be expressed as

$$net = \sum_{i=1}^{n} x_i w_i \quad \text{.....(1)}$$

The net input is then passed through an activation function *f (net)* and the output *y* of the node is computed as-

$$y = f\ (net) \quad \text{…….(2)}$$

In the feed-forward calculation, the nodes in the input layer receive the input signals which are passed to the hidden layer and then to the output layer. The signals are multiplied by the current values of weights, and then the weighted inputs are added to yield the net input to each neuron of the next layer. The net input of a neuron is passed through an activation or transfer function to produce the output of the neuron.

The net input to $j^{th}$ node of the hidden layer is given by-

$$neth_j = \sum_{i=1}^{ni} wh_{ji} x_i \quad \text{.....(3)}$$

Where, *ni* is the number of neurons in the input layer and $wh_{ji}$ is the connection weight between $i^{th}$ node of the input layer and $j^{th}$ node of the hidden layer. The output of $j^{th}$ node of the hidden layer $h_j$ is-

$$h_j = f(neth_j) \quad \text{…….(4)}$$

In this study activation functions TanhAxonalong with different two learning algorithms (Delta bar Delta and Levenberg-Marquardt) of artificial neural network are used and they are briefly described below.

**Activation Functions**

The activation function is the formula used to determine the output of a processing neuron. The TanhAxon applies a bias and tanh function to each neuron in the layer. This will be square of the range of each neuron in the layer to between -1 to 1. Such nonlinear elements provide a network with the ability to make soft decisions.

$$f(x_i, w_i) = \tanh[x_i^{lin}] \quad \text{.....(5)}$$

Where,

$x_i^{lin} = \beta x_1$ is the scaled and offset activity inherited from the linear Axon.

**Learning Algorithms**

**Delta-Bar-Delta:** The Delta-Bar-Delta is an adaptive step-size procedure for searching a performance surface. Step size and momentum are adapted according to the previous values of the error at the neurons. If the current and past weight updates are both of the same sign, it increases the learning rate linearly. The reasoning is that if the weight is being moved in the same direction to decrease the error, then it will get there faster with a larger step size. If the updates have different signs, this is an indication that the weight has been moved too far. When this happens, the learning rate decreases geometrically to avoid divergence (Haciismailoglu *et al.*, 2009).

**Levenberg–Marquardt:** The Levenberg–Marquardt (LM) algorithm is one of the most appropriate higher-order adaptive algorithms known for minimizing the MSE of a neural network. It is a member of a class of learning algorithms called "pseudo second- order methods". Standard gradient descent algorithms use only the local approximation of the slope of the performance surface (error vs. weights) to determine the best direction to move the

weights for lowering the error.

**Multiple linear regressions (MLR):** 1560 data point are used to developed regression equation and remaining 468 data sets are used to validate the developed equation. The regression equation is;

$$Y = b_0 + b_1X_1 + b_2X_2 + \ldots\ldots\ldots + b_nX_n \quad \ldots\ldots\ldots (6)$$

Where, Y is the dependent variable (evaporation), $b_0$, $b_1$, $b_2$,.....$b_n$ are the regression coefficient for the linear equation, and $X_1, X_2, \ldots\ldots X_n$ are the independent variables (relative humidity, wind velocity, sunshine hour and temperature).

**Criteria of Evaluation**

**Root mean square error (RMSE):** The RMSE is a frequently used measure of the differences between values predicted by a model and estimated, the values actually observed. RMSE is a good measure of accuracy. The root mean square error is zero for perfect fit and increased values indicate higher discrepancies between estimated and observed values. The root mean square errors of the models were computed by the following equation:

$$RMSE = \sqrt{\frac{\sum_{j=1}^{n}\left(Y_j - Y_{ej}\right)^2}{n}} \quad \ldots\ldots\ldots (7)$$

Where, $Y_j$ = Observed values; *Y*ej = Estimated values and; *n* = Number of observations

**Coefficient of determination ($R^2$):** The coefficient of determination ($R^2$) is a measure of the proportion of variance of a predicted outcome. With a value of 0 to 1, the coefficient of determination is calculated as the square of the correlation coefficient (R) between the sample and predicted data. Its value represents the percentage of variation that can be explained by the regression equation. A value of 1 means every point on the regression line fits the data. It is calculated by following formula:

$$R^2 = \frac{\sum_{i=1}^{n}(Yij - Yej)(Yie - Yme)}{\sqrt{\sum_{i-1}^{n}(Yij - Yme)^2 \sum_{i=1}^{n}(Yie - Yme)^2}} \quad \ldots\ldots\ldots (8)$$

Where,

Yij= observed value at the $i^{th}$ time step,
Yie = corresponding simulated values,
n = number of time steps,
Yej = mean of observational values and
Yme = mean value of the simulations

**Coefficient of efficiency (CE):** The coefficient of efficiency (CE) in percentage is computed by following equation-

$$CE = \left(1 - \frac{\sum_{i=1}^{n}(Yj - Yej)^2}{\sum_{i=1}^{n}(Yj - )^2}\right) \times 100 \quad \ldots\ldots\ldots (9)$$

Where, $Y_j$ = Observed values; *Y*ej = Estimated values and; *n* = mean of observed values

## RESULTS AND DISCUSSION

Various networks of single and two hidden layers were trained for a maximum iteration of 1000, step size 1, additive 1, multiplicative 0.10 and smoothing 0.50 with different hidden neurons to choose best suited networks was selected based on the minimum value of root mean square error (RMSE), maximum value of coefficient of determination ($R^2$) and coefficient of efficiency (CE) by trial and error method. Different ANN architectures were tried using these inputs and the appropriate model structures were determined for each input combination. Then, the ANN and MLR models were tested and the results were compared by means of coefficient of determination, coefficient of efficiency and root mean square error statistics. 1568 data sets were used for training and 468 data sets were used for testing for both ANN and MLR models. In case of Delta bar Delta and TanhAxon based evaporation estimation model was evaluated by the comparing ordinates of observed and estimated graphs. The coefficient of determination ($R^2$), root mean square error (RMSE) and coefficient of efficiency (CE) are evaluated shown in Table 1. The observed and estimated values of evaporation for training and testing period are shown in figures 2 &3, respectively. It is observed from above figures that there is a close agreement between observed and predicted evaporation and over all shape of the plot of estimated evaporation is similar to that of the observed evaporation. The value of RMSE were calculated by using equation (7), to select the best network for training and testing period varies from 0.8561 to 1.0322 for network (4-5-5-1). The value of $R^2$ were calculated by equation (8), during testing and training period $R^2$ varies from 0.9246 to 0.9046 for the same network (4-5-5-1). The value of CE was calculated by using equation (9), CE varies from 97.91% to 96.03% during training and testing period for the network (4-5-5-1).

Similarly in case of Levenberg Marquardt and Tanh Axon based evaporation estimation model, the observed and estimated values of evaporation for training and testing period are shown in figures 4&5, respectively. The value of RMSE during training and testing period varies from 0.8166 to 1.0062 for network (4-9-1). The value of $R^2$ during training and testing period varies from 0.9300 to 0.8975 for the same network (4-9-1), CE varies from 98.10% to 96.25% during training and testing period for the network (4-9-1).

Same as the multiple linear regression (MLR) models was evaluated by using various statistical and hydrologic indices viz. root mean square error (RMSE), coefficient of determination ($R^2$) and coefficient of efficiency (CE). The RMSE values during training and testing period varies from 1.0500 to 1.1250, the values of CE during training and testing period varies from 96.73% to 94.18%, the value of $R^2$ varies

**Table 1.** Performance indices of ANN and MLR based weekly evaporation estimation models

| Model Name | Networks | Training | | | Testing | | |
|---|---|---|---|---|---|---|---|
| | | RMSE | CE (%) | $R^2$ | RMSE | CE (%) | $R^2$ |
| Delta Bar Delta and TanhAxon | 4-5-5-1 | 0.8561 | 97.91 | 0.9246 | 1.0322 | 96.03 | 0.9046 |
| Levenberg-Marquardt and TanhAxon | 4-9-1 | 0.8166 | 98.10 | 0.9300 | 1.0062 | 96.25 | 0.8975 |
| Multiple-linear regression | | 1.0500 | 96.73 | 0.8795 | 1.1250 | 94.18 | 0.8658 |

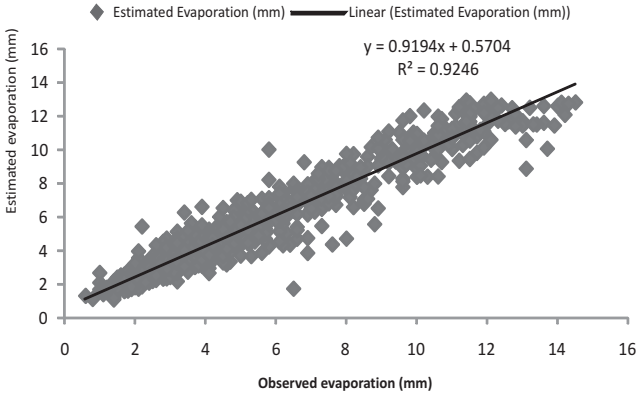


**Fig. 2.** Observed and estimated evaporation for Delta Bar Delta TanhAxon and combination of ANN model (4-5-5-1) during training period

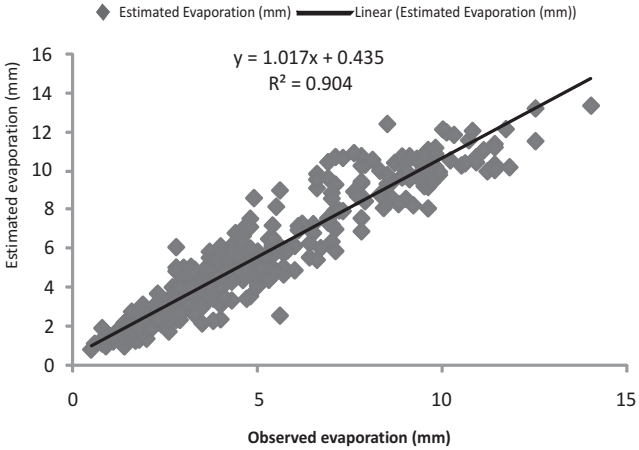


**Fig. 3.** Observed and estimated evaporation for Delta Bar Delta TanhAxon and combination of ANN model (4-5-5-1) during training period

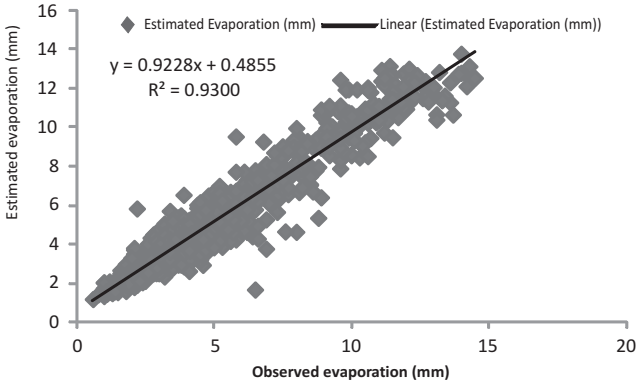


**Fig. 4.** Observed and estimated evaporation for Levenberg Marquardt Tanh Axon and combination of ANN model (4-9-1) during training period

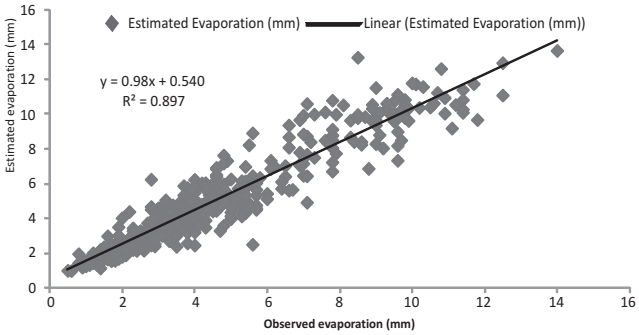


**Fig. 5.** Observed and estimated evaporation for Levenberg Marquardt Tanh Axon and combination of ANN model (4-9-1) during testing period

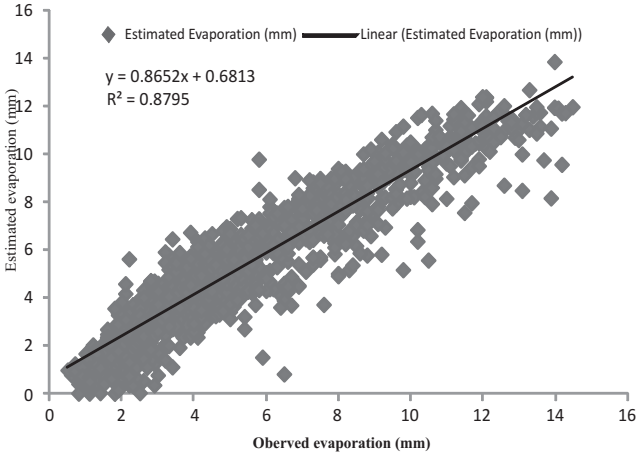


**Fig. 6.** Observed and estimated evaporation of MLR during training period

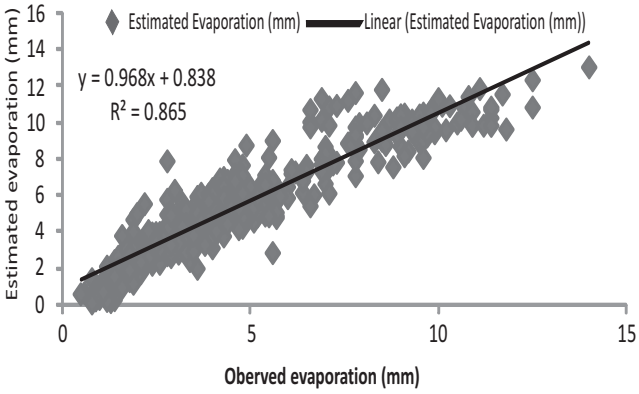


**Fig. 7.** Observed and estimated evaporation of MLR during testing period

from 0.8795 to 0.8658 during training and testing period for MLR model shown in table 1.

In case of testing period observed and estimated values of evaporation are shown in figure 7 for MLR and figures 3 and 5 for ANN respectively. Visual inspection of figures shows that, there is a fairly good agreement between observed and predicted evaporation values for both ANN and MLR models. But by performance indices, it is concluded that ANN models is better than MLR for evaporation estimation of Pantnagar.

## CONCLUSIONS

Artificial neural network gives better performance over multi- linear regression. Since there is no specific rule to determine the best structure of the network, a trial and error method was used for the selection of the best network among various structures of the artificial neural networks. In Delta bar Delta and TanhAxon combination the network (4-5-5-1), Levenberg-Marquardt and TanhAxon combination, the networks (4-9-1) were selected best suited network by trial and error. This study also concludes that a combination of mean air temperature, wind velocity, sunshine hours and mean relative humidity provides better performance for predicting the evaporation losses.

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# Impact of Disasters on Farm Households and Assessment of Farmer's Awareness to Disaster Events-An Economic Approach

**S. Usha Nandhini, P. Paramasivam and R. Sangeetha**

*Department of Agricultural Economics, Tamil Nadu Agricultural University, Coimbatore-641 003, India*
*E-mail:sunsigeco@gmail.com*

***Abstract***: In India due to climate change, severe losses have been recorded in agricultural sector than other areas. The main objective of the study is to analyse the impact of natural disasters on farm households and to assess the farmer's awareness to disaster events in the coastal area of Nagapattinam district of Tamil Nadu. The study was conducted in three coastal blocks of the district namely Nagapattinam, Thalainayir and Vedaranyam, which are severely affected by the natural disasters. The income level of the coastal farmers was found to be low after the effect of natural disaster and there existed differences in all the three affected regions. Out of the total size of 180 farmers, 60 per cent were aware of disaster events and 66.11 per cent of the farmers had adopted some of the techniques to overcome the disasters. The foremost alternative for the farmers in all the disaster prone region was government relief fund and insurance.

***Keywords***: Cyclone, Flood, Drought, Disaster, Adaptation

Climate change is the major factor for disaster events that affects and has negative impact on agriculture and in income of the rural farmers. According to Centre for Research on the Epidemiology of Disasters (2012) report across the globe there were 310 natural disasters, 9930 deaths related to natural disasters; 106 million people victimized by natural disasters; 115 countries were affected by disasters; and $180 billion wasted in damages. In India also, severe damages have been recorded in agriculture than other areas of livelihood security. According to Department of Economics and Statistics (2011), in Tamil Nadu, about 49 per cent of workers depend on agriculture sector for livelihoods. Climate related hazards directly impacts the production as well as livelihood of this huge population involved in agricultural sector. Nagapattinam is a multi-hazard prone district where the entire coast of the district is vulnerable to cyclone, flood and drought hazards with varying frequency and intensity. In a year, as many as five to six cyclones or floods hit these areas along the south-eastern coast of India. Every year these natural disasters in Nagapattinam district challenge agricultural production and these natural disasters have a devastating effect on the economy and most commonly include the agricultural impacts. The main aim of this study is to analyse impact of natural disasters on farm households and assessment of farmer's awareness to disaster events in the coastal area of Nagapattinam district of Tamil Nadu.

## MATERIAL AND METHODS

**Study area:** Among 13 costal districts along the eastern coast of Tamil Nadu, Nagapattinam district of Tamil Nadu was purposively selected because of the continuous exposure of the district to natural disasters such as cyclone, flood and drought. The study was conducted in three coastal blocks of the district namely Nagapattinam (cyclone region), Thalainayir (flood region) and Vedaranyam (drought region), which are severely affected by the natural disasters. In each of the three blocks two villages identified and from each village 30 farmers were selected (60 farmers each from cyclone, flood, drought region and 180 in total).

**Wilcoxon matched pairs signed-ranked test method:** Wilcoxon Matched Pair's Signed-Ranked test was employed to determine whether differences existed in the income of the rural farmers before and after the occurrence of natural disasters.

**Model specification:** Following Walker and Lev (1953) and B. H. Robbins (2010) the test is mathematically represented as ju

$$Z = \frac{4W - N(N+1)}{\sqrt{\frac{2N(N+1)(2N+1)}{3}(\pi^{+} + \pi^{-} - (\pi^{+} - \pi^{-})^{2})}}$$

Where: -

**Z** = the value by which the statistical significance of the difference between the two periods would be determined

**W** = Ranking the difference scores. Then, add up the rankings of both the positive scores and the negative scores and finally taking the smaller of those two values is the “W" used to calculate the Z statistics.

**N**= Number of sample size

**Regression model:** Regression model was used to study the relationship between factors that influenced the effects of natural disasters and the income of the rural farmers.

Ordinary Least Squares (OLS) Multiple Regression Model is expressed as,

Y = f (X1, X2, X3, X4, X5)

According to Anthony Ojonimi Onoja1 *et al*. (2012) explicit form is shown as: -

The Exponential functional form is explicitly modelled as follows;

Lny = b0 + b1 X1 + b2 X2 + b3 X3 + b4 X4 + b5 X5 + Ui

Where Y = Dependent variable

X's = Independent variables; U = error term

The dependent variable is the income level of the rural farmers during the period of natural disasters while the independent variables are the factors that increase the effects of natural disasters and they include the following:

Y = Income level of the rural farmers

$X_1$= Land degradation (3-point Likert type scale of measurement as low (1), moderate (2) and high (3) on the basis of perception and yield of the farmers over the years)

$X_2$ = climatic factor (dummy, 1 if there exist a good weather favourable for better yield and zero if otherwise)

$X_3$ = diversification in agricultural activities (dummy, 1 was used if diversified and zero if non-diversified)

$X_4$ = Standard of living of rural farmers 3-point (Likert type scale of measurement as low (1), moderate (2) and high (3) by measuring the yield of the farmers by cumulative score).

$X_5$ = Adoption of new technologies (dummy variable, one was used and zero if otherwise)

**Heckman Probit Model:** Following Maddison (2006), present study adopts the Heckman's selection model to analyse the perception of the farmers about the extreme events and the adaptation of new technologies to cope up the disaster situation. For this study, the first stage of the Heckman probit model considers whether the farmer perceived a climate change; this is the selection model. The second-stage model looks at whether the farmer tried to adapt to climate change, and it is conditional on the first stage, that is, a perceived change in climate. This second stage is the outcome model (Deressa*et al.*, 2008). Heckman's sample selectivity probit model is based on the following two latent variables:

Y1 = b'X + U1…….. (1)

Y2 = g'Z + U2 ……(2)

where $Y_1$ was the farmers' choice between adoption and non-adoption, $Y_2$ was the farmers' awareness to the occurrence of disaster events and those that were not aware. *X* is a *k*-vector of regressors in adoption equation; *Z* is an *m*-vector of regressors in awareness equation and the error terms $U_1$ and $U_2$ are jointly normally distributed, independently of *X* and *Z*, with zero expectations. Let $Y_2^*$ represent the propensity of a farmer being aware of disaster events rather than not. Then the relationship between the observed outcome $Y_2$ and the response propensity can be written as:

$Y_2$ = 1 if $Y_2^*$>0, $Y_2$ is a missing value, if $Y_2^*$< 0……. (3)

Let $Y_1^*$be the corresponding propensity to choose adaptation measures versus non-adaptation measures as a result of awareness to climate change. This variable is only observed when $Y_2$ =*1*, *i.e*., $Y_1$ is a choice between adaptation and non-adaptation, if the farmer was aware of disaster events and takes the value of 1 for adaptation and 0 for non-adaptation.

Y1 = 1 if Y1*> 0, $Y_1$ is a missing value, if $Y_1^* \leq 0$…… …. .(4)

The variable Y (size of adopter farmers) is only observed when $Y_2$ =*1* and $Y_1$ =1 (aware and adoption), while $Y_N$ (size of non-adopter farmers) is only observed when $Y_2$ =1 and $Y_1$=0 (aware but not adopt).

Although the researchers are primarily interested in the first model, the latent variable $Y_1$ is only observed if $Y_2$> 0. Thus, the actual dependent variable is:

Y = Y1 if Y2>≤0, Y is a missing value, if $Y_2$ 0 …… (5)

Consequently, without loss of generality, $U_2$ could be normalized such that its variance is equal to 1. If the sample selection problem is ignored, and Y is regressed on X using the observed Y's only, then the ordinary least squares (OLS) estimator of b will be biased, because

*E [Y1| Y2 > 0,X,Z] = b'X + rsf (g'Z)/F (g'Z)*…….. .. (6)

Where, *F* is the cumulative distribution function of the standard normal distribution,

*f*is the corresponding density,

's' is the variance of $U_1$, and 'r'is the correlation between $U_1$ and $U_2$.

Hence, E [Y1|Y2 > 0,X] = b'X + rsE (g'Z)/F (g'Z)|X]… (7)

The latter term causes sample selection bias, if r is non-zero. In order to avoid the sample selection problem, and to get asymptotically efficient estimators, the model parameters are estimated by maximum likelihood method. The first stage of the Heckman's sample selection model is the perceptions of changes to disaster (Equation 2). The second stage, which is the outcome model (Equation 1), is whether the people adopted to disaster condition, conditional on the first stage that she/he perceived a change in the situation.

The variables included in the selection as well as outcome model are detailed below.

## RESULTS AND DISCUSSION

**Impact of calamity events before and after disasters:** The nature of the calamity events and their impact varies considerably. Extreme weather events devastated farmlands

and can lead to crop failure and simultaneously affects the socio-economic status of the coastal farmers. Impact studies in Nagapattinam during normal years and disasters years allowed us to observe how floods, cyclone and droughts affected household income. Overall, the study revealed a decreases in income level and shows negative deviation. Deviation of the paddy yield from normal year were found to be -74 per cent in cyclone region, -65 per cent in flood region and -51 per cent in drought region which simultaneously reduces the income level of the farmers (Table 2) in all the three regions.

**Wilcoxon matched pairs signed rank test in disaster regions:** As mentioned in the methodology, difference in the income earned by the farmers before and after the effects of disasters in the study area were analysed through this test.

The test produced Z-values of-4.90, -6.57, and -3.56 in all the three affected region, which were significant when compared with the critical Z-value at 0.05 of 1.64. The result shows that there was a significant difference between the income earned by the farmers before and after the occurrence of natural disasters in all disasters affected regions.

Farmers attempted to reduce the loss in agricultural income during disaster years byseeking additional employment in the non-farm sector.This implies that farmers in these regions seek employment mainly as wage labour. During rainy days employment opportunity get reduced normally in flood and cyclone regions and hence the additional earning from non-farm employment were also found to be low.

**Factors influencing the income of coastal farmers affected by natural disasters:** Exponential functional form was chosen as the lead equation of the models, because it has the highest $R^2$ value.

Results of the exponential functional form revealed that there existed a negative co-efficient of the variable $X_2$ (climatic factor) significant at 1 per cent in all the three disaster regions, which indicated a negative relationship with

**Table 1.** Description of model variables for the Heckman probit model

| Outcome equation | Selection equation |
|---|---|
| Dependent variable | Dependent variable |
| Adaptation to disaster events (dummy: takes the value of 1 if adopted and 0 otherwise) | Farmers' perception towards disaster events (dummy: takes the value of 1 if perceived and 0 otherwise) |
| Independent variables | Independent Variables |
| Adaptation to disaster events | Education of the household head in years (continuous) |
| Education of the household head in years (continuous) | Age of the household |
| Experience in farming | Farm income from crop cultivation in Rs.(continuous) |
| On-farm income(continuous) | Non-farm income |
| Size of the household(continuous) | Information on disaster events |
| Farm size(ha) | Education of the household head in years (continuous) |
| Livestock ownership(dummy:1 if livestock owned and 0 otherwise) | |
| Extension on crop and livestock | |
| Credit(dummy:1 if there is access and 0 otherwise) | |
| Temperature | |
| Rainfall | |

**Table 2.** Impact of calamity events before and after disasters

| Particulars | Cyclone region | | Flood region | | Drought region | |
|---|---|---|---|---|---|---|
| | Normal year | Calamity year | Normal year | Calamity year | Normal year | Calamity year |
| Av.paddy yield (Kg $ha^{-1}$) | 4752 | 1229 | 4955 | 1729 | 4397 | 2150 |
| Deviation from normal year (%) | -74 | | -65 | | -51 | |
| Income from households | | | | | | |
| Non-farm income($Rsyr^{-1}$) | 30166 | 18053 | 32330 | 12708 | 54959 | 31968 |
| Deviation from normal year (%) | -51 | | -61 | | -41 | |
| On-Farm Income ($Rsyr^{-1}$) | 24340 | -25447 | 26022 | -19379 | 22953 | -18705 |
| Deviation from normal year (%) | -204 | | -219 | | -181 | |

**Table 3.** Test scores of Wilcoxon matched pairs signed rank test in disaster regions

| Income before disaster – Income after disaster | Cyclone region | Flood region | Drought region |
|---|---|---|---|
| (N) | | | |
| Negative ranks | 50.0[a] | 57.0[a] | 46.0[a] |
| Positive ranks | 10.0[b] | 3.0[b] | 14.0[b] |
| Ties | 0[c] | 0[c] | 0[c] |
| Total | 60 | 60 | 60 |
| Test statistics | | | |
| Z – value | -4.90[a] | -6.574[a] | -3.563[a] |
| Asymptotic significant (2-tailed) | 0.00 | 0.00 | 0.00 |

a -post < pre, b - post > pre, c - post = pre

**Table 4.** Factors influencing the income of coastal farmers in Nagapattinam district

| Variables | Cyclone region | Flood region | Drought region |
|---|---|---|---|
| | Co-efficient | Co-efficient | Co-efficient |
| Land degradation ($X_1$) | 0.61 (2.05) | -1.86* (-10.77) | -1.28* (-8.29) |
| Climatic factor ($X_2$) | -0.39* (-5.18) | -0.76* (-4.83) | -1.61* (-6.75) |
| Crop diversification ($X_3$) | 0.15** (2.11) | -0.01 (-0.12) | 0.18** (1.79) |
| Standard of living ($X_4$) | 0.09 (0.83) | 0.10 (0.91) | 0.13 (1.47) |
| Adoption of technologies($X_5$) | 0.22** (1.89) | 0.02 (0.18) | 0.32** (4.81) |
| Constant | 11.55 | 18.97 | 10.96 |
| $R^2$ | 0.86 | 0.75 | 0.81 |

Figures in parentheses under the independent variables are the respective t-values
*1% Significance level; ** 5% Significance level

the dependent variable (Table 6). According to fact on climate in Nigeria (Adedipe *et al.,* 2004), climate change increase the incidence of pests and diseases that attack and decimate forest trees. For climatic factor that affect income, the current analysis focussed with climate induced natural disasters such as floods, drought and cyclone as these are the most common weather related constraints in the study area. These variables were estimated against farm income of the farmers. Results shows that the association between the farm income and climatic factor was statistically significant at one per cent level and the coefficient for this variable had a negative sign in all the three regions, which implies that cyclone, flood and drought incidence negatively affected the farm income. Elasticity for the climatic factor indicates that a percentage change in the rainfall will increased the incidence of cyclone lead to the reduction in the income level of the farmer at 0.57 per cent in cyclone region. Similarly, in flood region a percentage change in the rainfall increased the incidence of flood and reduces the income level of the farmer at 2.6 per cent. Likewise in drought region, one percentage increase in temperature will increase dryness and reduces the income level of the farmer at 5.90 per cent.

Land degradation magnifies the risk of natural disasters, or by destroying natural barriers, leaves agriculture, forestry and rangelands more vulnerable to their effect (Sivakumar, 2006). It could also be observed in the present study that the variable $X_1$ (land degradation) showed a negative relationship with the dependent variable Ywith significance at one per cent level in flood and drought region. As land degradation is the major problem in these regions, a percentage increase in the degradation of the land due to erosion in flood region will decrease the income level of the farmer by 6.50 per cent and a percentage increase in land degradation due to water scarcity will decrease the income level of the farmer by 4.46 per cent in drought region. Diversification involves spreading of risk loss over several commodities instead of one (Odii, 2005).The variable $X_3$(crop diversification) had a positive coefficient, which is significant at five per cent in cyclone region and drought region indicates that for a unit increase in the practice of crop diversification will increase the income of the farmers by 0.78 per cent in cyclone region and 0.34 per cent in drought region.If farmers diversify their agricultural activities there will be an increase in the income.

Research on adoption of agricultural technologies indicates that there is a positive relationship between the level of adoption and the availability of credit (Yirga, 2007). Similarly in our study the variable $X_5$ (adoption of new technology) in cyclone and drought region shows a positive co-efficient which is significant at five per cent level in cyclone region and one per cent in drought region, which implies that for every unit increase in the usage of technology will increase the income of the farmers by 0.65 per cent in cyclone region and 0.61 per cent in drought region. As paddy is the main crop cultivated in the study area farmers will be benefitted if new technologies like SRI paddy cultivation, adaptation of flood tolerant varieties and usage of agricultural machineries etc. to reduce the cost of cultivation.

**Analysis of farmers' perceptions and adaptation to disaster events:** The results show that out of 180 farmers 60 per cent of the farmers were aware of disaster events and the remaining 40 per cent were not aware about the occurrence of disaster events and also revealed that 66.11 per cent of the farmers adopted some of the techniques like adoption of tolerant varieties, starting new land management practices, early or late sowing of the seeds, crop diversification practices etc., to overcome the disaster events. 33.88 per cent of the farmers were not adopting any technique.

Probit model was run and tested for its appropriateness

**Table 5.** Description of variables of the selection equation used in Heckman probitmodel

| Outcome equation | | | Selection equation | |
|---|---|---|---|---|
| Dependent variables | | | Dependent variables | |
| Description | Adapted farmers (%) | Non-adapted farmers (%) | Farmers perceived changes (%) | Farmers did not perceived changes (%) |
| | 66.11 | 33.88 | 60 | 40 |
| Independent variables | | | Independent variables | |
| Description | Mean | SD | Mean | SD |
| Education of the household head in years (continuous) | 6.99 | 3.01 | 6.99 | 3.01 |
| Age of the household (year) | 50.75 | 11.87 | - | - |
| Experience in farming (years) | - | - | 27.17 | 10.87 |
| Farm income from crop cultivation in Rs.(continuous) | 24331 | 12219 | | |
| Non-farm income (Rs) | 39152 | 13732 | 39152 | 13732 |
| Size of the household (numbers) | - | - | 4.64 | 1.08 |
| Farm size(ha) | - | - | 1.61 | 1.14 |
| Livestock ownership(dummy:1 if livestock owned and 0 otherwise | - | - | 0.72 | 0.45 |
| Extension on crop and livestock (dummy:1 if extension service is | - | - | 0.55 | 0.50 |
| Credit (dummy:1 if there is access and 0 otherwise) | - | - | 0.76 | 0.43 |
| Information on disaster events (dummy,Yes =1,No = 0) | 0.60 | 0.49 | - | - |
| Temperature (degree celcius) | | | 33.97 | 3.63 |
| Rainfall (mm) | - | - | 94.24 | 0.43 |

over the standard probit model and the results indicated the presence of a sample selection problem (dependence of the error terms from the outcome and selection models), justifying the use of the Heckman probit model with *rho* significantly different from zero with the likelihood function of the Heckman probit model significant with Wald $_{x}^{2}$= 68.10, and *p*< 0.0000 showing the strong explanatory power of the variables.

This result also assumes that large family size is normally associated with a higher labour endowment, which would enable a household to accomplish various agricultural tasks. For instance, Croppenstedt *et al.* (2003) argue that households with a larger pool of labour are more likely to adopt agricultural technology and use it more intensively because they have fewer labour shortages at peak times. Present analyses also revealed that family size of the farmer is significantly variable and has a positive coefficient, which implies that larger families tend to adopt more to disaster events than smaller farmers. It shows that increasing the size of the household by one person increases the probability of adaptation to disaster event by 10.10 per cent by engaging additional human power during the disaster period. The large family size is normally associated with a higher labour endowment, which would enable a household to accomplish various agricultural tasks, especially during peak seasons. Likewise, increasing farm size increases the probability of adoption by two per cent. The co-efficient of farm size is positively and significantly correlated, which implies that large scale farmers are more likely to adopt because there will be more capital and resources, so that it is possible for them to invest in new technologies. Pattanayak *et al.* (2003) pointed that availability of credit eases the cash constraints and allows farmers to buy inputs such as fertilizer, improved crop varieties, and irrigation facilities. Likewise in this study also access to credit has a strong influence on farmer's decisions to adapt during disaster events. The result shows that credit accessibility is positively and significantly related and shows that if farmer has access to credit his probability of adoption of technology to disaster events increases by 15 per cent. More financial resources makes the farmers to change the farming practices in response to changes during disaster events. Other variables like livestock ownership, extension on crop and livestock, and increasing rainfall have negative probability of adoption.

It could also be revealed from the result that perceiving to disaster events is positively related to education, age of the households, non-farm income and information on disaster events. Thefactors that are believed to create awareness

**Table 6.** Results of Heckman probit selection model

| Explanatory variables | Adaptation model | | Selection model | |
|---|---|---|---|---|
| | Regression (coefficients) | Marginal values (coefficients) | Regression (coefficients) | Marginal values (coefficients) |
| Education | 0.001 (0.884) | 0.002 (0.867) | 0.341* (0.000) | 0.115* (0.000) |
| Experience | -0.002 (0.479) | -0.001 (0.637) | - | - |
| Age of the household | - | - | 0.034** (0.0019) | 0.011** (0.012) |
| Farm income | 4.85E-06 (0.137) | 2.50E-06 (0.111) | 0.000 (0.384) | 0.0001 (0.387) |
| Non-farm income | - | - | 0.00001* (0.000) | 0.00002* (0.000) |
| Size of the household | 0.103** (0.002) | 0.101** (0.002) | - | - |
| Farm size(ha) | 0.087* (0.024) | 0.026* (0.014) | - | - |
| Livestock ownership | -0.20134* (0.027) | -0.20408* (0.026) | - | - |
| Credit | 0.145* (0.09) | 0.150* (0.02) | - | - |
| Temperature | -0.253 (0.407) | -0.162 (0.599) | - | - |
| Rainfall | -0.027* (0.000) | - 0.01* (0.000) | - | - |
| Constant | -5.108* (0.000) | | -4.36* (0.000) | |
| Total observations | | 180 | | |
| Censored | | 72 | | |
| Uncensored | | 108 | | |
| Wald Chi square (Zero slopes) | | 68.10 P<0.000 | | |

(Figures in parenthesis are P level); *1 % significant level; ** 5 % significant level

**Table 7.** Income management of farm households against disasters

| Source | Cyclone region | Flood region | Drought region | Total N=180 |
|---|---|---|---|---|
| Savings in bank | 14 | 6 | 11 | 31 |
| Sale of stored produce | 9 | 11 | 16 | 36 |
| Sale of fixed assets | - | 5 | 6 | 11 |
| Borrowing from friends and relatives | 12 | 17 | 14 | 43 |
| Borrowing from money lenders | 17 | 22 | 17 | 56 |
| Hypothecation of assets or jewellery | 6 | 18 | 15 | 39 |
| Bank loan | 19 | 25 | 28 | 72 |
| Agricultural labour and non-farm income | 29 | 30 | 38 | 97 |
| Government relief and Insurance | 58 | 55 | 51 | 164 |

Figures in parentheses are percentage to respective total

about disaster events, such as access to information on change, increase in non-farm income and increase in the education level increases the likelihood of adoption by 31.2, 0.01 and 11.5 per cent, respectively.

**Income management of farm households against disasters:** There are nine income management strategies that were posed the respondents to choose as many as they would expect to employ during a disaster situation. Table 7 shows the results of the income management of the rural household at the time of crop failure.

The foremost alternative for the farmers in all the disaster prone region was government relief fund and insurance. The other main income management measures followed by the farmers were agricultural income and non-farm income,

availing bank loan, borrowing from money lender, borrowing money from friends and relatives, hypothecation of assets and jewellery. Agricultural labour and non-farm income in drought region was found to be high due to the fact that they were highly engaged with other occupation like small scale industries, labour in prawn culture, etc.

Based on the results, of analysis discussed earlier, results showed that after the occurrence of natural disasters there was a reduction in the farmer's income. Since cyclones, flood and drought may have significant negative impact on rice production, assistance for rice farmers in this region should be made site specific. The Heckman probit selection model is employed to analyse the two-stage process of adaptation - perceiving changes due to disaster in the first stage and then adapting to perceived changes due to disaster in the second stage**.** Different households living in different agro-ecological settings use different adaptation methods. Moreover farmers should be aided to adapt disaster management strategies in respect to agriculture so as to reduce financial losses when these disaster occur. Income management is the coping mechanism influenced by the farmer's previous experience which also found to be the remedial action taken by the farmers whose survival and livelihood are threatened by the natural events.

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# Effect of Fish waste, Fish Guano and Compost on Growth, Yield and Quality of Broccoli (*Brassica oleracea* var. *italica*)

**Ravi Kiran, Sutanu Maji and Abha Mishra[1]**

*Department Applied Plant Science, Babasaheb Bhimrao Ambedkar University,*
*[1]Department Applied Animal Science, Babasaheb Bhimrao Ambedkar University, Lucknow-226 025, India*
*E-mail: majisutanu@gmail.com*

***Abstract***: The present experiment was conducted to find out the effect of fish waste, fish guano and compost on growth, yield and quality of broccoli (*Brassica oleracea* var. *italica*). The results showed significant effect of various treatments involving fish waste (16.60-50%), fish guano (16.60-50%) alone and in combination with farm yard manure (FYM 16.60-50%) and soil on vegetative growth, yield and quality attributing characters of broccoli. The maximum vegetative growth in terms of plant height, plant spreading, length of leaves were recorded under plants grown on soil (50%) supplemented with FYM and fish waste (25% each) but, maximum number of leaves and leaf diameter was found with growing media having mixture of soil 50% and fish guano 50%. In general, it was observed that fish guano had better potentiality to improve yield and curd quality because fish guano (50%) in combination with soil (50%) showed higher curd yield as well as better physico-chemical qualities of curd as compared to control and other treatments along with improvement in microbial populations in the media.

***Keywords***: Fish waste, Fish guano, Compost, Growth, Yield, Quality, Broccoli

Broccoli (*Brassica oleracea* var. *italica* Plank) an edible greenish curd producing plant in the cole family Brassicasae (Cruciferae) is eaten as a vegetable. The word *broccoli* comes from the Italian plural of *broccolo*, which means "the flowering crest of a cabbage" and is the diminutive form of *brocco*, meaning "small nail" or "sprout" (Anon., 2014). It is becoming very popular after introduction to USA at early 1920s (Denker, 2003) because it is rich in nutrients like Ca, Fe, Mg, P, K, Zn and vitamins like A, C, D, $B_1$, $B_2$, $B_3$, $B_5$, $B_6$ and $B_9$ eaten as vegetables in many forms (Anon., 2012; Devi and Singh, 2015). The chemical isothiocyanates are found in broccoli produces sulforaphane substrate that manufactures enzymes which are powerful cancer fighters. So, broccoli is one of the potential anti-oxidant sources and helpful to solve vitamin D deficiency. The glucosinolates, gluconasturtin and glucolorassiein present in broccoli have positive effect on detoxification system of body also a strong source of flavonoid – kemipherol, which proves the unique anti inflammatory benefits of broccoli.

Sprouting broccoli is a heavy feeder and farmers are repeatedly using chemical fertilizers to obtain maximum yield. As a consequence of continuous use of chemical fertilizers, farmers are facing the problem of soil deterioration, affecting soil flora and fauna and ultimately yield and quality of broccoli along with bad effect on environment and human health. Different kinds of waste have adverse effect on environment also and thus, waste management is now a big challenge. Among them fish waste management has been one of the problems having the greatest impact on the environment. Waste of fish farming has detrimental effects on the marine environment in particular become an issue of public concern (Arvanitoyannis and Kassaveti, 2008). Recently, treated fish waste has found many applications among which the most important are animal feed, biodiesel/biogas, dietic products (chitosan), natural pigments (after extraction), food-packaging applications (chitosan), cosmetics (collagen), enzyme isolation, Cr immobilization, soil fertilizer and moisture maintenance in foods (hydrolysates). Few researchers (Abbasi *et al*., 2002; Zhang *et al.*, 2002) earlier tried to utilize fish and fish products wastes along with other natural sources as emulsion and other forms and tested for their ability to reduce bacterial spot and increase yield of tomato and bell pepper under both greenhouse and field conditions. About 89 municipal waste ashes, including food scrap ash (FSA), animal waste ash (AWA), horticulture waste ash (HWA), sewage sludge ash (SSA) and incinerator bottom ash (IBA) were examined with the aim of evaluating their suitability for use in agriculture. Therefore, keeping these views of fish waste management in agriculture, the present experiment was designed for broccoli production with utilization of fish waste.

## MATERIAL AND METHODS

The experiment was conducted using broccoli cultivar KTS 1 during the *rabi* season of 2014-2015 at Babasaheb Bhimrao Ambedkar University, Lucknow, India to find out the influence of different sources of nutrients on growth, yield and

quality of broccoli. There were eight treatments including control in complete randomized block design with four replications. The fish waste collected from local markets was dried for 5-7 days at 80°**c.** When it was dried sufficiently, it was ground for easy mixing with soil. Fish guano was collected from National Bureau of Fish Genetic Resources (NBFGR), Lucknow and dried under hot air oven at 70°c for 1-2 days depending on quantity. Different treatment combinations were prepared by mixing these wastes with specified ratio (Table 1). The data were recorded for effects on vegetative growth (plant spreading, basal diameter, number of leaves, width and length of leaves), curd yield and physico-chemical quality attributes following standard methods as shggested by AOAC (2000). The recorded information was statistically analyzed (Panse and Sukhatme, 1985) using complete randomized block design and the treatment mean were compared at 5% level of significance.

**Table 1**. Treatment combinations

| | |
|---|---|
| $T_0$ | Control |
| $T_1$ | Soil @ 50% + FYM @ 50% |
| $T_2$ | Soil @ 50% + fish waste 50% |
| $T_3$ | Soil @ 50% +fish guano @ 50% |
| $T_4$ | Soil @ 50% + FYM @ 25% + fish waste @ 25% |
| $T_5$ | Soil @ 50% + FYM @ 25% + fish guano @ 25% |
| $T_6$ | Soil @ 50% + fish guano @ 25%+ fish waste @ 25% |
| $T_7$ | Soil @ 50% + FYM @ 16.60% + fish waste @ 16.60% + fish guano @ 16.60% |

Control- Soil (100%) without any amendment which is normally treated as standard practice

## RESULTS AND DISCUSSION

Results revealed that various treatments increased plant height significantly as compared to control (Table 2). Among treatments, growing media soil + fish guano (50% each) significantly increased plant height (18.28 cm) at 30 days after transplanting (DAT), however, maximum plant height (36.75 cm) was recorded with soil @ 50% + FYM @ 25% + fish waste @ 25%) at 90 DAT, which was statistically *at par* with soil @ 50% + FYM @ 50%, soil @ 50% + fish waste 50%, soil @ 50% +fish guano @ 50%, soil @ 50% + FYM @ 25% + fish waste @ 25% and soil @ 50% + FYM @ 16.60% + fish waste @ 16.60% + fish guano @ 16.60%. Although, plant spreading was found maximum (26.75 cm East-West direction) under soil @ 50% + FYM @ 25% + fish waste @ 25% and in North-South direction (24.25 cm) under soil @ 50% +fish guano @ 50%, but statistically there were no significant difference between the treatments in both the directions at 90 DAT. The growth in basal diameter of stem did not follow a specific pattern at all the three stages of

**Table 2.** Effect of fish waste, fish guano and compost on vegetative growth of broccoli

| Treatment | Plant height (cm) | | Plant spreading E-W (cm) | | | Plant spreading N-S (cm) | | | Basal diameter of plants (cm) | | | Number of leaves | | | Length of leaves (cm) | | | Width of leaves (cm) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 30 DAT | 90 DAT | 30 DAT | 60 DAT | 90 DAT | 30 DAT | 60 DAT | 90 DAT | 30 DAT | 60 DAT | 90 DAT | 30 DAT | 60 DAT | 90 DAT | 30 DAT | 60 DAT | 90 DAT | 30 DAT | 60 DAT | 90 DAT |
| $T_0$ | 13.70 | 27.50 | 10.70 | 16.58 | 20.25 | 11.25 | 15.75 | 15.75 | 3.85 | 4.35 | 4.70 | 7.88 | 12.75 | 13.50 | 8.50 | 10.50 | 11.50 | 6.50 | 7.25 | 8.75 |
| $T_1$ | 16.30 | 33.50 | 12.25 | 22.25 | 24.00 | 13.40 | 19.75 | 23.75 | 4.03 | 5.18 | 5.50 | 10.50 | 14.50 | 15.50 | 10.00 | 11.50 | 13.00 | 8.00 | 8.50 | 10.75 |
| $T_2$ | 16.00 | 32.00 | 11.00 | 21.00 | 22.75 | 13.50 | 21.25 | 21.25 | 4.08 | 5.25 | 4.90 | 11.00 | 15.00 | 17.50 | 12.00 | 14.50 | 15.75 | 8.25 | 9.00 | 12.00 |
| $T_3$ | 18.28 | 35.75 | 14.60 | 20.25 | 21.25 | 15.28 | 21.50 | 24.25 | 4.03 | 4.75 | 5.10 | 11.00 | 16.50 | 17.50 | 11.75 | 15.25 | 16.75 | 11.25 | 12.50 | 16.75 |
| $T_4$ | 16.50 | 36.75 | 13.25 | 24.00 | 26.75 | 13.00 | 18.50 | 23.50 | 4.18 | 5.20 | 5.10 | 8.75 | 16.00 | 17.00 | 13.00 | 17.00 | 18.25 | 8.75 | 9.50 | 12.75 |
| $T_5$ | 14.50 | 28.75 | 14.50 | 17.50 | 20.25 | 10.75 | 16.50 | 18.35 | 3.78 | 4.03 | 4.45 | 9.50 | 12.75 | 13.75 | 10.25 | 12.25 | 13.00 | 9.25 | 9.50 | 12.25 |
| $T_6$ | 16.75 | 28.50 | 11.50 | 20.75 | 21.75 | 11.25 | 18.25 | 19.25 | 4.08 | 4.88 | 4.85 | 10.25 | 17.50 | 20.25 | 12.50 | 15.75 | 16.50 | 9.00 | 9.50 | 12.25 |
| $T_7$ | 14.75 | 33.25 | 13.00 | 21.00 | 23.50 | 11.25 | 17.75 | 21.04 | 3.90 | 4.90 | 4.70 | 10.75 | 17.50 | 17.25 | 11.75 | 15.25 | 14.50 | 10.50 | 10.75 | 14.75 |
| CD (p = 0.05) | 3.01 | 6.18 | 3.46 | 5.52 | NS | 3.30 | 4.82 | NS | NS | 0.89 | 0.71 | NS | NS | 5.36 | 3.48 | 5.12 | NS | 2.96 | 2.65 | 4.28 |

growth. It was noted maximum (4.18 cm) when crops grown under soil @ 50% + FYM @ 25% + fish waste @ 25% at 30 DAT although the treatment effects were statistically not significant. But, it was maximum of 5.25 cm under soil @ 50% + fish waste 50% at 60 DAT while soil @ 50% + FYM @ 50% showed significantly maximum basal diameter (5.50 cm) at 90 DAT followed by soil @ 50% +fish guano @ 50% and soil @ 50% + FYM @ 25% + fish waste @ 25%. Interestingly, the lowest diameter was noted under plants grown under soil @ 50% + FYM @ 25% + fish guano @ 25% even lower than the control at 30, 60 and 90 DAT. In case of number of leaves (Table 2), it was observed that there was no significant changes at 30 and 60 DAT, however, at 90 DAT maximum number of leaves were counted when plants were grown on media comprising soil @ 50%, fish guano @ 25% and fish waste @ 25%. The treatment effects were found non-significant on length of leaves at 90 DAT while it significantly varied at 30 and 60 DAT and at all stages of growth (30, 60 and 9 DAT) highest leaf length was measured in the treatment with soil supplemented with 25% FYM and 25% fish waste. However, growing media comprising 50% soil and 50% fish guano showed the highest width of leaves significantly superior to the other treatments. From these observations, it might be assumed that the average vegetative growth was better when crops grown in soil @ 50% + FYM @ 25% + fish waste @ 25% media mixture closely followed by soil @ 50% +fish guano @ 50%. The similar kind of result was also observed by Muoneke *et al*. (2014) and Irshad and Javed (2006). It was found that the enhancement of growth behaviour and apical dominance of broccoli was increased mostly by soil+ fish guano (each of 90%) and soil + FYM + fish waste (each 25%) potting mixture that might be due to more soil moisture holding capacity of soil mixture. It might contain good amount of nitrogenous compound, which enhanced vegetative growth because Olsen and Olsen (2011) also advised to dilute the fish waste emulsion before use to avoid scorching effect due to more nitrogen content.

Table 3 showed the yield and yield attributing characters of broccoli as affected by various treatments. The average weight of curd with and without guard leaves was recorded maximum (425.50 g and 340.25 g, respectively) in soil supplemented with 50% fish guano, which also reflected on the highest curd yield per hectare of 27.03 g $ha^{-1}$ and 21.60 g $ha^{-1}$, respectively with and without guard leaves. The better vegetative growth produced more photosynthates, which might help to increase curd yield. The number of slips per head was maximum under soil @ 50% +fish guano @ 50% but, number of frauds per head was recorded maximum under soil @ 50% + FYM @ 25% + fish waste @ 25%. The result was also in accordance with work of Abbasi *et al*. (2002) and Gagnon and Berrouard (1994) who reported positive response in pepper and tomato.

The observations on physico-chemical characteristics of broccoli curd (Table 4) showed that curd the diameter was maximum (12.50 cm) under soil @ 50% + FYM @ 25% + fish guano @ 25% followed by soil @ 50% + fish waste 50%, which was similar to soil @ 50% + fish waste 50% and soil @ 50% + FYM @ 16.60% + fish waste @ 16.60% + fish guano @ 16.60% and in both the case the minimum length and diameter was lowest under control. Length was the highest under $T_3$ (20.50 cm) while the effect was non-significant in case of curd length. Total soluble solids (TSS) improved significantly by the treatments and curds from plants grown under soil composition of soil and fish guano 50 % each showed maximum TSS of 8.02 ºB followed by control while other treatments did not show any significant improvement. Similarly, vitamin C content was also increased by fish guano 50% followed by close to combination of FYM (25%), fish waste (25%) and soil (50%). Although the total sugars and

**Table 3.** Effect of fish waste, fish guano and compost on curd yield of broccoli

| Treatment | Weight of the curd with guard leaf (g) | Weight of the curd without guard leaf (g) | Yield (q $h^{-1}$) | | Number of frauds/head | Number of slip per head |
|---|---|---|---|---|---|---|
| | | | With guard leaves | Without guard leaves | | |
| $T_0$ | 335.75 | 260.5 | 21.31 | 16.54 | 11.55 | 23.88 |
| $T_1$ | 365.25 | 290.5 | 23.19 | 18.44 | 12 | 24.5 |
| $T_2$ | 376.5 | 280.25 | 23.9 | 17.79 | 12.5 | 24.63 |
| $T_3$ | 425.5 | 340.25 | 27.03 | 21.6 | 11.5 | 26.32 |
| $T_4$ | 345.25 | 290.25 | 21.92 | 18.43 | 12.9 | 24.8 |
| $T_5$ | 378.5 | 290.25 | 24.03 | 18.43 | 12.13 | 24.93 |
| $T_6$ | 354.75 | 270.25 | 22.52 | 17.16 | 11.88 | 24.58 |
| $T_7$ | 367.75 | 301.25 | 23.35 | 19.12 | 11.85 | 24.63 |
| CD (p = 0.05) | 5.29 | 40.81 | 2.14 | 2.14 | 0.61 | 1.59 |

Treatment details in table 1

**Table 4.** Effect of fish waste, fish guano and compost on physico-chemical quality of broccoli

| Treatment | Curd diameter (cm) | Curd length (cm) | TSS (°B) | Vitamin C (mg/100g) | Total sugars (%) | Non reducing sugar (%) |
|---|---|---|---|---|---|---|
| $T_0$ | 10.75 | 15.25 | 7.2 | 67.43 | 2.1 | 0.2 |
| $T_1$ | 11.5 | 17.25 | 7.17 | 69.03 | 2.51 | 0.28 |
| $T_2$ | 12.25 | 16.25 | 6.57 | 68.28 | 2.23 | 0.36 |
| $T_3$ | 12.25 | 20.5 | 8.02 | 71.9 | 2.84 | 0.41 |
| $T_4$ | 11.25 | 18.25 | 6.05 | 70.05 | 2.66 | 0.3 |
| $T_5$ | 12.5 | 16.25 | 6.59 | 67.7 | 2.24 | 0.25 |
| $T_6$ | 11.5 | 19.25 | 6.52 | 69.33 | 2.44 | 0.26 |
| $T_7$ | 12.25 | 18.5 | 6.69 | 67.75 | 2.06 | 0.26 |
| CD (p=0.05) | 1.96 | NS | 1.22 | 2.99 | NS | NS |

Check table 1 for details

non- reducing sugar were increased by soil @ 50% +fish guano @ 50% but, the effects were non-significant. It is quite clear that in general, the quality of broccoli curd was improved by the fish waste, fish guano and FYM treatments or supplements as potting mixture. These positive effects might be due to good assimilation of nutrients and better management of organic matter, which might help in betterment of microbial population in rhizospheric soil (Table 5). Gelmesa *et al*. (2013) explained that increase of TSS might be due to export of assimilates from leaves or better vegetative growth in case of tomato.

**Table 5.** Microbial analysis of potting mixture as influenced by fish waste, fish guano and FYM

| Treatments | Microbial count (CFU/g soil mix) |
|---|---|
| $T_0$ | $3.8 \times 10^5$ |
| $T_1$ | $4.5 \times 10^7$ |
| $T_2$ | $3.7 \times 10^6$ |
| $T_3$ | $4.8 \times 10^7$ |
| $T_4$ | $2.9 \times 10^4$ |
| $T_5$ | $4.1 \times 10^6$ |
| $T_6$ | $6.8 \times 10^7$ |
| $T_7$ | $3.1 \times 10^6$ |

## CONCLUSION

The fish waste, fish guano and compost could be utilized for broccoli production. The growing media supplemented with fish guano 50% as potting mixture was the best for higher curd yield and quality improvement of broccoli.

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# Participation of Marine Fisheries Cooperative Societies in Social Development of Fisher Community

**Suhas Wasave[1], Arpita Sharma[2] , Dr. S. K. Datta[3], K. D. Kokate[4], Shekhar Ojha[2], Asha Landge[5] and Sangita Wasave[6]**

[1]*FEES Division, ICAR-CIFE, Mumbai-400 061, India*
[2]*Central Institute of Fisheries Education, Mumbai-400 061, India*
*3Centre for Management in Agriculture, Indian Institute of Management, Ahmedabad*
[4]*Director of Extension, Mahatma Phule Krishi Vidyapeeth, Rahuri (MS)*
[5]*Central Institute of Fisheries Education, Mumbai-400 061, India*
[6]*College of Fisheries, Shirgaon, Ratnagiri-415629, India*
*E-mail: suhaswasave@gmail.com*

***Abstract:*** Fisheries cooperative societies are viewed as organizations, helping the fisher community to improve their social, welfare and economic status. As per the preliminary report of Department of Fisheries, Government of Maharashtra (2012) there is 304 registered marine fisheries cooperative societies, among these 266 (87.5%) are functioning in Maharashtra. These societies are involved in a number of social development activities. A study was conducted in the fisheries cooperative societies in Maharashtra among six coastal districts viz. Mumbai suburban, Mumbai, Thane, Raigad, Ratnagiri and Sindhudurga with an objective to analyze the role of marine cooperative societies in the social development process of fisher members. Ten most important social development variables were selected by analyzing the variables using orthogonal rotation (varimax). The responses were measured on three point scale from "High participation" to "Low participation" as responded by key informants. The correlation matrix was used to determine the relationship among selected social development variables. Discrimination among these variables on the basis of mean values was done using "Optimal scaling" technique. The significance level was tested among correlated variables and Chi-square test was used by cross-tabulating the variables against selected districts to show regional variation. It was found that cooperative societies of Maharashtra are performing well with reference to social development activities such as appreciation for educational activities, financial assistance to affected fishers, establishing a cooperative store, donation for religious activities, organizing health camps, etc. Correlation matrix showed no correlation among the variables, indicating each and every variable was not associated with each other. The majority of social development variable showed significance difference ($P<0.05$) at 5% significance level. Health camp organized by cooperative societies showed highest means among discriminated variables. Almost 85% of social development variables showed a significant difference ($P<0.05$) when cross tabulated on a regional basis. The result strengthens the hypotheses that, each and every activity is independent of each other. Cooperative can have a participatory discussion with members so as to find the needs and then design social development programmes according to needs of members.

***Keywords:*** Fisheries, Cooperative, Social, Development

## INTRODUCTION

Cooperative principles (such as self-help, self-reliance, self-responsibility, and democracy) argue that a viable, autonomous, self-reliant and self-sustaining cooperative movement can play a major role in the economic and social development of disadvantaged people (Ortmann and King, 2007). Fisheries cooperative is an ideal type of organization for use in improving the welfare of fishers in development projects (Meynell, 1984). Cooperatives provide a means by which disadvantaged groups can work together, share the risks and solve their common problems (Zarafshani *et al*., 2010).

In India, like in other sectors, cooperatives exist in fisheries also. The Indian fisheries cooperative history can be traced with the introduction of a first fisheries cooperative society organized under the name of *'Karla Machhimar (Fishermen) Co-operative Society'* in Ratnagiri district of Maharashtra in the year 1913. The state of West Bengal was next to have fisheries cooperative society in the fishery sector in 1918. In the same year, Tamil Nadu also organized one fisheries cooperative society (Mishra, 1997). Today, in India there are One National Level Federation, 23 State Level Federations, 125 Central (District/ Regional Level Federations) and 15,526 primary societies with the membership at the primary level of 2.09 Million (FISHCOPFED, 2012).

Fisheries cooperative society is one of the basic organizations which have strong roots in the cooperative sector of Maharashtra. There are 2,830 primary fisheries cooperative societies with a total membership of 2,56,667 fisher members, 37 fisheries cooperative unions and two federations working in the State (Economic Survey of Maharashtra, 2011-12). Among the total fisher population, around 57% are the members of primary cooperative

societies and total of 25% represent marine fisheries cooperative societies in Maharashtra. The 304 primary marine fisheries cooperatives are spread in the six coastal districts of Maharashtra State. The total membership of primary marine fisheries cooperatives of Maharashtra is 1,14,068. (DOF, Maharashtra, 2012). It is clear from above discussion that majority of fisher villages have fisheries cooperatives. However, Department of Fisheries, Government of Maharashtra reports that there are 304 registered cooperative societies and among these, 266 are functioning (87.5%) in Maharashtra. These fisheries cooperative societies work for the welfare of their members.

There is a need to document the various social development activities undertaken by those cooperatives. Accordingly, a study was conducted with the objective to analyze the role of marine cooperative societies in the social development process of fisher members.

## MATERIAL AND METHODS

Out of the 266 functional marine fisheries cooperative societies of Maharashtra, around 15% cooperatives were selected i.e. 39 cooperatives. These 39 cooperatives represent six coastal districts of Maharashtra i.e., Mumbai suburban, Mumbai, Thane, Raigad, Ratnagiri and Sindhudurga. Members of all these cooperative societies were involved in capturing fish for domestic and export consumption as the main source of income generation. A structured schedule was prepared and was administrated to key informants of cooperative societies. Information on the cooperative societies on various social developments was elicited from the key informants of cooperative societies. The level of participation in social development activities of cooperative societies was recorded on three-point Likert scale from “High participation” to “Low participation”.

A total of 17 social development activities undertaken by cooperative societies were reported. Among these, most important activities were selected by factor analysis using orthogonal rotation (varimax). Care was taken to choose most appropriate variables contributing to social development. The activities chosen were providing public transportation service (bus, lorry etc.), public water supply, organization of health camps, establishing or promoting medical store, providing services of rural doctor, establishing and operating cooperative store of fishery requisites, donations for religious activities, appreciation for educational achievements, financial assistance to fisher members affected by accidents / disaster and creating recreational facilities. This is presented in Table 1.

The correlation matrix was used to determine the relationship among variables while discrimination among the variables of social activities was tested on the basis of means by “Optimal scaling” technique. A significance level of correlated variables of social development activities was also analyzed. Chi-square test was used by cross-tabulating the variables against the districts to show regional variation. All statistical analysis was carried out using SPSS version 16.

**Table 1.** Factor analysis of social development activity by cooperatives

| Activities | Score for factor |
|---|---|
| Appreciation for educational achievements | 0.89 |
| Facilitating public water supply | 0.85 |
| Organizing health camps | 0.80 |
| Developing cooperative store | 0.80 |
| Financial assistance | 0.74 |
| Donation to religious activities | 0.68 |
| Recreational facility | 0.68 |
| Public transportation | 0.55 |
| Facilitating rural doctor | 0.22 |
| Medical store | 0.19 |
| Eigenvalues | 6.636 |
| Percent variance | 51 |

## RESULTS AND DISCUSSION

The contribution of cooperative societies in social and community services is the strength of organization (Meynell, 1984). Further, he also advises that it is not an area to be entered before the cooperative is on a sound financial footing. The exception to this general rule may perhaps be that of education and training and the provision of infrastructure such as roads etc. These may normally require an input from outside sources such as government and the cooperative apex organization.

**Public transportation:** Only 2.5% of cooperative societies claimed that they had “Great deal” in making available public transportation service in the village for their members. The majority (72.5%) of cooperative societies revealed that they were “Not at all” part and parcel of public transportation service while 15% mentioned their role as “Very little” and 5% each stressed “Good deal” and “Moderate” in availing public transportation service in the village. ANOVA shows no significant difference $F$ (5, 33)=1.965, $p$=.110 among cooperative societies in all districts providing public transportation service.

**Facilitating public water supply:** In availing public water supply in the village, 32.5% of cooperative societies of all districts played “Good deal”, while 12.5% mentioned that they had “Great deal”. 10% of cooperative societies had

"Moderate" role, 2.5% cooperative societies had "very little" participation and 42.5% of cooperative societies declared that their role in the public water supply was "nil". No significant difference $F(5, 33)=.220$, $p=.951$ was found among cooperative societies in all districts in providing public water supply in the village when applied ANOVA test.

**Organization of health camps:** Cooperative societies were found active in the organization of health camps to their members. The 22.5% of cooperative societies claimed that they had "Great deal", 12.5% had "Good deal", 25% had "Moderate" and 7.5% had "Very little" role in organizing health camps, while 32.5% of cooperative societies declared that they "Not at all" participated in organization of health camps for their members. ANOVA shows no significant difference $F(5, 33)=.675$, $p=.645$ among cooperative societies in all districts in organizing health camps for their members.

**Medical store facility:** The majority (90%) of cooperative societies in districts declared that they had "Not at all" medical store facility made avail for their members. The 2.5% of cooperative societies had "Great deal" and "Good deal" respectively and 5% claimed that they had a "Very little" contribution in availing medical store facility to their members. A significant difference $F(5, 33)=.458$, $p=.804$ was not found among cooperative societies in all districts in availing medical store facility to their members when applied ANOVA test.

**Facilitating rural doctor:** About 2.5% of cooperative societies in all districts claimed that they had "Great deal" and 5% of cooperative societies had "Good deal" in availing rural doctor in cooperative area, while 5% mentioned that they had "Very little" role and majority 87.5% had "Not at all" involved in availing rural doctor. No significant difference $F(5, 33)=.534$, $p=.749$ was found among cooperative societies in all districts in availing rural doctor facility in the cooperative area.

**Developing cooperative store:** The 30% of cooperative societies from all districts had claimed "Great deal" in creating cooperative store facility for their members while 12.5% mentioned "Good deal." The 17.5 and 2.5% stressed "Moderate" and "Very little" participation respectively and 37.5% of cooperative societies had "Not at all" participated in creating cooperative store facility for their members. There was significant difference $F(5, 33)=2.647$, $p=.041$ was found among cooperative societies in all districts in creating cooperative store facility to their members. Post hoc test revealed that cooperative societies of Mumbai suburban district were significantly different than cooperative societies of Raigad and Mumbai districts.

**Donation for religious activity:** Maximum 37.5% of cooperative societies had "Great deal" while 30% claimed for "Good deal" in giving away donations for religious activities. 12.5% cooperative societies had "Not at all" and "Moderate" and 7.5% had "Very little" contributions for religious activities. ANOVA test shows no significant difference $F(5, 33)=1.692$, $p=.164$ among cooperative societies in all districts donating for religious activities.

**Appreciation for educational activities:** About 47.5% of cooperative societies in all districts claimed "Great deal" in donating for educational activities while 20% had stressed "Good deal." About 7.5 and 5% of cooperative societies had mentioned "Moderate" and "Very little " contribution for educational activities, while 20% of cooperative societies declared "Not at all" contribution for educational activities. ANOVA test shows no significant difference $F(5, 33)=1.304$, $p=.286$ among cooperative societies in all districts in donating for educational activities.

**Financial assistance for affected fisher member:** Half (50%) of the cooperative societies from all districts claimed "Great deal" in providing financial assistance to affected fisher members, while 25% claimed "Good deal", 5% had "Moderate" and 20% cooperative societies declared "Not at all" assistance for affected fisher members from their cooperative societies. ANOVA test shows no Significant difference $F(5, 33)=1.982$, $p=.107$ among cooperative societies in all districts in providing financial assistance for affected fisher members.

**Recreational facility:** The 20% of cooperative societies from all districts claimed "Great deal" in creating recreational facility for their members in the cooperative area, while 7.5% had "Good deal", 2.5% had "Very little" and 70% of cooperative societies declared "Not at all" participation in creation of recreational facility for their members. ANOVA test shows the significant difference $F(5, 33)=2.946$, $p=.026$ among cooperative societies in all districts in creating a recreational facility for their members. Post hoc test revealed that cooperative societies of Mumbai district were significantly different than other districts cooperatives in creating a recreational facility for their members.

The analysis was done to examine the interrelations among the independent variables of social development activity. Factor scores on each factor were correlated with each other factor. The results for correlation matrix are given in Table 2.

Correlation matrix showed no correlation among social development variables. It indicated that each and every variable is independent and were not associated with each other. An attempt was also made to find out the combined effect of social development variables by cross-tabulating each variable against other variables. It also reveals that there was no combined effect of any of the two variables on social development process undertaken by cooperative

societies in the cooperative area.

An effort was made to test the significance level with reference to the correlation among all the variables of social development activities. The hypothesis tested was social development variables is independent of each other. The results are depicted in Table 3.

Correlation among social development activity variables showed each variable was significantly different from each other. The social welfare activities undertaken by cooperatives on the basis of the financial status of cooperatives, fulfill the needs of their members, to maintain the social status among society and to influence the peoples in cooperative activities. Therefore, these activities do not have relation to each other and carried out independently as per requirements. This result strengthens the hypotheses that, each and every activity is independent of each other.

In next step of the analysis, the variables of social development activity were further rotated for measurement of discrimination among themselves with mean values. The result of discrimination among activities is given in Table 4.

The results of discrimination of variables of social development activity on the basis of means showed highest mean (0.681) for the variable 'health camp organized by cooperative societies' while lowest mean (0.316) was for the variable 'financial assistance to fisher members affected by accidents / disasters'. This showed the influence of independent variables like health camp was more than the financial assistance by cooperative societies.

In the final part of analysis, all the variables of social development activity were cross-tabulated independently against each district to find out the regional differences among cooperatives in social development activity. The result indicated that the majority of cooperative societies among all districts were involved in social development activities. The 'high participation' of fisheries cooperative societies of Maharashtra was found for activities such as 'donating for religious activity', 'appreciating educational achievements', 'providing public water supply', 'establishing cooperative store' and 'providing financial assistance to fisher members affected by accidents / disaster', while the cooperative societies scored 'average participation' with reference to 'organization of health camps'. Cooperative societies rated 'low participation' score for the social activities which includes 'public transportation', 'medical store',

**Table 2.** Correlation Matrix of variables of social development activity

| Activities | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Public transportation | | | | | | | | | | | | |
| Facilitating public water supply | 0.509 | | | | | | | | | | | |
| Organizing health camp | 0.430 | 0.798 | 0.654 | 0.386 | 0.753 | | | | | | | |
| Medical store | 0.436 | 0.399 | 0.684 | 0.636 | 0.257 | 0.397 | | | | | | |
| Facilitating rural doctor | 0.425 | 0.425 | 0.682 | 0.662 | 0.301 | 0.453 | 0.889 | | | | | |
| Cooperative store | 0.483 | 0.669 | 0.490 | 0.243 | 0.846 | 0.766 | 0.286 | 0.306 | | | | |
| Donation to religious activities | 0.194 | 0.411 | -0.00 | -0.44 | 0.346 | 0.341 | -0.100 | -0.110 | 0.413 | | | |
| Educational activity | 0.375 | 0.774 | 0.417 | 0.201 | 0.782 | 0.753 | 0.244 | 0.286 | 0.716 | 0.526 | | |
| Financial assistance | 0.401 | 0.655 | 0.372 | 0.180 | 0.631 | 0.566 | 0.222 | 0.260 | 0.422 | 0.416 | 0.687 | |
| Recreational facility | 0.579 | 0.592 | 0.480 | 0.033 | 0.483 | 0.516 | 0.348 | 0.336 | 0.429 | 0.379 | 0.541 | 0.491 |

**Table 3.** Significance level among correlated variables of social development activity

| Activities | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Public transportation | | | | | | | | | | | | |
| Public water supply | .000 | | | | | | | | | | | |
| Health camp | .003 | .000 | .000 | .008 | .000 | | | | | | | |
| Medical store | .003 | .006 | .000 | .000 | .057 | .006 | | | | | | |
| Rural doctor | .003 | .003 | .000 | .000 | .031 | .002 | .000 | | | | | |
| Cooperative store | .001 | .000 | .001 | .068 | .000 | .000 | .039 | .029 | | | | |
| Donation to religious activities | .118 | .005 | .492 | .002 | .015 | .017 | .273 | .253 | .004 | | | |
| Educational activity | .009 | .000 | .004 | .110 | .000 | .000 | .067 | .039 | .000 | .000 | | |
| Financial assistance | .006 | .000 | .010 | .137 | .000 | .000 | .087 | .055 | .004 | .004 | .000 | |
| Recreational facility | .000 | .000 | .001 | .421 | .001 | .000 | .015 | .018 | .003 | .009 | .000 | .001 |

**Table 4.** Discrimination of variables of social development activity on the basis of means

| | Discrimination range | | Mean |
|---|---|---|---|
| | 1 | 2 | |
| Public transportation | 0.612 | 0.512 | 0.562 |
| Public water supply | 0.770 | 0.366 | 0.568 |
| Health camp | 0.799 | 0.563 | 0.681 |
| Medical store | 0.502 | 0.360 | 0.431 |
| Rural doctor | 0.544 | 0.457 | 0.501 |
| Cooperative store | 0.622 | 0.276 | 0.449 |
| Donation to religious activities | 0.341 | 0.499 | 0.420 |
| Educational activity | 0.637 | 0.191 | 0.414 |
| Financial assistance | 0.510 | 0.121 | 0.316 |
| Recreational facility | 0.560 | 0.259 | 0.409 |
| % of Variance | 58.463 | 35.458 | 46.960 |

'facilitating rural doctors' and 'creating recreational facilities' for members. All cooperative societies of Thane and Sindhudurga districts had high participation in 'providing financial assistance to fisher members affected by accidents / disaster' and overall 74% of cooperative societies among all districts provided financial assistance to fisher members affected by accidents / disaster. All cooperative societies of Mumbai suburban and Thane were found to be involved in 'providing a donation for religious activities' while 66.7% of cooperative societies had 'provision for giving a donation to religious activities' all over Maharashtra. All cooperative societies of Mumbai district supporting 'educational achievements' of the fisher children, while 83.3% of cooperative societies from Mumbai suburban district support 'educational achievements'. Overall, about 66.7% of cooperative societies found supporting 'educational achievements' in coastal districts of Maharashtra.

The low participation of cooperative societies was found in social activities such as establishing medical store (92.3%), availing rural doctor (92.3%), public transportation (87%), and creating recreational facility (71.8%). All of the cooperative societies from Mumbai and Mumbai suburban districts had low participation in availing medical store and rural doctor. Details of district wise social development activities carried out by cooperative societies are given in Table 5.

Chi-square analysis was carried to test the hypothesis that social development activities conducted by cooperative societies among all districts are same. The test revealed that social activities among the cooperative societies of all districts were significantly different ($p$<0.05) from each other except in social activity 'establishing cooperative store'.

Findings of the study revealed that marine cooperative societies were playing an important role in the social development of their fisher members. Overall, cooperative societies of Maharashtra state are performing well in the social factors such as appreciation for educational activities, financial assistance to affected fishers, establishing a cooperative store, donation for religious activities, organizing health camps, etc.

The contribution of cooperative societies in developing the public water supply was found low in the study area. The medical facilities such as a rural doctor, medical store were hardly carried out by cooperative societies in the study area. The social activity such as facilitating rural doctors and medical store needs to be established in the cooperative area. There should be a regular organization of health camps in the cooperative area to monitor the health status of fisher members. In the present study, very few recreational facilities were found to be undertaken by cooperative societies. Two cooperative societies had a future plan to establish multipurpose mall; which includes fishery requisites shop, processing hall, fish storage facility, a fish outlet for fresh and dry fishes, multipurpose hall - for fisher members, canteen, grocery shop, food stall, etc. The recreational facilities such as community hall, canteen need to be established by cooperative societies as the community hall can be utilized for community meetings, Annual General Meeting's of a cooperative society, training, film shows, community functions, marriages functions, etc.

## CONCLUSIONS

Fisheries cooperative societies are involved in different social development activities in Maharashtra. Their involvement in social development activities such as donating for religious activities, appreciating educational achievements of fisher children's, providing public water supply, establishing a cooperative store and providing financial assistance to fisher members affected by accident / disaster. Overall, the participation of the marine fisheries cooperatives is found to be average and can be further improved by participatory discussions with members so as to find the needs and then design social development programmes according to needs of members. The social development programmes of the cooperatives can also be supported by the Department of Fisheries.

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**Table 5.** Social development activity of cooperative societies cross tabulated with districts

| Variables | | Districts* | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | | Mumbai suburban | Mumbai | Thane | Raigad | Ratnagiri | Sindhudurga | |
| Public transportation | Low participation | 5 | 3 | 5 | 11 | 8 | 2 | 34 |
| | Average | 0 | 0 | 1 | 1 | 0 | 0 | 2 |
| | High participation | 1 | 0 | 0 | 0 | 1 | 1 | 3 |
| Public water supply | Low participation | 3 | 1 | 2 | 7 | 4 | 1 | 18 |
| | Average | 0 | 0 | 2 | 0 | 2 | 0 | 4 |
| | High participation | 3 | 2 | 2 | 5 | 3 | 2 | 17 |
| Health camp | Low participation | 1 | 2 | 1 | 7 | 3 | 2 | 16 |
| | Average | 3 | 0 | 2 | 2 | 3 | 0 | 10 |
| | High participation | 2 | 1 | 3 | 3 | 3 | 1 | 13 |
| Medical store | Low participation | 6 | 3 | 5 | 11 | 9 | 3 | 37 |
| | Average | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | High participation | 0 | 0 | 1 | 1 | 0 | 0 | 2 |
| Rural doctor | Low participation | 6 | 3 | 5 | 10 | 9 | 3 | 36 |
| | Average | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | High participation | 0 | 0 | 1 | 2 | 0 | 0 | 3 |
| Cooperative store | Low participation | 0 | 2 | 2 | 8 | 3 | 1 | 16 |
| | Average | 1 | 0 | 1 | 1 | 4 | 0 | 7 |
| | High participation | 5 | 1 | 3 | 3 | 2 | 2 | 16 |
| Donation to religious activity | Low participation | 0 | 0 | 0 | 5 | 2 | 1 | 8 |
| | Average | 0 | 1 | 0 | 2 | 2 | 0 | 5 |
| | High participation | 6 | 2 | 6 | 5 | 5 | 2 | 26 |
| Educational activity | Low participation | 1 | 0 | 1 | 5 | 2 | 1 | 10 |
| | Average | 0 | 0 | 1 | 1 | 1 | 0 | 3 |
| | High participation | 5 | 3 | 4 | 6 | 6 | 0 | 26 |
| Financial assistance | Low participation | 3 | 0 | 0 | 4 | 3 | 0 | 10 |
| | Average | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | High participation | 3 | 3 | 6 | 8 | 6 | 3 | 29 |
| Recreational facility | Low participation | 4 | 0 | 4 | 11 | 7 | 2 | 28 |
| | Average | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | High participation | 2 | 3 | 2 | 1 | 2 | 1 | 11 |

* Note : 1 = Mumbai suburban; 2 = Mumbai; 3 = Thane; 4 = Raigad; 5 = Ratnagiri; 6 = Sindhudurg

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# Optimization of Stocking Density for Duckweed (S*pirodela polyrrhiza* L.Schleiden) Fed Semi-intensive Carp Poly-Culture System

**Brahma Nand Shukla, Meera D. Ansal*, Vaneet Inder Kaur and Asha Dhawan**

*College of Fisheries, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana-141 004, India*
**E-mail: ansalmd@gmail.com*

***Abstract:*** An outdoor experiment was conducted to assess productivity of non-duckweed fed (NDWF) and duckweed (*Spirodela polyrrhiza* L.Schleiden) fed (DWF) semi-intensive carp poly-culture systems, stocked with Indian major carps (*Catla catla* Ham., *Labeo rohita* Ham and *Cirrhinus mrigala* Ham) and exotic carps (*Cyprinus carpio* Linn. and *Ctenopharyngodon idella* Val.). Fish in NDWF group was fed daily with green fodder (Maize/Berseem) @ 5% body weight (BW) of grass carp (*C. idella*) and dry diet (rice bran + mustard meal 1:1) @ 1.5% BW of fish other than grass carp, while fish in DWF groups was fed daily with fresh duckweed @ 20% BW of grass carp (*C. idella*), catla (*C. catla*) and common carp ©. *carpio*) for 135 days. Duckweed feeding did not affect water quality in DWF groups and supported optimum zooplankton production up to stocking density of 12,500 fry $ha^{-1}$. Survival of fish in DWF groups remained unaffected up to stocking density of 12,500 fry $ha^{-1}$, but declined at stocking density 15,000 fry $ha^{-1}$. Duckweed feeding supported higher growth in *C. catla* and *C. idella*, while growth of *C. mrigala* and *C. carpio* remained unaffected. However, growth of *L. rohita* declined significantly in all the DWF groups.

***Keywords***: Aquaculture, Fish, Grass carp, Growth, Productivity, Survival, Water quality

The basic concept of semi-intensive carp polyculture system, where surface, column and bottom feeding fishes are cultured together, is to make maximum use of available natural food in all the three zones of the pond for higher productivity. Both natural and supplementary feed plays a vital role in semi-intensive aquaculture systems. Natural food (plankton) production is triggered and maintained in the pond by regular supply of organic manures or inorganic fertilizers, while various types of supplementary feeds are also used to supplement natural food for higher fish growth and productivity. Besides being a major input (more than 60 % of total input cost), supplementary feed is one of the sources responsible for pollution in semi-intensive aquaculture systems. Unconsumed/left over feed, partially digested feed (faecal matter) and added organic matter leads to excess detritus accumulation, ammonia production and eutrophication, which ultimately elevates the biological oxygen demand (BOD) of the system leading to poor water quality conditions, with special reference to dissolved oxygen levels (Cho and Bureau, 1997).

Supplementary feed being the major source of nutrient enrichment; pollution control in aquaculture systems has to start with feed management. In view of this, there is need to develop a model, where maximum percentage of feed is consumed before contributing to BOD of the system and optimum water quality is maintained without much management. Poly-culture of surface, column and bottom feeding carps itself addresses the problem to some extent, where the bottom feeders help in reducing BOD by consuming a considerable amount of detritus produced in a system. It could be further achieved through introduction of some suitable feeding regime, ensuring maximum feed utilization and less waste production.

Introduction of herbivorous species like grass carp (*Ctenopharyngodon idella*) in carp poly-culture system holds ample scope in this direction. Semi digested vegetation based faecal matter produced by grass carp forms a nutrient rich food for the detritus feeding fishes like mrigal and common carp and also serves as quality manure for plankton production for other species in the system (Skillicorn *et al*., 1993). Being natural food of many herbivorous fishes, aquatic plants can be easily integrated in a grass carp based poly-culture system. Among the various aquatic plants, surface floating duckweeds (*Lemna, Spirodela* and *Wolffia*) hold great potential due to its fast growth rate and high nutritive value i.e., high protein content (up to 45% on dry matter basis), better essential amino acid profile (high lysine and methionine content) and less fibre content (7-14%) as compared to most of the plant based feed resources (Ansal *et al*., 2008, 2010; Ansal and Dhawan, 2009).

Although duckweed fed poly-culture system is expected to have an edge over traditional poly-culture system and has been reported to support higher fish productivity (Azim and Wahab, 2003; Kabir *et al.,* 2009), but not much work has been carried out in case of grass carp based crap poly-culture systems. It is expected to support higher stocking

density (SD) in comparison to traditional semi intensive poly-culture system, without any additional nutrient input and supplementary feeding.

## MATERIAL AND METHODS

An experiment was carried out at Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, Punjab, in 80m$^2$ outdoor cemented tanks for 135 days with 4 treatments each replicated twice (Table 1). A 5 cm thick soil layer was spread at the bottom of each tank for supporting the detritus food chain. Lime was added for disinfecting the tanks and maintaining water pH between the optimum ranges for carp culture (7.5-9.0). After 20 days of manuring, each tank was stocked with fry of Indian major carps [catla, *Catla catla* (7.42g)*, rohu, Labeo rohita* (7.67g) and mrigal, *Cirrhinus mrigala* (7.75g)] and exotic carps [grass carp, *Ctenopharyngodon idella* (5.55g) and *common carp, Cyprinus carpio* (7.40g)] @ 10,000 fry ha$^{-1}$ in NDWF group and @10,000, 12,500 and 15,000 fry ha$^{-1}$ in $DWF_1$, $DWF_2$ and $DWF_3$ groups, respectively, in the ratio of 3:4:3 for surface (*C. catla*), column (*L. rohita* and *C. idella*) and bottom feeders (*C. mrigala* and *C. carpio*), respectively.

Fish was fed with supplementary feed once a day after sunrise at a fixed time and fixed place to ensure maximum utilization of feed by the fish. Fish in NDWF group was fed with green fodder [Maize (*Zea mays)* and Barseem (*Trifolium alexandrinum*)] @ 5% body weight (BW) of grass carp and dry diet (rice bran + mustard meal 1:1) @ 1.5% BW of fish other than grass carp. Fish in $DWF_1$, $DWF_2$ and $DWF_3$ groups was fed with fresh duckweed (*Spirodela polyrrhiza*) @ 20% BW of grass carp, catla and common carp for 135 days, on the basis of preliminary findings that catla and common carp also consume duckweeds directly. Fresh duckweed from livestock (dairy) waste water bioremediation unit of College of Fisheries was harvested daily (Fig. 1) for feeding the fish in $DWF_1$, $DWF_2$ and $DWF_3$ groups. In case of NDWF group, the tanks were manured with CD @ 625kg ha$^{-1}$ every fortnight, while no manuring was done in case of DWF groups.

The proximate analysis of different feeds and feed ingredients w.r.t. crude protein (CP), crude fibre (CF), ether extract (EE), total ash (TA) and nitrogen free extract (NFE) was done on dry matter (DM) basis (Table 2) by following the methods of AOAC (2000). Samples of green fodder (maize and clover/barseem) and duckweed, used to feed the fish during different months, were dried and pooled for proximate analysis. During the study period, the water quality parameters and plankton production were recorded at fortnight intervals. Growth of fish was recorded at monthly

**Table 1.** Details of treatments

| Parameters | Non-duckweed fed (NDWF) group | Duckweed fed (DWF) groups | | |
|---|---|---|---|---|
| | (Control) | DWF1 | DWF2 | DWF3 |
| Stocking density (fry ha$^{-1}$) | 10,000 | 10,000 | 12,500 | 15,000 |
| Manuring with Cow dung | Pre-stocking @ 5000kg ha$^{-1}$ Post-stocking @ 625kg ha$^{-1}$ fortnight$^{-1}$ | No manuring | No Manuring | No Manuring |
| Feeding | Fodder Maize/berseem @ 5% BW of grass carp Dry diet- Rice bran + Mustard meal (1:1) @ 1.5% BW of catla, rohu, mrigal and common carp | Fresh Duckweed @ 20% BW of grass carp, catla and common carp | Fresh Duckweed @ 20% BW of grass carp, catla and common carp | Fresh Duckweed @ 20% BW of grass carp, catla and common carp |

**Table 2.** Percent proximate composition, gross energy and cost of different feeds and feed ingredients (dry matter basis)

| Feed/feed ingredient | Crude protein | Ether extract | Crude fibre | Ash | Nitrogen free extract | Gross energy (Kcal g$^{-1}$) | Cost[3] of feed Kg$^{-1}$ (₹) |
|---|---|---|---|---|---|---|---|
| Berseem | 13.12 | 2.76 | 24.36 | 12.51 | 47.25 | 2.93 | 1.25 |
| Maize | 10.50 | 1.34 | 25.73 | 8.86 | 53.57 | 2.90 | 1.40 |
| Rice bran[1] | 14.30 | 1.60 | 22.95 | 9.50 | 51.52 | 3.06 | 9.70 |
| Mustard meal [1] | 36.70 | 1.25 | 24.09 | 7.75 | 30.21 | 3.41 | 18.20 |
| Dry diet[2] | 25.50 | 1.42 | 23.52 | 8.62 | 40.94 | 3.24 | 13.95 |
| Duckweed | 31.25 | 1.65 | 11.64 | 24.25 | 31.21 | 3.18 | 0.30 |

[1]Solvent extracted [2]Rice bran + mustard meal (1:1); [3]As per market price/production cost at the time of experiment

(A) (B)

**Fig. 1.** A) Duckweed based bioremediation unit for recycling of livestock shed waste water
B) Harvesting of duckweed biomass from bioremediation unit for feeding the fish in DWF groups

intervals, while survival of fish was termination of experiment. Different water quality parameters [temperature, pH, dissolved oxygen (DO), total alkalinity (TA), ammonical-nitrogen ($NH_3$-N), nitrite-nitrogen ($NO_2$-N), nitrate-nitrogen ($NO_3$-N), and soluble/ortho-phosphates ($PO_4^{3-}$)] and plankton production were analysed as per APHA (1991). A random sample of 10 fish of each species from each tank was collected to record total body length (TBL) and body weight (BW) of fish. Net weight gain (NWG), percent net weight gain (% NWG), specific growth rate (SGR), condition factor (K), feed conversion ratio (FCR) and protein efficiency ratio (PER) for every treatment were calculated as per standard methodology. The data was analysed with a Statgraphic statistical package (Statgraphics version 2.6).

## RESULTS AND DISCUSSION

**Water quality parameters**: The water quality parameters (pH, D.O.,TA, $NH_3$-N, $NO_2$-N, $NO_3$-N and ortho-$PO_4^{3-}$) in all the treatments were well within the recommended range (Boyd and Tucker, 1998) for carp culture, throughout the culture period and the differences among treatments were insignificant (Table 3). The results are in agreement with earlier reported by Azim and Wahab (2003), Chowdhury *et al*. (2008) and Kabir *et al*. (2009). No significant differences were observed with respect to total zooplankton (ZP) population in NDWF, $DWF_1$ and $DWF_2$ (Table 4). Although, with increase in SD to 15,000 fry $ha^{-1}$ ($DWF_3$ group), total ZP population declined significantly as compared to $DWF_2$ but it did not differ significantly from NDWF and $DWF_1$ groups. The duckweed feeding supported higher number of fish in terms of plankton production, without any additional manure or fertilizer application, up to stocking density of 15,000 fry $ha^{-1}$. Predominance of different ZP groups in all the treatments was in the order copepod > cladocera >rotifer >ostracoda. Azim and Wahab (2003) however observed no significant difference in total ZP population in treatments with different stocking densities (15,000 - 17,000 $ha^{-1}$) in a Thai silver barb based poly-culture system. Thy *et al*. (2008) also observed no significant effect of duckweed feeding on plankton population in a tilapia based poly-culture system. Differences of present results with earlier reports can be attributed to variations among studies with respect to culture conditions and species involved.

**Survival:** Duckweed feeding did not affect overall survival of fish up to SD of 12,500 fry $ha^{-1}$ ($DWF_1$ and $DWF_2$ groups). However, with increase in SD to 15,000fry $ha^{-1}$ ($DWF_3$), overall survival of fish declined by 7.11% and 6.32% as compared to $DWF_2$ and $DWF_1$/ NDWF groups, respectively

**Table 3.** Physico-chemical parameters of water in different treatments

| Parameters | NDWF (Control) | $DWF_1$ | $DWF_2$ | $DWF_3$ |
|---|---|---|---|---|
| Temperature (°C) | 22.32[a] | 22.17[a] | 22.33[a] | 22.35[a] |
| pH | 8.23[a] | 8.28[a] | 8.30[a] | 8.26[a] |
| DO ($mgl^{-1}$) | 11.62[a] | 10.48[a] | 10.99[a] | 11.14[a] |
| TA (mg $CaCO_3$ $l^{-1}$) | 224.20[a] | 212.50[a] | 210.60[a] | 218.30[a] |
| $NH_3$-N ($mgl^{-1}$) | 0.085[a] | 0.074[a] | 0.070[a] | 0.062[a] |
| $NO_2$-N ($mgl^{-1}$) | 0.036[a] | 0.023[a] | 0.026[a] | 0.033[a] |
| $NO_3$-N ($mgl^{-1}$) | 0.417[a] | 0.438[a] | 0.487[a] | 0.416[a] |
| Ortho-$PO_4^{3-}$ ($mgl^{-1}$) | 0.061[a] | 0.085[a] | 0.102[a] | 0.065[a] |

Values with same superscripts in a row do not differ significantly ($P \leq 0.05$)

**Table 4.** Mean Zooplankton population (no. $l^{-1}$) in different treatments

| Zooplankton group | NDWF (Control) | $DWF_1$ | $DWF_2$ | $DWF_3$ |
|---|---|---|---|---|
| Copepoda | 219.71$^{ab}$ | 213.41$^{ab}$ | 254.96$^{a}$ | 171.49$^{b}$ |
| Cladocera | 187.70$^{a}$ | 156.28$^{a}$ | 180.31$^{a}$ | 151.59$^{a}$ |
| Rotifera | 124.45$^{a}$ | 116.49$^{a}$ | 133.97$^{a}$ | 141.87$^{a}$ |
| Ostracoda | 86.81$^{a}$ | 89.80$^{a}$ | 107.26$^{a}$ | 80.99$^{a}$ |
| Total zooplankton | 618.70$^{ab}$ | 576.01$^{ab}$ | 676.52$^{a}$ | 518.97$^{b}$ |

Values with same superscripts in a row do not differ significantly ($P \leq 0.05$)

(Table 5). In spite of higher SD in DWF groups, the water quality parameters remained within the optimum levels for carp culture (Table 3). Duckweed feeding had a positive effect on the water quality and hence, supported higher SD as compared to NDWF group, without affecting the overall survival of fish. Among all the species, mrigal recorded highest average survival (91.17%) followed by common carp, rohu, grass carp and catla. Effect of duckweed feeding and SD on fish survival varied with species. Both rohu and common carp registered higher survival in DWF groups and SD did not appear to have any undesirable effect on fish survival. However, survival of grass carp, mrigal and catla declined in DWF groups with increase in SD.

**Growth:** Growth of fish in NDWF and DWF groups varied with species and effect of SD enhancement in DWF groups was also species specific. Among all the species, both catla and grass carp recorded significantly higher weight gain (in DWF groups (Table 6). Among DWF groups, catla and grass carp recorded maximum net weight gain (NWG) at SD 12,500 and 15,000 fry $ha^{-1}$, respectively. Duckweed feeding did not appear to have any positive effect on growth of bottom feeders, mrigal and common carp. In case of mrigal, there were no significant NWG differences among NDWF and $DWF_1$ (SD 10,000 fry $ha^{-1}$) and $DWF_2$ (SD 12,500 fry $ha^{-1}$) groups, but a significant decline was observed in $DWF_3$ group (SD 15,000 fry $ha^{-1}$). However, in case of common carp, $DWF_2$ (SD 12,500 fry$ha^{-1}$) supported NWG similar to that of NDWF group, while it was significantly less in both $DWF_1$ (SD 10,000 fry $ha^{-1}$) and $DWF_3$ (SD 15,000 fry $ha^{-1}$) groups. As compared to NDWF group, catla and grass carp registered higher NWG and SGR in all the duckweed fed groups. Duckweed feeding also supported better condition factor (K-value) in catla

**Table 5.** Comparative survival (%) of fish in different treatments

| Species | Treatments | | | | |
|---|---|---|---|---|---|
| | NDWF | $DWF_1$ | $DWF_2$ | $DWF_3$ | Average survival |
| *C. catla* | 68.74 | 64.60 | 66.70 | 62.50 | 65.61 |
| *L. rohita* | 75.00 | 78.10 | 75.00 | 79.20 | 76.82 |
| *C. mrigala* | 95.83 | 91.70 | 96.70 | 80.60 | 91.17 |
| *C. carpio* | 70.83 | 79.20 | 86.70 | 72.20 | 77.21 |
| *C. idella* | 78.12 | 75.00 | 67.50 | 62.50 | 70.78 |
| Overall survival | 77.70 | 77.70 | 78.50 | 71.40 | |

**Table 6.** Growth of fish in different treatments

| Growth Parameter | Treatments | | | |
|---|---|---|---|---|
| | NDWF (Control) | $DWF_1$ | $DWF_2$ | $DWF_3$ |
| | *C. catla* | | | |
| Initial BW (g) | 7.40$^{a}$ | 7.50$^{a}$ | 7.40$^{a}$ | 7.40$^{a}$ |
| Final BW (g) | 22.40$^{b}$ | 30.80$^{a}$ | 34.20$^{a}$ | 25.40$^{b}$ |
| NWG (g) | 15.00 | 23.30 (+55.33 ) | 26.80 (+78.66) | 18.00 (+20.00) |
| SGR | 0.32 | 0.40 | 0.44 | 0.36 |
| K-value | 1.25 | 1.31 | 1.29 | 1.17 |
| | *L. rohita* | | | |
| Initial BW (g) | 7.50$^{a}$ | 7.30$^{a}$ | 7.70$^{a}$ | 8.20$^{a}$ |
| Final BW (g) | 42.80$^{a}$ | 37.10$^{b}$ | 36.70$^{b}$ | 29.60$^{c}$ |
| NWG (g) | 35.30 | 29.80 (-15.58) | 29.00 (-17.84) | 21.40 (-39.37) |
| SGR | 0.50 | 0.46 | 0.45 | 0.37 |
| K-value | 1.10 | 1.07 | 1.11 | 1.08 |
| | *C. mrigala* | | | |
| Initial BW (g) | 7.70$^{a}$ | 8.00$^{a}$ | 7.70$^{a}$ | 7.60$^{a}$ |
| Final BW (g) | 20.60$^{a}$ | 19.20$^{ab}$ | 18.70$^{ab}$ | 17.80$^{b}$ |
| NWG (g) | 12.90 | 11.20 ( -13.17) | 11.00 ( -14.72) | 10.20 (-20.93) |
| SGR | 0.28 | 0.25 | 0.26 | 0.24 |
| K-value | 0.98 | 0.93 | 0.92 | 0.9 |
| | *C. carpio* | | | |
| Initial BW (g) | 7.20$^{a}$ | 7.40$^{a}$ | 7.50$^{a}$ | 7.50$^{a}$ |
| Final BW (g) | 80.60$^{a}$ | 64.30$^{b}$ | 76.90$^{a}$ | 62.00$^{b}$ |
| NWG (g) | 73.40 | 56.90 ( -22.47) | 69.40 ( -5.44) | 54.50 (-25.74) |
| SGR | 0.70 | 0.62 | 0.67 | 0.61 |
| K-value | 1.35 | 1.39 | 1.28 | 1.26 |
| | *C. idella* | | | |
| Initial BW (g) | 5.30$^{a}$ | 5.60$^{a}$ | 5.60$^{a}$ | 5.70$^{a}$ |
| Final BW (g) | 27.30$^{c}$ | 46.30$^{b}$ | 45.40$^{b}$ | 51.10$^{a}$ |
| NWG (g) | 22.00 | 40.70 ( +85.00) | 39.80 ( +80.90) | 45.40 (+106.36) |
| SGR | 0.47 | 0.61 | 0.60 | 0.63 |
| K-value | 1.24 | 1.24 | 1.25 | 1.30 |

NWG= Net weight gain, SGR= Specific growth rate, K-value = condition factor,
Values with different superscripts in a row differ significantly ($P \leq 0.05$)
Values in parentheses represent change over NDWF control group

($DWF_1$ and $DWF_2$), common carp ($DWF_1$) and grass carp ($DWF_3$). Among all the species, duckweed feeding failed to support optimum growth in L. rohita, which was significantly less in all the DWF groups.

The overall results reveal that duckweed feeding supported higher growth in catla and grass carp and optimum growth in mrigal and common carp at stocking density of 12,500 fry $ha^{-1}$. It can be attributed to higher nutritive value of duckweed (Table 2) as compared to green fodder (maize/berseem) and dry diet used in NDWF group. Further, superior essential amino acid profile of duckweed (*Spirodela*) closely resembles animal protein (Iqbal, 1999) and fulfils the essential amino acid requirement of freshwater carps completely, except methionine requirement (Hertrampf and Piedad-Pascual, 2000). Higher digestibility of duckweed (owing to lower fibre content) further ensures more availability of nutrients for growth as compared to other terrestrial feed stuffs. Higher ash content in duckweeds (Table 2) also ensures optimum availability of macro- and micro-nutrients required for optimum growth and good health of fish, which is being supported by higher condition factor (K-value) of fish in DWF groups in the present study. Among the different duckweed fed groups, $DWF_1$ and $DWF_2$ appeared to have positive effect on the condition factor (K) of catla, common carp and grass carp, while in $DWF_3$, higher K-value was recorded only in case of grass carp. Condition factor reflects length-weight relationship of fish and has been used as an index to compare growth and wellbeing of fish based on the principle that heavier fish of a given length are in better condition. The overall results therefore, reveal that duckweed feeding supported higher productivity as compared to traditionally practised carp feeding strategies, without any additional nutrient input in the form of manures or fertilizers.

The results are in agreement with that of Azim and Wahab (2003), who recorded positive effect of duckweed feeding on growth rates of Thai silver barb (*Barbodes gonionotous*), common carp (*C. carpio*) and catla (*C. catla*) in a poly-culture system, while rohu (*L. rohita*) was not affected by duckweed. In Bangladesh, over 10t $ha^{-1}yr^{-1}$ fish productivity has been recorded in duckweed fed carp poly-culture ponds (Iqbal, 1999). Thy *et al*. (2008) also reported higher yield (3.12t $ha^{-1}$ 4$months^{-1}$) in a duckweed fed poly-culture ponds (tilapia, common carp and mrigal) as compared to non-duckweed fed ponds (1.45$tha^{-1}$ 4 $months^{-1}$). Kabir *et al*. (2009) reported 31.2% higher fish production from a duckweed fed poly-culture system, having silver carp (*Hypophthalmichthys molitrix*), Thai silver barb *(B. gonionotus*), Nile tilapia *(Oreochromis niloticus*), common carp (*C. carpio* var. *communis*) and mrigal *(C. mrigala),* as compared to non-duckweed fed system. The results of present study fitted well into the concept of maximum feed utilization and less waste production, thus enabling the culture system to support higher stocking densities owing to better water quality.

**Economics:** Duckweed feeding not only reduced cost of supplementary feeding, but also enhanced fish growth significantly (Table 7). As compared to NDWF group, 7.90%, 45.11% and 37.67% of higher fish biomass was harvested from $DWF_1$, $DWF_2$, and $DWF_3$ groups, respectively. Best FCR (1.18) value (on DM basis) was in $DWF_2$ group followed by $DWF_1$ (1.21), $DWF_3$ (1.42) and NDWF (1.70) groups. Maximum PER (2.70) was in $DWF_2$ group followed by $DWF_1$ (2.65), NDWF (2.45) and $DWF_3$ (2.27) groups. Maximum net income, with respect to fish growth enhancement and saving on supplementary feed cost, was recorded in $DWF_2$ group, which was 98.36% higher than the NDWF group followed by $DWF_3$ (85.48%), and $DWF_1$ (47.26%) groups. Feed cost for production of 1 Kg fish varied from ₹4.79 ($DWF_2$) to 5.79 ($DWF_3$) in duckweed fed groups, which was far less than recorded in case of NDWF group (₹22.29). This can be attributed to huge differences in the cost of fresh duckweed

**Table 7.** Economic evaluation of different treatments

| Parameters | NDWF (Control) | $DWF_1$ | $DWF_2$ | $DWF_3$ |
|---|---|---|---|---|
| Total fish biomass harvested $tank^{-1}$ (kg) | 2.15 | 2.32 (+7.90) | 3.12 (+45.11) | 2.96 (37.67) |
| Total value fish @ ₹70 $Kg^{-1}$ (A) | 150.50 | 162.40 | 218.40 | 207.20 |
| Total feed given (kg) (on DM basis) | 3.67 | 2.81 | 3.70 | 4.20 |
| Total feed cost (₹) (B) | 47.93 | 11.35 (-76.31) | 14.94 (-68.83) | 16.95 (-64.63) |
| Earning with respect to feed cost (₹) (A-B) | 102.57 | 151.05 (+47.26) | 203.46 (+98.36) | 190.25 (+85.48) |
| FCR (Natural food not taken into account) | 1.70 | 1.21 | 1.18 | 1.42 |
| PER | 2.45 | 2.65 | 2.70 | 2.27 |
| Feed cost $kg^{-1}$ fish production (₹) | 22.29 | 4.89 | 4.79 | 5.70 |

-Parentheses indicate % change over NDWF control group
-Average DM content in berseem, maize and duckweed, used in the present studywas 19.20, 28.30 and 7.43%, respectively.

as compared to supplementary feeds traditionally used in case of NDWF system.

Although, stocking density of fish can be enhanced up to 15,000 $ha^{-1}$ in a DWF polyculture system for higher productivity and net profit, but maximum net profit, in terms of feed cost reduction and fish growth enhancement could be achieved at stocking density of 12,500$ha^{-1}$**.** Further, DWF carp poly-culture system can be well integrated with duckweed based live-stock waste water bioremediation projects for additional environmental benefits in terms of waste management and nutrient recycling.

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# Post Harvest Quality Analysis of Chickpea Seeds Grown under Rainfed Conditions

**Harpreet K. Oberoi, Anil K. Gupta[1], Satvir Kaur[1], and Inderjeet Singh**

*Department of Plant breeding and Genetics and [1]Department of Biochemistry,*
*Punjab Agricultural University, Ludhiana-141004, India*
*Email: harpreetoberoi@pau.edu*

***Abstract*:** The present two year study was designed to investigate the post harvest quality of chickpea seeds comprising two drought tolerant (*desi* - PDG 3 and PDG 4) and five drought susceptible (*desi* - PBG 1, GPF 2, PBG 5 and *kabuli* - L 550 and BG 1053) cultivars grown under rainfed and normal recommended irrigated conditions. Under rainfed grown chickpea cultivars mature seeds exhibit decrease in starch that might be the reason for observed increase in total sugars content compared to normal irrigated conditions whereas rainfed conditions led to decrease in total proteins. Reduced water availability resulted in decreased Fe content but increase in Zn content in mature seeds of almost all the chickpea cultivars. Higher phytic acid noted might have resulted in lower Fe levels. Proline and total phenols were found to increase under rainfed conditions and tolerant cultivars were seen have more accumulation of these non-enzymatic antioxidants. Lower levels of saponins and trypsin inhibitors were noticed due to rainfed grown conditions which are nutritionally desirable. Therefore, the study revealed that rainfed can induce variation in chickpea seed quality and further investigations are needed to enhance our understanding of how different abiotic stresses effect early seed development.

***Keywords*:** Post harvest seed, Chickpea, Rainfed conditions, Quality, Minerals

Chickpea (*Cicer arietinum* L.) is one of the oldest and second most important grain legume. The annual total production of chickpea is over 11 million metric tons, of which India alone contributes more than 70%. It serves as a good source of proteins (20-25%), carbohydrates and minerals (like Zn and Fe) (Kashiwagi *et al.*, 2015). Its protein quality is better than other legumes such as pigeon pea, black gram and green gram (Kaur and Singh, 2005; Sharma *et al.*, 2013). Thus, chickpea is considered a functional food or neutraceutical which provide a cheap source of protein and energy to the developing world. In addition also helps in alleviating food related health problems.

The presence of anti-nutritional factors such as trypsin inhibitors, saponins, phytic acid, phenolic compounds and tannins limits the availability of nutrients present in the leguminous crops (Sharma *et al.*, 2013). Mineral nutrients play a fundamental role in the biochemical and physiological functions of biological systems. Micronutrient malnutrition particularly of Fe and Zn is a growing concern worldwide. One sustainable agricultural approach to reducing micronutrient malnutrition globally is to enrich staple food crops with micronutrients or decreasing antinutrient substances that inhibit micronutrient bioavailability. So the nutritional quality of chickpea is further dependent on the status of antinutrients such as phytates, tannins, and protease inhibitors in mature dry seeds (Oberoi *et al.*, 2010).

Plants develop under a wide range of maternal environments, depending on the time of emergence, prevailing competition from other plants, and presence or absence of other biotic or abiotic stress factors (Gallaghera *et al*., 2010). Abiotic stresses occurring during seed development have a profound effect on quantitative and qualitative aspects of seeds (Saini and Westgate, 2000). There are several reports indicating their inhibitory effects on seed-filling processes, eg. drought in the case of wheat (Singh *et al*., 2012) and soybean (Spears *et al*., 1997) and high temperature in the case of maize (Wilhelm *et al*., 1999) and wheat (Wardlaw, 2002). The adverse effects of these abiotic stresses on seed development have been associated with inhibition of photosynthesis (Munier-Jolain *et al*., 1998), senescence of source leaves (Yang *et al*., 2001), hormonal imbalance (Nayyar and Walia, 2004), restriction in uptake of assimilates into seeds (Wilhelm *et al*., 1999), metabolic dysfunction in source or sink organs (Ahmadi and Baker, 2001) and vascular disturbances (Krapp and Stitt, 1995).

During the past several decades, the primary objective of plant breeding programs has been to increase yield, a quest that will remain a principal concern in providing the calorie intake required for the growing world population. However, equally important but largely overlooked in breeding programs is the nutritional quality of chickpea. Comparatively fewer observations exist in legumes on effects of drought stress on seed composition and no observation in case of chickpea. The present study was conducted with a view to assess the impact of drought stress in field on biochemical metabolites (both nutritional and antinutritional) and

micronutrients in *desi* (tolerant and susceptible) and *kabuli* (susceptible) chickpea cultivars.

## MATERIAL AND METHODS

**Plant Material and *Experimental Conditions*** *:* Seven chickpea cultivars PDG 3 and PDG 4 (drought tolerant) and PBG 1, PBG 5, GPF 2, L 550 and BG 1053 (drought susceptible), were grown in fields of the Punjab Agricultural University, Ludhiana, (30◦54_N, 75◦48_E, elevation 247 m above mean sea level), India. The experimental soil was loamy sand with pH about 7.8–8.0. The seeds were sown in $4m^2$ plots with a row space of 30 cm. The four middle rows were left intact for grain yield determination and two outside rows were used for sampling. The experimental design was a randomized complete block with three replications. Under the irrigated treatment, plants were watered throughout the period from sowing to maturity according to the recommended agronomic practices. All irrigations were withheld from the plants subjected to the drought treatment except the presowing irrigation for field preparation. Therefore, the drought-treated plants received water only available through rainfall. The weather data of total rainfall for the crop season of two years (2008-09 and 2009-10) was collected from the field meteorological observatory and during the crop season rainfall was scanty which helped in the development of drought stress. Mature chickpea seeds after harvesting were crushed to fine powder in pestle and mortar and the contents were passed through 80µm sieve to have uniform powder which was stored for extraction and assay of various biochemical components.

**Extraction and estimation of nutritional components**

***Total sugars and starch:*** Total soluble sugars were extracted from 200mg crushed chickpea powder by crushing with 80% ethanol followed by 70% ethanol (Kaur *et al*., 2000). From the pooled extract, total soluble sugars were estimated (Dubois *et al*., 1956). The sugar free residue was dried at 60˚C and used for the estimation of starch (Yoshida *et al*., 1976).

***Total proteins*****:**100 mg of powdered chickpea seeds were kept overnight in 25ml of 0.1 N NaOH to extract total proteins from them. The supernatant after centrifugation at (5000g) was used for the estimation of total proteins (Lowry *et al*., 1951).

***Minerals analysis*** **:** Minerals were extracted by digesting the seed powder (200mg) with nitric acid and perchloric acid (4:1) solution and estimated by atomic absorption spectrometer with model No. AAS 240 (Varian).

**Extraction and estimation of Non-enzymatic components**

***Total phenols*****:** Phenolic compounds were extracted by refluxing the 400mg seed powder with 80% aqueous methanol. The refluxed material after filtration was used for estimating total phenols (Swain and Hills, 1959). The standard curve was prepared by using gallic acid (10-50µg).

***Proline:*** Proline was extracted from 300mg of chickpea powder with 3% sulfosalicylic acid and estimated by the method described by Kaur *et al*. (2013).

**Extraction and estimation of antinutritional components**

***Phytic acid*****:** The phytic acid was extracted from the 100mg powered seeds with 1.2% HCl and precipitated with ferric chloride (Zemel and Shelef, 1982) and organic phosphorous was estimated by the method of Rouser *et al*. (1974). A standard curve was also prepared by using sodium phytate (5-25µg) as standard.

***Tannins*****:** Tannins were extracted from the powdered seeds (50 mg) and estimated using Folin-Denis reagent along with tannic acid (10-100 µg) as standards, the intensity of colour was measured at 700nm (Sadasivam and Manickam, 1992).

**Protease inhibitors:** The protease inhibitor was extracted and estimated by method of Hajela *et al*., (1999). The powdered seed (100 mg) was homogenized with 3 ml of 0.1 M phosphate buffer (pH 7.5) containing 0.1 M NaCl and centrifuged at 10000 x g for 20 minutes. The supernatant was incubated at 80˚C for 20 minutes and then again centrifuged at 10000 x g for 20 minutes. The supernatant was used for assaying the bovine trypsin inhibition by using N -benzoyl-DL-arginine p-nitroanilide (BAPNA) as a substrate .One inhibitor unit is defined as the quantity of inhibitor which inhibits 50% of trypsin activity.

**Saponins:** Saponins were extracted with acetone and later with methanol from the 500mg seed powder and estimated (Fenwick and Oakenfull, 1983, Baccuou *et al*., 1977). The amount of saponin was calculated from standard curve using saponin (0-40µg) as standard.

**Statistical analysis**

Means and standard deviations were calculated for various nutritional and antinutritional factors. Factorial CRD was used to determine whether there were significant differences among cultivars and parameters and to find interaction of cultivars with parameters.

## RESULTS AND DISCUSSION

**Nutritional components**

**Total sugars and starch:** The restricted irrigation conditions caused increase in total sugars content in the seeds and an average increase of about 51% was observed in PBG 5 (Table 1). However, under rainfed conditions the content (greater than 100 mg/g) was more in tolerant cultivars seeds than in all other cultivars. The accumulation of soluble sugars is strongly correlated to the acquisition of drought tolerance in

plants (Hoekstra and Buitnik, 2001). It has also been suggested that sugars interact with proteins and membranes through hydrogen bonding, thereby, preventing protein denaturation under dehydration stress (Ramanjulu and Bartels, 2002). Higher total sugars content in seeds of drought tolerant cultivars under drought stress could be the reason for tolerant behavior under water deficit stress and increase in sugar content could also provide some tolerance to even susceptible cultivars. Behboudian *et al*. (2001) while studying the effect of water stress on chickpea observed that though terminal water stress caused about 30% reduction in yield but it led to higher accumulation of soluble sugars in the seeds.

Drought induced limitation on seed sink capacities may also differentially hinder seed sink strength leading to reduced accumulation of storage products such as starch. Thus, water stress had a significant influence on starch content in seeds of tolerant and susceptible cultivars. A reduction in starch content was observed in all the stressed plant seeds except PBG 5 (Table 1). Gebeyehu *et al*. (2010) reported similar observation of drought induced decrease in seed starch accumulation in common bean genotypes. In both tolerant and susceptible chickpea cultivars, an increase in total soluble sugars, with concomitant decrease in starch contents under rainfed conditions suggested that drought induces starch sugar interconversion. A drought induced decrease in starch contents may also be associated with inhibition of starch synthesis, which might be due to either reduced availability of glucose or because of direct effects of water stress on the activity of soluble starch synthase (Parida *et al*., 2007).

**Total proteins:** In general, drought stress resulted in small decline in protein content (Table 1). The total protein content in mature seeds of seven cultivars under irrigated conditions ranged from 211.25 to 236.25 mg $g^{-1}$ and 209.33 to 233.47 mg $g^{-1}$, respectively, whereas under rainfed conditions it ranged from 187.50 to 220.36 mg $g^{-1}$ and 186.10 to 220.04 mg $g^{-1}$, respectively. Pandey *et al*. (2001) raised chickpea plants under irrigated and unirrigated field conditions to observe the effect of leaf nitrogen and soluble protein content after flowering during seed development. Leaf nitrogen and soluble protein content were higher in irrigated than in unirrigated plants. In present study, drought resulted in a marginal decrease in total protein of seeds. The present data also showed a significant increase in free amino acids in mature seeds (Table 1). These results would suggest that the decrease in the protein contents can be related to the increase in amino acids, which are proposed to function in osmotic adjustment, protection of cellular macromolecules, maintaining cellular pH, and scavenging of free radicals are proposed functions of free amino acid accumulation (Parida *et al*., 2007).

**Minerals:** Decreasing water availability may affect the uptake of mineral elements in plant tissues by affecting root growth and nutrient mobility in soil and nutrient uptake (Samarah *et al*., 2004). However, plant species and genotypes within species differ in their response to nutrient element uptake under water stress (Garg, 2003). According to World Health Organization, deficiencies in Zn and Fe rank 5$^{th}$ and 6$^{th}$, respectively, among the risk factors responsible for illness in developing countries (WHO, 2002). Moreover, Fe and Zn are also important for seedling development and early establishment of crop, especially in micronutrient poor soil.

Iron and zinc concentrations of chickpea range from 32.1-133.0 to 29.6-60.3 mg/Kg, respectively (Attia *et al*., 1994; Ereifej *et al*., 2001; Rincon *et al*., 2003). In the present study, irrigated and rainfed conditions resulted in significant variation in chickpea seeds micronutrients, particularly, Fe content. Seed Fe content ranged from 97-158 mg/Kg and 40-101 mg/Kg under irrigated and rainfed conditions, respectively (Table 1). PBG 1 (susceptible *desi* cultivar) and PDG 3 (tolerant *desi* cultivar) showed higher Fe content under irrigated conditions. However, under rainfed condition L550 along with PBG 1 registered higher Fe content in both years. On average , percent reduction in average Fe content was more in PBG 5 followed by PDG 3 and then by PBG 1. About 10-61% decrease in Fe was recorded as a result of water deficit conditions. Effect of treatments on Fe accumulation was variable among the cultivars and across the years.

Effect of treatments (irrigated and rainfed) on Zn contents was significant in both years 2008-09 and 2009-10 (Table 1). In general, Zn content increased in response to rainfed conditions except in PBG 1 (*desi* susceptible cultivar) and BG 1053 (*kabuli* susceptible cultivar). Cultivars showed significant variation in Zn content accumulation. Similar to this experiment result, Babaeian *et al*. (2011) reported increasing concentration of seeds zinc under water deficit stress in seed filling stage in rape seed. Peleg *et al*. (2009) suggested that grain Zn concentrations are important for better growth and tolerance to biotic and abiotic stress factors during seed germination. On an average, PDG 4 have more percentage increase in Zn under rainfed condition. However, average content of Zn was recorded to be more in PBG 5 under both conditions. Zn content varied from 45-71 mg/Kg under irrigated condition and 50-88 mg/Kg under rainfed condition.

Maximum percentage decline in iron content was observed in seeds of PBG 5. The *kabuli* cultivars had relatively less decline in iron content under rainfed

**Table 1.** Nutritional contents (total sugars, starch, total proteins, Iron and Zinc) in post harvested mature seeds of *desi* and *kabuli* chickpea cultivars under irrigated and rainfed conditions

| Type | Cultivars | Year | Treatment | Total Sugars (mg $g^{-1}$) | Starch (mg $g^{-1}$) | Total Proteins (mg $g^{-1}$) | Fe (mg $Kg^{-1}$) | Zn (mg $Kg^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| Desi Tolerant | 'PDG3' | 2008-09 | I | 2.22 | 5.38 | 234.9 | 157.5 | 51.9 |
| | | | R | 2.95 | 4.38 | 220.4 | 97.1 | 59.2 |
| | | 2009-10 | I | 2.57 | 7.27 | 220.9 | 139.8 | 59.7 |
| | | | R | 3.29 | 7.00 | 217.9 | 80.2 | 66.1 |
| | 'PDG4' | 2008-09 | I | 5.74 | 5.31 | 228.8 | 135.4 | 46.4 |
| | | | R | 6.50 | 4.19 | 215.9 | 92.4 | 61.9 |
| | | 2009-10 | I | 3.09 | 7.43 | 219.5 | 131.5 | 53.3 |
| | | | R | 4.32 | 7.62 | 220.0 | 90.1 | 62.3 |
| Desi Susceptible | 'PBG1' | 2008-09 | I | 4.36 | 4.56 | 211.3 | 152.3 | 59.7 |
| | | | R | 2.86 | 4.69 | 187.5 | 99.7 | 52.3 |
| | | 2009-10 | I | 3.71 | 6.84 | 220.9 | 147.0 | 50.1 |
| | | | R | 4.00 | 5.43 | 200.2 | 92.9 | 52.1 |
| | 'GPF2' | 2008-09 | I | 2.18 | 4.75 | 236.3 | 110.2 | 53.0 |
| | | | R | 2.69 | 3.94 | 210.1 | 93.5 | 61.1 |
| | | 2009-10 | I | 2.57 | 7.40 | 233.5 | 96.7 | 45.1 |
| | | | R | 2.86 | 6.10 | 205.0 | 84.7 | 52.3 |
| | 'PBG5' | 2008-09 | I | 4.27 | 5.19 | 235.0 | 141.9 | 55.5 |
| | | | R | 5.52 | 4.88 | 210.5 | 58.0 | 61.1 |
| | | 2009-10 | I | 2.23 | 7.08 | 209.3 | 107.1 | 70.6 |
| | | | R | 3.57 | 6.13 | 186.1 | 40.3 | 88.1 |
| Kabuli Susceptible | 'L550' | 2008-09 | I | 5.47 | 5.50 | 236.3 | 123.0 | 52.9 |
| | | | R | 3.29 | 4.63 | 211.3 | 100.8 | 61.9 |
| | | 2009-10 | I | 3.29 | 7.90 | 222.1 | 117.2 | 51.1 |
| | | | R | 3.88 | 6.17 | 203.6 | 92.9 | 60.4 |
| | 'BG1053' | 2008-09 | I | 4.76 | 5.25 | 230.0 | 97.0 | 58.9 |
| | | | R | 3.95 | 3.94 | 199.5 | 92.0 | 50.0 |
| | | 2009-10 | I | 2.87 | 6.45 | 233.2 | 105.5 | 57.7 |
| | | | R | 3.48 | 6.32 | 210.2 | 90.7 | 57.4 |
| CD (p=0.05) | | 2008-09 | Cultivars (A) | A : 4.55; B : 2.43 | A : 17.73; B : 9.48 | A: 13.99; B: 7.48 | A: 0.16; B: 0.09 | A: 0.63; B: 0.33 |
| | | 2009-10 | Treatment (B) | A : 7.06; B : 3.77 | A : 28.99; B : 15.5 | A : 15.58; B : 8.33 | A : 0.32; B : 0.17 | A : 0.57; B : 0.31 |

conditions. Hussein and Camilia (2011) had also shown decreased uptake of Fe as a result of missing irrigation and on the contrary the uptake of Zn increased in fenugreek varieties. Non significant negative correlation between iron and zinc content was observed in irrigated crop (2008-09) under rainfed conditions. However, in year 2009-10, a significant negative correlation (r = -0.9) has been observed. For example, under stress though iron content is less in seeds but same is not true for the zinc content. This indicated that both the systems might be independent but then negative correlation might indicate that if one (iron) is unable to be absorbed the advantage is to the other one (zinc), that is possible if some part of uptake is common and not totally independent of each other.

Therefore, it indicates that water stress during seed filling had a pronounced effect on quality of chickpea seeds. Mechanisms of photo-assimilation and seed storage processes under drought stress need further probing in chickpea for any conclusive information on this aspect.

**Non-enzymatic antioxidant components**

**Total Phenols:** The range of total phenols in the seeds of chickpea cultivars grown under irrigated conditions was 1.42

mg $g^{-1}$ to 2.81 mg $g^{-1}$ in year 2008-09 and 1.64 mg $g^{-1}$ to 2.60 mg $g^{-1}$ in year 2009-10 (Table 2). On the contrary, in seeds of cultivars under rainfed conditions total phenols content ranged from 2.58 mg $g^{-1}$ to 3.91 mg $g^{-1}$ in 2008-09 and 2.00 mg $g^{-1}$ to 3.69 mg $g^{-1}$ in 2009-10. Content of total phenols in seeds of tolerant cultivars under both conditions was higher compared to susceptible cultivars in both years. However, increase in total phenols was observed in the mature seeds of all the cultivars due to drought stress. The synthesis and release of phenolic compounds are induced by various abiotic and biotic stresses (Koc *et al*., 2010). It has been shown that phenolic compounds can be involved in the hydrogen peroxide scavenging cascade in plant cells as phenols are oxidized by peroxidase and contribute in scavenging of hydrogen peroxide (Singh and Malik, 2011).

**Proline:** Immature legume seeds accumulate proline before ripening, leading to the assumption that proline might be important for the development of generative organs (Lehman *et al.*, 2010). Proline which increases proportionately faster than other amino acids in plants under water deficit conditions, has been suggested as a parameter for selecting drought resistance varieties and in present study the average proline level increased approximately 3-fold in rainfed PDG 3 and PDG 4 seeds compared to irrigated seeds (Table 2). Similarly, higher proline content was in L 550 (2-3 fold) and BG 1053 (3-4 fold). However, in comparison to seeds of tolerant desi cultivars obtained from rainfed fields, proline content in *kabuli* and other *desi* cultivars were lower under rainfed environment.

Increased accumulation of proline in chickpea cultivars seed obtained from the crop grown under rainfed condition might be due to the decreased activity of proline dehydrogenase, a catabolic enzyme of proline (Parida *et al*., 2007). Bates (1973) reported tremendous free proline accumulation as one of the most dramatic stress characteristics. Thus, increase in proline in seeds of crop grown under rainfed conditions was high enough to be considered as the principle solute that may provide protection by overcoming drought effect through osmotic adjustment, and serves as storage forms of nitrogen and carbon for future use under less stressful conditions. Nayyar *et al*. (2005) observed an accumulation of proline in seed reserve of chickpea under chilling stress and Behboudian *et al*. (2001) reported increase of proline in seeds of water stressed chickpea plants.

**Antinutritional components**

**Phytic acid:** Phytic acid is naturally present in all legume crops and plays three physiological roles in the seed: phosphorus storage, energy storage, and triggering cessation of metabolism to ensure seed dormancy (Nikolopoulou *et al*., 2007). In general, phytic acid was more in seeds of *desi* and *kabuli* cultivars obtained from rainfed crop than in seeds of irrigated crop (Table 2). The average of phytic acid in tolerant *desi* chickpea was from 19 to 34 mg $g^{-1}$, in susceptible *desi* chickpea from 14 to 35 mg $g^{-1}$ and in *kabuli* cultivars from 16 to 33 mg $g^{-1}$ under irrigated and rainfed conditions. There is no significant change in different cultivars on the basis of maximum and minimum range of phytic acid. In *kabuli* cultivars seeds, mean accumulation of phytic acid and average percentage increase was found to be lower than *desi* cultivars due to rainfed condition. Drought resulted in non-significant and significant, respectively, decrease in phytic acid content in PDG 3 and L 550 during Ist year compared to irrigated control condition. Environmental factors, such as growing location, year, climate and soil factors, are important influences on synthesis of phytic acid in legume seeds (Nikolopoulou *et al*., 2007). Bueckert *et al*. (2011) showed that phytic acid in chickpea seeds is influenced by temperature and rainfall during the growing season. Therefore, it can be proposed that crop grown under rainfed conditions resulted in increase in phytic acid concentration in the seeds.

This higher phytic acid might be responsible for the lower Fe contents (Table 1) observed in the present study. Phytic acid by virtue of its ability to chelate iron ensures the removal of $Fe^{2+}$ which alone has been shown to cause the production of reactive oxygen species and lipid peroxidation by oxidation of $Fe^{3+}$ which is relatively inert. The prevention of the oxidative events by ROS ordinarily catalysed by the free and weakly bound iron may be an important antioxidant function of phytic acid within plant seeds and may contribute towards explaining why seeds belonging to many plant species are viable for a long time, in spite of the fact they contain a potentially dangerous mixture of iron, oxygen and unsaturated fatty acids (Doria *et al*., 2009).

**Tannins:** The pattern of changes in tannin content was not similar to that of phenols under rainfed conditions (Table 2). Tannins decreased in BG 1053 (*kabuli* susceptible cultivar) whereas in L 550, the other *kabuli* susceptible cultivar, some increase was observed in both years under rainfed conditions. However, these changes were not significant. In 2008-09, both tolerant (PDG 3 and PDG 4) cultivars and PBG 1 showed decrease in tannins content in seeds obtained from rainfed crop over seeds of irrigated crop and in year 2009-10, trend was just opposite. Out of *desi* and *kabuli* susceptible chickpea cultivars, in general accumulation of tannins was more in *desi* seeds obtained from rainfed crop. However, average tannin content was noticed to be almost comparable under both conditions.

**Trypsin inhibitor:** Trypsin inhibitor in seeds was high in crop

**Table 2.** Non-enzymatic antioxidant (total phenols and proline) and antinutritional components (phytic acid, tannins, trypsin inhibitor and saponins) in post harvested mature seeds of *desi* and *kabuli* chickpea cultivars under irrigated and rainfed conditions

| Type | Cultivars | Year | Treatment | Total phenols (mg $g^{-1}$) | Proline (mg $g^{-1}$) | Phytic Acid (mg $g^{-1}$) | Tannins (mg $g^{-1}$) | Trypsin Inhibitor | Saponins (mg $g^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|
| Desi Tolerant | 'PDG3' | 2008-09 | I | 2.66 | 1.43 | 30.93 | 2.90 | 460.6 | 6.46 |
| | | | R | 3.91 | 4.77 | 27.62 | 2.62 | 421.0 | 5.44 |
| | | 2009-10 | I | 1.80 | 1.64 | 19.61 | 3.02 | 538.2 | 4.84 |
| | | | R | 3.05 | 3.81 | 28.01 | 3.44 | 461.1 | 3.16 |
| | 'PDG4' | 2008-09 | I | 2.81 | 1.66 | 28.05 | 3.61 | 412.0 | 8.85 |
| | | | R | 3.21 | 6.07 | 31.57 | 2.96 | 329.4 | 9.01 |
| | | 2009-10 | I | 1.86 | 1.62 | 23.47 | 3.18 | 400.2 | 6.48 |
| | | | R | 3.30 | 5.29 | 34.45 | 3.79 | 455.5 | 4.27 |
| Desi Susceptible | 'PBG1' | 2008-09 | I | 1.49 | 1.78 | 27.25 | 2.74 | 338.0 | 6.49 |
| | | | R | 2.86 | 2.40 | 31.94 | 2.88 | 301.1 | 6.60 |
| | | 2009-10 | I | 1.72 | 1.44 | 17.48 | 3.10 | 401.2 | 5.27 |
| | | | R | 2.00 | 3.45 | 23.00 | 3.22 | 364.6 | 3.76 |
| | 'GPF2' | 2008-09 | I | 1.58 | 1.38 | 19.36 | 2.99 | 231.5 | 6.54 |
| | | | R | 2.90 | 2.68 | 31.05 | 3.13 | 300.9 | 5.73 |
| | | 2009-10 | I | 1.67 | 1.62 | 22.90 | 3.08 | 382.9 | 7.89 |
| | | | R | 3.02 | 2.54 | 35.26 | 3.25 | 401.0 | 5.79 |
| | 'PBG5' | 2008-09 | I | 1.57 | 1.26 | 14.46 | 3.08 | 356.4 | 7.53 |
| | | | R | 2.66 | 2.11 | 20.16 | 3.09 | 273.1 | 6.77 |
| | | 2009-10 | I | 1.65 | 1.85 | 25.62 | 3.15 | 460.2 | 6.32 |
| | | | R | 2.82 | 2.50 | 36.74 | 3.20 | 370.7 | 5.22 |
| Kabuli Susceptible | 'L550' | 2008-09 | I | 2.40 | 1.26 | 21.14 | 2.58 | 342.2 | 8.03 |
| | | | R | 3.14 | 3.71 | 16.90 | 2.68 | 217.6 | 6.67 |
| | | 2009-10 | I | 1.64 | 1.33 | 21.66 | 2.89 | 420.5 | 5.79 |
| | | | R | 2.88 | 4.33 | 32.92 | 3.13 | 396.2 | 4.48 |
| | 'BG1053' | 2008-09 | I | 1.42 | 1.08 | 21.90 | 2.43 | 328.7 | 6.95 |
| | | | R | 2.58 | 4.42 | 28.09 | 2.33 | 379.6 | 7.40 |
| | | 2009-10 | I | 2.60 | 1.47 | 26.21 | 2.99 | 444.2 | 7.89 |
| | | | R | 3.69 | 3.97 | 33.80 | 2.74 | 472.2 | 5.27 |
| CD (p=0.05) | | 2008-09 | Cultivars (A) | A : 0.09; B : 0.05 | A : 0.43; B : : 0.23 | A : 3.89; B : 2.08 | A : 0.17; B : 0.09 | A : 23.14; B : 2.36 | A : 0.43; B : 0.23 |
| | | 2009-10 | Treatment (B) | A : 0.16; B : 0.08 | A : 0.42; B : : 0.23 | A : 1.76; B : 0.94 | A : 0.35; B : 0.19 | A : 27.88; B :14.90 | A : 0.47; B : 0.25 |

obtained from irrigated fields than seeds obtained from crop raised under rainfed conditions (Table 2) with the exception of GPF 2 (*desi* susceptible) and BG 1053 (*kabuli* susceptible) where trypsin content increased under restricted water conditions. *Kabuli* susceptible cultivars under both conditions had more trypsin inhibitor than *desi* susceptible cultivars. The level of trypsin inhibitor varies from 231.5 to 460.6 units $g^{-1}$ in non stressed seeds of 2008-09 and 217.6 to 421.0 units $g^{-1}$ in stressed seeds of 2008-09. On the other hand, in non stressed and stressed seeds of year II trypsin inhibitor varies from 328.7 to 538.2 units $g^{-1}$ and 364.6 to 461.1 units $g^{-1}$, respectively.

However, Srinivasan *et al*. (2009) reported an increase in trypsin protease inhibitors under abiotic stress in maize. Lower trypsin inhibitor level in stressed seeds implied that it did not play important role in tolerance against drought stress and our results corroborates with Singh *et al*. (2012) who reported decrease in trypsin inhibitors in wheat genotypes under the influence of drought stress. The poor digestibility of proteins and inhibitory effects on absorption and utilization of

mineral such as calcium, iron and zinc have been attributed to the presence of trypsin inhibitors.

**Saponin:** In general, seeds of crop obtained from rainfed fields have lower saponin content as compared to seeds obtained from irrigated fields (Table 2). Average value of saponins for two years was more in seeds obtained from irrigated crop in comparison with seeds obtained under rainfed conditions. Saponins interact with biomembranes of animals and disturb the fluidity of biomembranes leading to holes and pores and cells become leaky and die (Jain *et al*., 2009). Saponins also reduce the absorption of nutrients either directly by binding with or by inactivating enzymes involved in the digestion process (Alexander *et al*., 2009). Similar to trypsin inhibitor saponins were lowered by drought stress in chickpea cultivars. Both these are antinutritional factors and from nutritional point of view to have low content of trypsin inhibitors and saponins is desirable. PDG 3 cultivar has the lowest saponin content out of the seven cultivars taken for present study.

In the present investigation, higher phytic acid and phenolic compounds in seeds of tolerant cultivars grown under stress conditions might be responsible for conferring more tolerance to them.

The findings of this study demonstrate that changes observed in biochemical metabolites and mineral content under stress conditions are associated with adaptation of plants to stresses. It can also be inferred that drought stress can induce variation in chickpea seed quality and further investigations are needed to enhance our understanding of how different abiotic stresses effect early seed development.

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# Evaluation of Crude Plant Extracts and Biopesticides for Eco-friendly Management of Lepidopterous Insect Pests in Cabbage

**S.D. Sharma and Ramesh Lal[1]**

*CSK HPKV, HAREC, Bajaura, [1]KVK, Bajaura, Kullu-175 125, India*
*E-mail: sukhdevsharma40@gmail.com*

***Abstract***: A field experiment was carried out during summer 2013 at Bajaura (Kullu) Himachal Pradesh to find the efficacy of different plant extracts and biopesticides against lepidopterous insect pests attacking cabbage crop. The results revealed that though the highest mortality (100%) of the lepidopterous caterpillars was recorded at 3 days after treatment (DAT) containing chemical pesticides ($T_4$) yet both the biopesticidal formulations viz. $T_1$ (*Melia* 5 % formulation @ 5 ml/L) and $T_3$ (Neemban (0.15%) @ 5 ml/L and treatment with plant extract i.e. $T_2$ (extract of the mixture of leaves of 5 plants) were also equally effective resulting in 82.16, 82.23 and 80.00 per mortality of the larvae (early instars ), respectively following first spray and 79.75, 75.62 and 75.94 per mortality after 3 days of the second spray. Data on the yield and yield attributing parameters of cabbage showed that the proportion of unmarketable heads of cabbage under respective treatments $T_1$, $T_3$ and $T_2$ was 7.87, 8.40 and 7.72 per cent as compared to 44.00 per cent in the control and the marketable yields recorded from these treatments were also significantly higher than the control and statistically at par with each other. i.e. 459.95, 439.15 and 462.95 q/ha as compared to 224.02 q/ha in the control. Yield loss under these treatments was 3.12, 3.50 and 2.72 per cent, respectively as compared to 35.14 per cent in the control.

***Keywords***: Plant extracts, Biopesticides , Lepidopterous insect pests, *Pieris brassicae*

Cabbage (*Brassica oleracea* var. *capitata* Linn.) is an important vegetable crop of Himachal Pradesh. In lower Kullu valley, different varieties of this crop are grown almost throughout the year but crop grown during summer (March-September) is an important off season crop. This crop is jeopardized by the ravages of many species of insects at one or the other stage of its growth and among them lepidopterous insect pests are the most serious and often causing major yield loss. To safeguard the crop from these insect-pests, farmers resort to frequent and indiscriminate use of variety of toxic and broad spectrum synthetic chemical pesticides. Pesticides do have a good control of it, but the high proportion and indiscriminate use of these chemicals is highly toxic and has immediate adverse effects on human health, wildlife, local food sources such as cattle or fish, beneficial insects and biodiversity (Vanlaldiki *et al.*, 2013; Sharma *et al.*, 2014). These impacts emanate from direct exposure in use, spray drift, washing work clothes used while spraying, home pesticide storage, pesticide dumps and persistence in the environment. Over the last few decades, there has been increasing focus on plant derived products to fight and reduce losses caused by agricultural pests and diseases due to ecological considerations (Facknath, 2006; Amoabeng *et al.*, 2013; Shashni and Sharma, 2013) . A number of plant species like *Azadirachta indica, Melia azedarach, Lantana camara, Cannabis sativa, Nerium indicum, Eucalyptus* sp., *Ricinus communis, Solanum nigerum* are known to possess insecticidal properties (Prakash *et al.*, 2008; Sharma and Gupta, 2009) . The compounds from these plants have a number of useful activities like toxicity, repellence, feeding and oviposition deterrence and insect growth regulator activity etc. on pests of agricultural importance (Mordue, 2004; Hasheminia *et al*., 2013). Moreover plant derived products are presumed to be less toxic to non-target organisms, easily biodegradable and therefore do not persist in the environment as opposed to synthetic products which often end up being pollutants (Isman, 2006). Also from the viewpoint of poor and small holder farmers there is a dire need to find an alternative to commercially extracted botanical insecticides like pyrethrum and azadirachtin which are relatively expensive and difficult to obtain. The present studies were therefore undertaken to study the effect of different locally available crude plant extracts and biopesticides on the incidence of lepidopterous insect pests of cabbage and to examine the effect of plant extracts and biopesticides on the yield and yield attributing parameters of cabbage under the lower mid hill geographic conditions of Himachal Pradesh.

## MATERIAL AND METHODS

The study was carried out at two locations, one at the farm of Entomology section, Hill Agricultural Research and Extension centre, Bajaura at an altitude of 1090m above mean sea level, Kullu, Himachal Pradesh during summer 2013 (31.8$^0$N latitude and 77$^0$E longitude) and other at farmers field near the station. The experiments were laid out

in randomized block design in both the cases comprising of 5 treatments each replicated four times. One month old seedlings of cabbage (cv. Varun) were transplanted in the last week of March at a spacing of 60cm x 45cm in plot size of 4.50m x 2.70m. All the recommended agronomic practices were followed to raise the crop. Five treatments including control were $T_1$: *Melia* 5 % formulation @ 5 ml $L^{-1}$ followed by the same spray after 10 days of 1st spray; $T_2$ : Extract of the mixture of leaves of 5 plants viz. *Cannabis sativa* (bhang), *Roylea cineria* (karvi), *Juglans regia* (walnut), *Nerium sp* (kaner) & *Melia azedarach* (darek) @ 1 kg each in 30 litres cow urine and fermented for 10-12 days with daily intermittent stirring and used @ 5% with Triton X-100 (0.05%) as emulsifier followed by the same spray after 10 days of 1st spray; $T_3$: Neemban (0.15%) @ 5 ml $L^{-1}$ + *Trichoderma viride* @ 5g $l^{-1}$ + *Pseudomonas florescense* @ 5g/litre + Streptocycline 100mg/litre followed by the same spray after 10 days of 1st spray; $T_4$: Lambda-cyhalothrin @ 0.004% @ 8ml/10 litres followed by Malathion 50EC @10ml/10 litres after 10 days of first spray and $T_5$: Control (No spray). For preparing the extract of mixture of leaves of 5 plants, 1 kg fresh leaves of each plant were fermented in 30 litres of fresh cow urine in a plastic drum of 50 litres capacity. The drum was covered airtight. The contents were stirred intermittently with a wooden stick for 5-7 minutes on alternate days first in clock wise and then anticlock wise direction. After 10-12 days there was a complete fermentation of the leaves as evinced by the pungent smell emanating from the contents. Before spray, the solution was sieved through muslin cloth (Anonymous, 2012-13).

The plant extract so prepared was used at 5% concentration by adding Triton X-100 at the concentration of 0.05% as emulsifier. The data were recorded on lepidopterous insect- pests mainly larvae of cabbage butterfly (*Pieris brassicae)*, diamondback moth (*Plutella xylostella*) cabbage semi-looper (*Plusia orichalcea*) and tomato fruit borer (*Helicoverpa armigera)* infesting cabbage . Two sprays were given to the crop at 10 days interval and the first spray was initiated immediately after the appearance of eggs of these insects 35 days after the transplanting of the crop in the first week May. The larvae of *P. brassicae* were first to appear and the larvae of other insects appeared 6-8 days after the appearance of the larvae in the former case. Pre and post treatment larval counts were recorded on 6 plants per plot after different days and the data of two trials were pooled (Table 1) and mean population per plant was worked out. Data on the proportion of plants that formed the heads, marketable heads and unmarketable heads due to insect attack were recorded under different treatments (Anonymous, 2012-13). Marketable yield and un-marketable yield due to insect attack was recorded plot wise under different treatments and converted to q/ha. Yield loss by insects (%) under different treatments was also calculated. Economics of different treatments was calculated on the basis of market price of cabbage (Rs. 1500 $q^{-1}$); insecticides/ fungicides viz: lambda-cyhalothrin @ Rs. 520 $L^{-1}$, malathion 50 EC @ Rs. 320 $L^{-1}$, neembaan (0.15%) @ Rs. 320 $L^{-1}$, streptocycline @ Rs. 5,500 $Kg^{-1}$, *Trichoderma viride* @ Rs. 140 $Kg^{-1}$, *Pseudomonas florescense* @ Rs. 185 $Kg^{-1}$, Triton X-100 @ Rs. 1300 $L^{-1}$, labour charges for the collection and preparation of extract of leaves of 5 plants (Rs. 510 $ha^{-1}$ @ Rs 170 $day^{-1}$; total 3 man days) and labour charges for pesticide application (Rs. 1,700 $ha^{-1}$ @ Rs. 170 $day^{-1}$: total 10 man days $ha^{-1}$). Net additional return (Rs $ha^{-1}$) of each module was calculated by subtracting the total cost (Rs $ha^{-1}$) of pesticide application from net return (Rs $ha^{-1}$) on the pesticide application over the control. Net return per rupee invested was calculated by dividing the net additional return (Rs $ha^{-1}$) with cost of pesticide application. The data of both the trials were pooled and were calculated through angular transformations, subject to ANOVA for RBD and means were compared using significant difference at 5% probability using CPCS-1 data analysis package.

## RESULTS AND DISCUSSION

Data presented in Table 1 showed that all the biopesticidal/ plant extract treatments were significantly superior to untreated control in protecting the crop from lepidopterous insect pests after 1, 2 and 3 days of treatment. Though the highest mortality (100%) was recorded after 3 days of application with treatment having chemical pesticides i.e. $T_4$ consisting of lambda-cyhalothrin @ 0.004% followed by Malathion 50 EC after 10 days of 1st spray, yet $T_1$ (*Melia* 5 % formulation) and $T_3$ (Neemban (0.15%) @ 5 ml/L ) both the biopesticidal formulations and $T_2$ (extract of the mixture of leaves of 5 plants) were also equally effective resulting in 82.16, 82.23 and 80.00 per mortality of the larvae (larvae of early instars i.e. up to the second instar) , respectively. Similarly, 3 days after second spray, the larval mortality recorded with these biopesticides and plant extracts was 79.75, 75.62 and 75.94, respectively. The present results regarding the effectiveness of biopesticides like Neemban (0.15%) on lepidopterous insects of cabbage find support from Raut and Simon (2010) and Meena *et al*. (2011). However Panigrahi (2010) and Vanlaldiki *et al*. (2013) reported *Bacillus thuringiensis* var. *kurustaki* to be highly effective against these pests. The effectiveness of the treatment containing extract of the mixture of leaves of 5 plants ($T_2$) may be due to the additive or synergistic action of the various compounds present in the leaves of the individual

**Table 1.** Efficacy of plant extracts and biopesticides on the control of larvae of different insect pests infesting cabbage

| Treatment | Pre-treatment larval count (No. of larvae plant$^{-1}$) | Post treatment larval mortality (%) after days of 1st spray | | | Larval count after 10 days (no. of larvae plant$^{-1}$) | Post treatment larval mortality (%) after days of 2nd spray) | | |
|---|---|---|---|---|---|---|---|---|
| | | 1st-day | 2nd-day | 3rd day | | 1st-day | 2nd-day | 3rd day |
| $T_1$ | 95.59 (9.83) | 62.96 (7.99) | 72.36 (8.56) | 82.16 (9.12) | 55.33 (7.50) | 62.04 (7.93) | 66.37 (8.19) | 79.75 (8.98) |
| $T_2$ | 98.60 (9.97) | 60.33 (7.89) | 74.36 (8.68) | 80.00 (8.99) | 47.16 (6.93) | 37.52 (6.19) | 56.13 (7.54) | 75.94 (8.77) |
| $T_3$ | 96.21 (9.86) | 62.39 (7.96) | 72.33 (8.56) | 82.23 (9.12) | 42.24 (6.57) | 63.67 (8.04) | 70.33 (8.44) | 75.62 (8.75) |
| $T_4$ | 96.30 (9.86) | 90.89 (9.58) | 97.81 (9.94) | 100.00 (10.04) | 34.75 (5.97) | 83.31 (9.17) | 86.21 (9.34) | 93.51 (9.72) |
| $T_5$ (Control) | 95.80 (9.86) | 0.00 (1.00) | 0.00 (1.00) | 0.00 (1.00) | 69.75 (8.40) | 0.00 (1.00) | 0.00 (1.00) | 0.00 (1.00) |
| CD (p=0.05) | NS | 0.23 | 0.16 | 0.12 | 0.32 | 0.26 | 0.44 | 0.11 |

Figures in the parentheses are square root transformations

**Treatment details:**

$T_1$: *Melia* 5 % formulation @ 5 ml/L followed by the same spray after 10 days of 1st spray.

$T_2$: Extract of the mixture of leaves of 5 plants viz.*Cannabis sativa* (bhang), *Roylea cineria* (karvi), *Juglans regia* (walnut), *Nerium sp* (kaner) & *Melia azedarach* (darek) @ 1 kg each in 30 litres cow urine and fermented for 10-12 days and used @ 5% with Triton X-100 (0.05%) as emulsifier followed by the same spray after 10 days of 1st spray.

$T_3$: Neemban (0.15%) @ 5 ml/L+ *Trichoderma viride* @ 5g/litre + *Pseudomonas florescense* @ 5g/litre + Streptocycline 100mg/litre followed by the same spray after 10 days of 1st spray.

$T_4$: Lambda-cyhalothrin @ 0.004% @ 8ml/10 litres followed by Malathion 50EC @10ml/10 litres after 10 days of 1st spray.

$T_5$: Control (No spray).

plants. The present observations regarding the mortality of different larvae in $T_2$ are in conformity to those of Hernandez and Vendramin (1997) who reported larval mortality above 80 % with the aqueous extract of *Melia azedarach and Azadirachta indica* against *S. frugiperda* and Sharma and Gupta (2009) who reported plant extract (5%) of *M.azedarach* and *A. indica* effective against *P. brassicae* infesting cabbage with more than 80% protection to cabbage foliage. Berg (2000) reported that extract of dried leaves of *M. azedarach* L. mixed with distilled water filtered after 48 hours, applied to leaves of cabbage, destroyed 90 % of *P. xylostella* L. Sharma (2014) also reported plant extracts prepared from M. *azedarach*, and biopestcides like neemban effective for the control of leaf miner in pea crop.

Data on the yield and yield attributing parameters of cabbage (Table 2) showed that the proportion of unmarketable heads of cabbage under respective treatments $T_1$, $T_3$ and $T_2$ was 7.87, 8.40 and 7.72% as compared to 44% in the control and the marketable yields recorded from these treatments were also significantly higher than the control and statistically at par with each other i.e. 459.95, 439.15 and 462.95 q ha$^{-1}$ as compared to 224.02 q ha$^{-1}$ in the control. Yield loss under these treatments consisting of *Melia* 5% formulation, Neemban (0.15%) @ 5 ml L$^{-1}$ and extract of the mixture of leaves of 5 plants was 3.12, 3.50 and 2.72%, respectively as compared to 35.14% in the control. The present study also finds support from the findings of Prakash and Agarwal (2010) and Defago *et al*. (2005) who have reported better yield and beneficial effects of biopesticides with reduced incidences of insect pests on different crops. However Mwine *et al.* (2013) reported extract of pencil tree (*Euphorbia tirucalli*) to be effective and Rangad *et al.* (2014) reported botanical annonin as highly effective against the cabbage insect pests. Also Hasheminia *et al*. (2013) reported that milk thistle (*Salybium marianum*) extracts had toxic, deterrent and feeding inhibitory effects on *P. brassicae* and the secondary chemicals present in the extract affect enzymatic activities and the levels of non-enzymatic molecules in this insect. Though the highest net additional returns of Rs. 37,440.50 and net returns/rupee invested (8.31) were recorded in case of $T_4$ in the present findings yet $T_2$ (extract of mixture of leaves of 5 plants) also recorded higher net additional returns of Rs. 30,954.50 and net returns/rupee invested as 6.35 (Table 3) than the other treatments viz. $T_1$ and $T_3$ consisting of use of biopesticides. This is because of the low input cost involved in the use and preparation of crude plant extract. These findings are in close agreement to those of Amoabeng *et al.* (2013) who reported reduced production cost, high yield and better profit particularly for the small farmers in controlling the lepidopterous insects in cabbage with the use of crude plant extracts.

**Table 2.** Effect of different plant extracts and biopesticides on the yield attributing characters and yield of cabbage

| Treatment | Plants (%) that formed head | Proportion of | | Marketable yield (q ha$^{-1}$) | Yield loss (%) |
|---|---|---|---|---|---|
| | | Marketable heads | Unmarketable heads due to insect attack | | |
| $T_1$ | 92.70 (9.68) | 92.13 (9.65) | 7.87 (2.97) | 459.95 | 3.12 (2.01) |
| $T_2$ | 92.28 (9.68) | 92.28 (9.65) | 7.72 (2.95) | 462.95 | 2.72 (1.92) |
| $T_3$ | 94.79 (9.79) | 91.60 (9.62) | 8.40 (3.06) | 439.15 | 3.50 (2.11) |
| $T_4$ | 100.00 (10.05) | 97.65 (9.93) | 2.35 (1.83) | 503.65 | 1.64 (1.60) |
| $T_5$ (Control) | 80.20 (9.00) | 56.00 (7.54) | 44.00 (6.70) | 224.02 | 35.14 (6.01) |
| CD (p=0.05) | 0.24 | 0.89 | 0.22 | 29.85 | 0.32 |

Figures in the parentheses are square root transformations; Treatment details; same as given in Table 1

**Table 3.** Economics of different plant extracts and biopesticides against lepidopterous insects

| Treatments | Marketable yield (q ha$^{-1}$) | Net additional returns (Rs. ha$^{-1}$) | Net returns per Rs. invested |
|---|---|---|---|
| $T_1$ | 459.95 | 28652.00 | 5.01 |
| $T_2$ | 462.95 | 30954.50 | 6.35 |
| $T_3$ | 439.15 | 24888.24 | 3.37 |
| $T_4$ | 503.65 | 37440.50 | 8.31 |
| $T_5$ (Control) | 224.02 | | |

It is concluded that in view of the safety to the human health and ecology, plant extracts prepared from mixture of leaves of 5 plants viz. bhang, karvi, walnut, darek and kaner and biopestcides like neem were effective for the control of lepidopterous insect pests in cabbage and could be used for the control of these insect pests particularly against the early instars of the caterpillars. The use of crude plant extracts holds an edge over biopesticides and constitutes a viable approach for the management of lepidopterous insect pests in cabbage and provides an opportunity to the poor farmers to reduce production cost as most of the plants often grow wild in and around farms and can be obtained with little effort and minimal cost. Moreover, there is no gainsaying in the fact that due to increasing awareness regarding the environmental pollution associated with continuous use of synthetic pesticides and campaigns to 'live organic' there is a renewed interest in the use of botanicals for crop protection.

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# Mode of Perpetuation and Impact of Weather Parameters in Development of Anthracnose Disease of Walnut *Marssonina juglandi* (Lib.) Magnus

**Mudasir Hassan, Khurshid Ahmad, N.A. Khan and M.A. Bhat**

*Department of Plant Pathology*
*Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar-191 121, India*
*E-mail: hmudasir72@gmail.com*

***Abstract*:** Perpetuation studies were conducted on *Marssonina juglandis*(Lib.) Magnus causing Anthracnose disease of walnut revealed that the pathogen perpetuated in the form of acervuli on both leaves and twigs and produced viable conidia up to the end of May. The disease development under field conditions on leaves was found to be highly correlated with mean minimum temperature, followed by mean maximum temperature and mean minimum relative humidity, where as positive correlation with average rainfall on leaves, negative correlation with maximum relative humidity was observed. The disease development on twigs was highly correlated with mean minimum temperature, followed by mean maximum temperature, where as it showed negative correlation with rainfall and maximum and minimum relative humidity. Multiple correlation coefficients indicated strong relationship between leaf and twig intensity and weather parameters, there by establishing that rainfall, relative humidity (morning and evening) and temperature (maximum and minimum) had cumulative effect during the course of disease development and induced more than 99.0 and 92.8 per cent variation in leaf and twig intensity of anthracnose.

***Keywords*:** *Marssonina juglandis* (Lib.) Magnus, Walnut, Anthracnose, Perpetuation, Disease intensity, Weather parameters

Anthracnose is the wide spread foliar disease of *Juglans* spp. and the fungus attacks leaves, nuts and shoots of the current season growth (Berry, 1977; Belisario *et al.*, 2008). Symptoms develop on the leaves and fruits as irregular necrotic areas that are often surrounded by small chlorotic halos. The disease causes premature defoliation, slows down plant growth, reduces quantity and quality of nut crops, thereby resulting in huge economic loss in the walnut cultivation regions of the world. Walnut anthracnose results in reduction in quantitative parameters such as size, mass and actual crop of nuts, failure in metabolic processes in leaves and change in biochemical indices (David, 1997; Belisario *et al.*, 2008**;** Van Sambeek, 2003; Kalkisim, 2012). Survival of the pathogen is a crucial component in the dissemination of disease (Agrios, 2005). Saremi and amiri (2010) reported that the fungus commonly overwintered in fallen walnut leaves, infected during the preceding summer in walnut orchards. They also reported that this disease caused 60-80% yield losses in quality and quantity in Iran. Climate not only affect plants but also affects the pathogens, insect pests and weeds that reduces crop yield (Anderson *et al.,* 2004). The classic disease triangle recognizes the role of environmental factors in disease development on crops, as no virulent pathogen can induce disease on a highly susceptible host if weather parameters are not favourable (Agrios, 2005). The present investigation was carried out to study the mode of perpetuation of the pathogen and correlate the development of anthracnose disease of walnut (intensity) on leaves and twigs with the weather parameters.

## MATERIAL AND METHODS

**Disease development with respect to weather parameters:** Five walnut plants (8-10years old) were randomly selected and earmarked in the last week of March 2013 at Shalimar campus of SKUAST-K. Marked plants were examined regularly for first appearance of disease and subsequently at 15 days interval beginning from mid April for recording disease intensity on leaves and twigs. The observations on per cent disease intensity on leaves were recorded using 0-5 scale of (Townsend and Henberger, 1943) with slight modifications given as Grade = per cent leaf area: 0 = No infection/ disease, 01= Upto 10.0, 02=10.1-20.0,03=20.1-30.0, 04=30.1-50.0, 05 = >50.0. Similarly the observations on per cent disease intensity on twigs were recorded using the similiar 0-5 scale of (Townsend and Henberger, 1943) with slight modifications given as mentioned above. Per cent disease intensity (PDI) was calculated

$$\text{Per cent disease intensity} = (\sum(n \times v))/(N \times G) \times 100$$

Where,

$\sum$= Summation

n = Number of diseased leaves/twigs in each category

v = Numerical value of the category

N = Total number of leaves/ twigs examined, and

G = Highest grade value

The meteorological data regarding mean maximum and minimum temperature, relative humidity that prevailed around the SKUAST-K were recorded during the period of investigation in the orchard itself. The data regarding rainfall and number of rainy days were obtained from meteorological observatory at SKUAST-K. The different parameters were then correlated with the disease intensity for drawing the inferences. The rate of disease progress was calculated by using the following formula (Vanderplank, 1963)

$$R = \frac{2.303}{T_2 - T_1} \text{ Log } 10 \frac{X_2}{X_1}$$

Where,

R = rate of disease progress or infection rate

$T_2 - T_1$ = time interval

$X_1$ = disease at time $T_1$

$X_2$ = disease at time $T_2$

The test of significance for simple correlation was carried out using Student's t-test (Snedecor and Cochran, 1986). To determine the joint effect of different independent variables in the development of disease (intensity) during the course of study, multiple correlation coefficients were worked out and linear multiple regression models developed for prediction of intensity on leaves and twigs. Adequacy of fitted regression equations were judged with the help of coefficient of multiple determination. The effect of various environmental factors on disease progress was estimated using linear multiple regression analysis with the prediction equations as:

Yl= b0 + b1X1 + b2X2 + ……..……+ b5X5

Yt= b0 + b1X1 + b2X2 + ……..+ b5X5

Yl per cent disease intensity of leaves, Yt percent disease intensity of twigs, b0 the constant and b1 to b5 the regression coefficients of X1 to X5, respectively.

**Perpetuation:** The anthracnose diseased leaves and twigs were kept on the ground surface in autumn 2013 to study their role in producing viable acervuli and conidia or producing any perfect state for initiating primary infection during following spring 2014. Walnut leaves and twigs bearing typical symptoms of anthracnose disease were collected from walnut orchard during the month of November. The presence of fungus in the diseased tissue was ensured before hand. The material thus collected was put into different sets of nylon mesh bags. The diseased leaves and twigs (in separate bags) were kept on ground surface below the walnut trees for overwintering under natural conditions. The diseased material from each set was examined for viability of fungus at weekly intervals starting from lst week of March.Randomly10 leaf discs of 1sq.cm taken from each sample were examined for the presence of acervuli. These were then crushed in 10 ml of sterilized distilled water and were centrifuged at 3000rpm for 15 minutes. After discarding the supernatant sterile water was added to the pellet to make 5ml of spore suspension and the number of conidia was counted with the help of haemocytometer. To check the conidial viability during spring at weekly intervals, three drops of spore suspension of each sample were placed at each cavity slide and were replicated thrice. These were incubated at 21°C for 48 hours in a moisture chamber. Presence of spores on the overwintering anthracnose lesions and their viability was also studied by harvesting spores from lesions by simply washing them and counting the suspension on petriplates. Spores germination in water was tested as per slide germination technique (Wellman and Mccallan, 1943).

## RESULT AND DISCUSSION

The presence of acervuli was observed on the leaves and twigs throughout the course of study. However, the acervuli were immature on both leaves and twigs upto 1st week of April. These acervuli contained only mycelium upto the 1st week of April, while as formation of conidia was observed from 2nd week of April which coincided with the emergence of leaves in the walnut. However the average number of acervuli on leaves and twigs reached upto maximum of 4.2 and 5.8 per $cm^2$ of leaf and twig area, respectively in the 3rd week of May and decreased thereafter due to increase in sampling time (Table 2). The average number of conidia on leaves increase with every subsequent observation with maximum of $0.85 \times 10^6$ per ml in the 2nd week of May which decreased during subsequent observations upto $0.22 \times 10^6$ per ml in the 3rd week of June. The conidia were also examined for their viability. The conidia (51.60%) were viable even on the first day of their appearance which reached maximum of 84.23 per cent and decreased thereafter with every subsequent observation with increase in sampling time. Similarly, the average number of conidia obtained from twigs was to increase with every subsequent observations with maximum of $1.29 \times 10^6$ per ml in the 2nd week of May which decreased during subsequent observations upto $0.89 \times 10^6$per ml in the last week of June. The viability reached upto maximum of 85.08 per cent in the 2nd week of May and decreased thereafter with every subsequent observation with increase in sampling time. However, no perfect state of the pathogen was observed during the investigation. The present investigation is in complete agreement with the findings of Sharma *et al.* (2009) who reported Acervuli as source of primary infection for *Marssonina leaf blotch* of apple and also in agreement with the findings of Dimova and Arnaudov (2008), Saremi and

Amiri (2010) and Veghelyi and Penzer (1990) as the pathogen causing anthracnose disease of walnut overwinters primarily on infected leaf debris as acervuli and the development of conidia and secondary infection occurred almost continuously until late summer. During the course of present study, no perfect state of the pathogen was observed and also no literature is available regarding its occurrence in India.

**Effect of weather parameters on development of walnut anthracnose:** The disease initiated under field conditions in the last week of May on both leaves as well as on twigs, when the mean atmospheric temperature both maximum and minimum were 21.4°C and 8.4°C, respectively and mean relative humidity both maximum and minimum were 84.66 and 56.40 per cent, respectively. Gradual increase in minimum temperature from 8.4°C to 18.6°C and mean minimum relative humidity from 56.4 to 65.0 per cent, coupled with moderate rainfall favoured the gradual spread of disease from 19.06 to 95.00 per cent on leaves and from 20.0 to 30.2 per cent on twigs. The maximum rate of disease progress was observed during the first fortnight of May on both leaves and twigs which coincided with the favourable temperature and relative humidity for its progress. (Table 2; Fig. 1 and 2).

The correlation coefficients of per cent disease intensity on leaves and twigs of walnut with mean maximum and minimum temperature, mean maximum and minimum relative humidity and mean rainfall are presented in (Table 3). The percent disease intensity on leaves showed positive correlation with mean minimum and maximum atmospheric temperature with correlation coefficients of 0.94 and 0.72, respectively followed by mean minimum relative humidity (r = 0.24) and mean rainfall (r = 0.03). However, a negative correlation was observed with mean maximum relative humidity(r =-0.50). The per cent disease intensity on twigs showed positive correlation with mean minimum and maximum atmospheric temperature with correlation coefficients of 0.88 and 0.77, respectively. However a negative correlation was observed with mean rainfall, mean maximum and minimum relative humidity with correlation coefficients of -0.17, -0.74 and -0.07, respectively on twigs. The joint effect of weather parameters, viz. rainfall, relative humidity (morning and evening )and temperature (maximum and minimum) on leaf and twig intensity recorded during 2013 was highly significant and contributed 98.10 and 86.20 percent variation in leaf and twig intensity, respectively (Table 4). Multiple correlation coefficients indicated strong relationship between leaf and twig intensity with weather variables, there by establishing that rainfall, relative humidity (morning and evening)and temperature (maximum and minimum) had accumulative effect on the disease development and contributed more than 99.0 and 92.8 per cent variation in leaf and twig intensity respectively. The present investigation is in complete agreement with Hashemi

**Table 1.** Presence of acervuli and viability

| Date of observation | Leaves/ $cm^2$ | | | | Twigs/$cm^2$ | | | |
|---|---|---|---|---|---|---|---|---|
| | Stage of acervuli | Average no of acervuli | Average no of conidia $\times 10^6$/ ml | Viability (%) | Stage of acervuli | Average no of acervuli | Average no ofconidia$\times 10^6$/ ml | Viability (%) |
| 1/3/2014 | I | 2.2 | Nil | Nil | I | 2.4 | Nil | Nil |
| 7/3/2014 | I | 2.2 | - | - | I | 2.3 | - | - |
| 14-3-2014 | I | 2.3 | - | - | I | 2.5 | - | - |
| 21-3-2014 | I | 2.6 | - | - | I | 2.9 | - | - |
| 28-3-2014 | I | 2.5 | - | - | I | 3 | - | - |
| 4/4/2014 | M | 2.8 | - | - | I | 3.3 | - | |
| 10/4/2014 | M | 3 | 0.35 | 51.6 | M | 3.5 | 0.37 | 54.88 |
| 17-4-2014 | M | 3 | 0.45 | 70.32 | M | 3.6 | 0.53 | 69.66 |
| 24-4-2014 | M | 3.2 | 0.5 | 65.5 | M | 3.6 | 0.67 | 78.09 |
| 1/5/2014 | M | 3.4 | 0.65 | 73.04 | M | 4 | 0.98 | 74.88 |
| 8/5/2014 | M | 4 | 0.85 | 79.8 | M | 4.9 | 1.29 | 85.08 |
| 15-5-2014 | M | 4.2 | 0.55 | 84.23 | M | 5.8 | 1.21 | 78.64 |
| 22-5-2014 | M | 4.1 | 0.22 | 49.64 | M | 5.4 | 1.12 | 64.66 |
| 28-5-2014 | E | 3 | Nil | Nil | M | 3.6 | 0.89 | 40.44 |
| 4/6/2014 | D | - | - | - | E | 2.4 | - | - |

I = immatureM = mature, D = decomposed leaves, E= Empty,-= Nil

**Table 2.** Effect of weather parameters on the development of anthracnose disease on walnut leaves and twigs

| Date of observation (fortnightly) | Average temperature (°C) | | Average rainfall (mm) | Average relative humidity | | Disease intensity (%) | | Disease progress rate | |
|---|---|---|---|---|---|---|---|---|---|
| | Maximum | Minimum | | RH1 | RH2 | Leaves | Twigs | Leaves | Twigs |
| 30-04 -2013 | 20.1 | 8.2 | 6.45 | 92.3 | 61.6 | 0 | 0 | 0 | 0 |
| 15-05-2013 | 21.4 | 8.4 | 1.78 | 84.7 | 56.4 | 19.06 | 20 | 0.195 | 0.195 |
| 30-05-2013 | 26.53 | 9.99 | 2.01 | 75.1 | 42.6 | 20.3 | 20.13 | 0.003 | 3E-04 |
| 14-06-2013 | 29.73 | 14.36 | 4.46 | 79.9 | 52.3 | 30.36 | 21.21 | 0.026 | 0.003 |
| 29-06-2013 | 29.13 | 15.45 | 2.68 | 78.9 | 48 | 46.93 | 22.91 | 0.028 | 0.005 |
| 14-07-2013 | 28.02 | 16.84 | 3.57 | 79.3 | 59.3 | 71.98 | 24.82 | 0.028 | 0.005 |
| 29-07-2013 | 31.75 | 18.6 | 0.8 | 74.1 | 47.6 | 89.31 | 27.98 | 0.014 | 0.008 |
| 13-08-2013 | 29.01 | 18.48 | 9.81 | 81.3 | 59.2 | 92.36 | 30.2 | 0.002 | 0.005 |
| 28- 08-2013 | 28.18 | 17.89 | 2.08 | 80.5 | 65.4 | 95 | 0.2 | 0.001 | 0 |

RH1 = Maximum relative humidity, RH2 = Minimum relative humidity

**Table 3.** Correlation coefficients between disease intensity on leaves and twigs with weather parameters (2013)

| Disease Intensity | Average temperature(°C) | | Average rainfall (mm) | Average relative humidity (%) | |
|---|---|---|---|---|---|
| | Max. | Min. | | Max. | Min. |
| Leaves | 0.72 | 0.94 | 0.03 | -0.5 | 0.24 |
| Twigs | 0.77 | 0.8 | -0.17 | -0.74 | -0.07 |

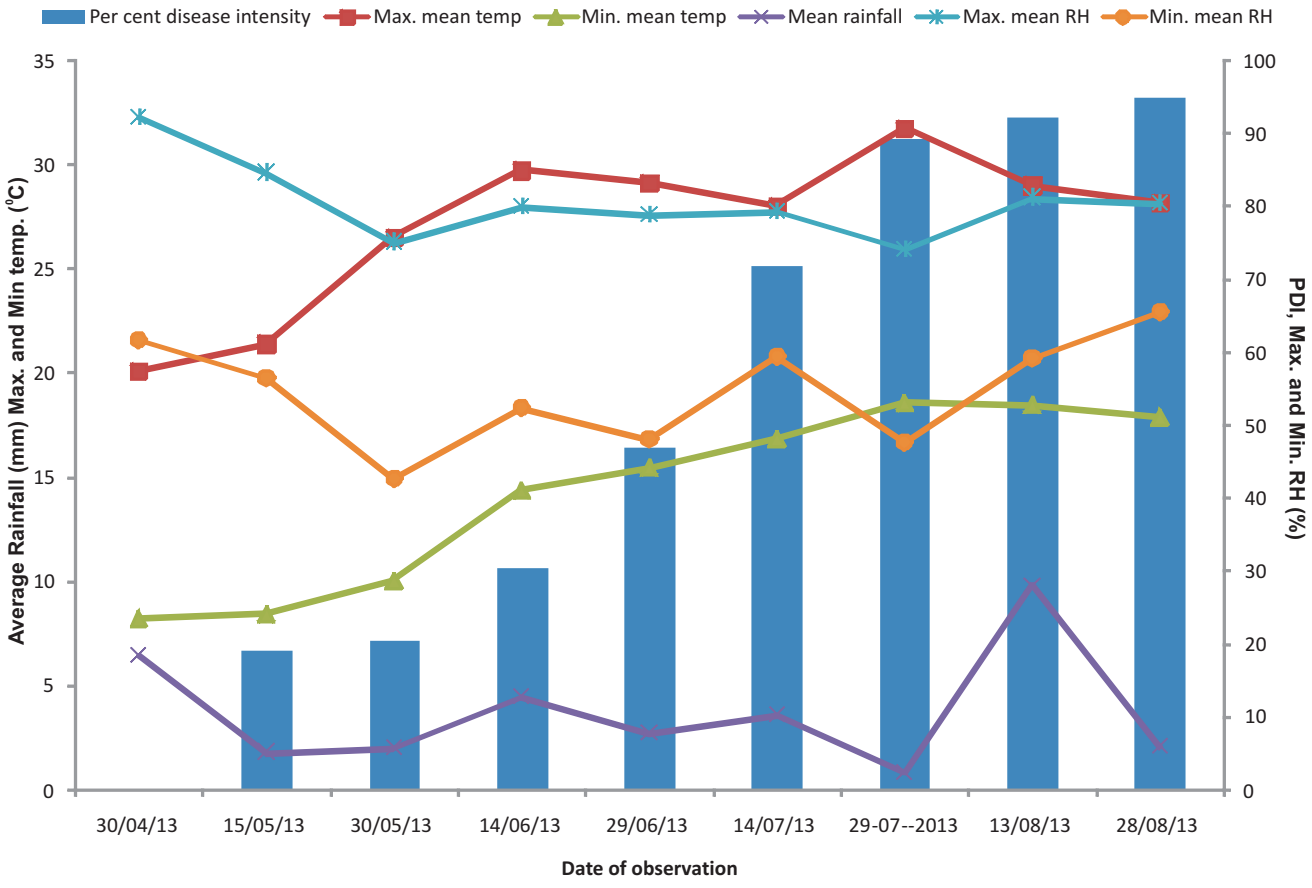


**Fig. 1.** Effect of weather parameters on the development of walnut anthracnose on leaves

**Table 4.** Multiple regression model of leaf and twig intensity in walnut

| Plant part | Multiple correlation coefficient | Coefficient of multiple determination | Regression equation |
|---|---|---|---|
| Leaves | 0.99 | 0.981 | Y=431.45-9.57X1+12.61X2+0.034X3-3.99X4+0.377X5 |
| Twigs | 0.928 | 0.862 | Y=164.57-0.909X1+0.891X2+0.023X3-2.013X4+0.556X5 |

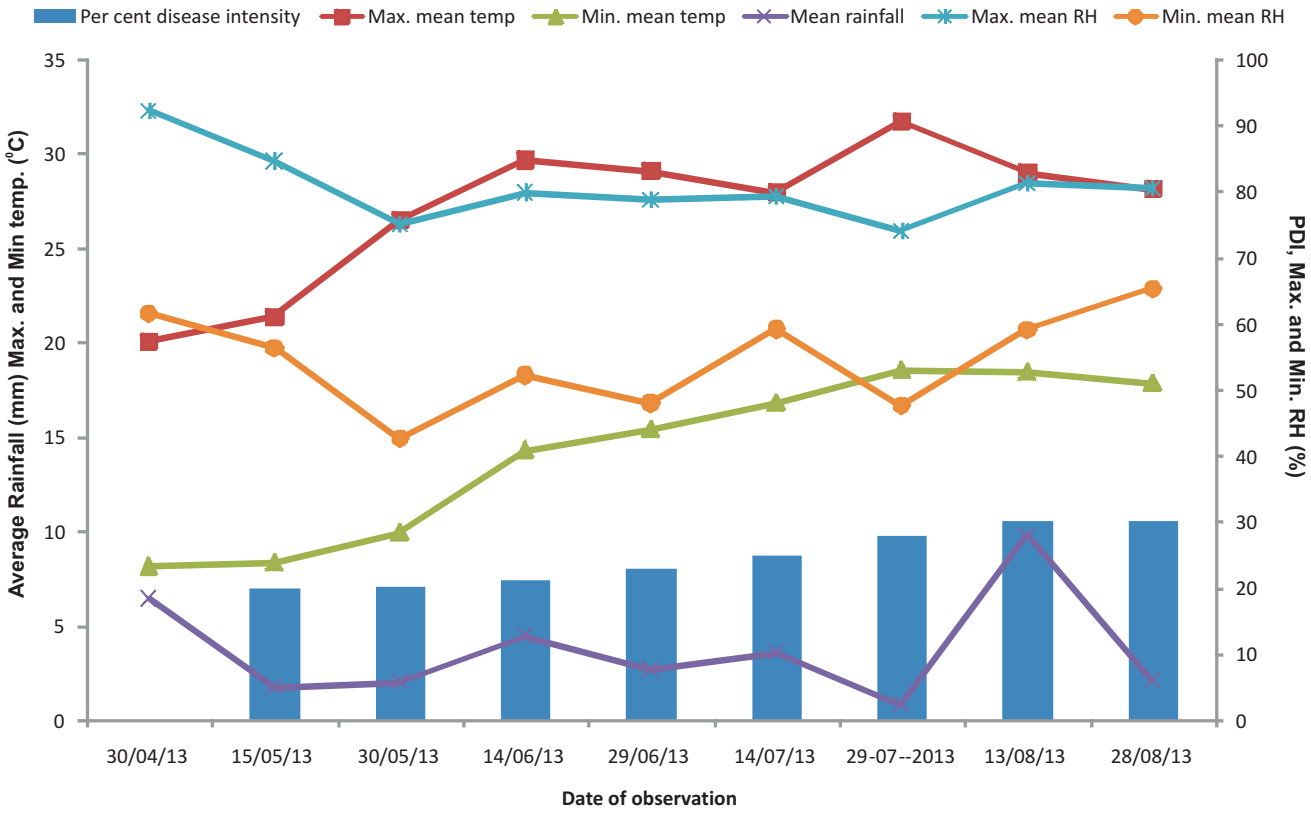


**Fig. 2**.Effect of weather parameters on the development of walnut anthracnose on twigs

(2005).

In present experiment it was observed that the pathogen causing anthracnose disease of walnut perpetuates through the infected plant debris from one season to the other season. Furthur, the correlation of weather variables such as rainfall, relative humidity (morning and evening) and temperature (maximum and minimum) revealed that correlation with mean minimum and maximum atmospheric temperature, mean minimum relative humidity and mean rainfall had a positive effect on disease development on leaves whereas, a negative correlation was observed with mean maximum relative humidity. Similarly, disease development on twigs showed positive correlation with mean minimum and maximum atmospheric temperature. However a negative correlation was observed with mean rainfall, mean maximum and minimum relative humidity on twigs Multiple correlation coefficients indicated that rainfall, relative humidity (morning and evening) and temperature (maximum and minimum) had a cumulative effect on the disease development.

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# Effect of Organic and Inorganic Sources of Fertilizers on Plant and Soil in Pomegranate Orchard

**N. Thirupathi, S.N. Ghosh and D. Roy**

*Bidhan Chandra Krishi Viswavidyalaya, Mohanpur-741 252, India.*
*E-mail: profsnghosh@yahoo.co*

***Abstract:*** The three years pooled data revealed that highest plant height (16.457 cm), stem girth (20.313 cm) and plant spread towards east-west (20.626 cm) and north-south (21.84 cm) were with the application of 265.6 g N + 725.6 g P + 622.4 g K ($T_2$) through organic and inorganic fertilizer. Soil characters like pH, organic carbon, nitrogen and phosphorous, leaf nitrogen and leaf phosphorous were with 241.6 g N + 711.6 g P + 592.42 g K ($T_4$), whereas, the highest soil potassium and leaf potassium contents were with the application of 328 g N + 828 g P + 620 g K ($T_7$).The pooled analysis of three year data also indicates that 241.6 g N + 711.6 g P + 592.42 g K ($T_4$), through organic and inorganic fertilizers showed highest fruit yield before monsoon (12.76 kg plant$^{-1}$), total fruit yield (24.106 kg plant$^{-1}$), maximum fruit length (7.767 cm), fruit breadth (8.033 cm) and fruit weight (189.463 g), juice content (74.613), TSS/acid ratio and minimum acidity (0.293) while, 265.6 g N + 725.6 g P + 622.4 g K plant$^{-1}$ ($T_2$) through organic and inorganic fertilizer showed highest TSS (14.067 Brix) and total sugars (11.717 %). Application of 241.6 g N + 711.6 g P + 592.42 g K ($T_4$) through three split doses was found as a good approach for production of high yield and good quality pomegranate fruits in a larger quantity before monsoon started (before June).

***Keywords***: Inorganic fertilizers, Laterite soil, Organic fertilizers, Pomegranate, Quality, Yield

Pomegranate (*Punica granatum* L.) is a well-known table fruit of tropical, subtropical and regions of the world. It is being grown since ancient times for its fruit, ornamental and medicinal purpose and in recent times, it has emerged as a commercially important fruit crop. In West Bengal, the crop has been introduced in the red laterite zone of the state for its dry and hot climatic condition. Among seven cultivars studies, Ruby was the best in all aspects (Tarai and Ghosh, 2006). The quality of pomegranate fruits is strongly dependent on the cultivars, growing regions, climate, maturity and cultural practices (Poyrazoglu *et al*., 2002; Tehranifar *et al*., 2010). In India, most of the fertilizer recommendations in pomegranate are on the basis of higher quantity of inorganic fertilizers. Use of such high quantity of N, P, K although, was helpful for increasing the production but may have deleterious effect on the soil environment. When only inorganic fertilizers were used continuously balanced nutrient supply is necessary not only for obtaining higher and regular yields of better quality fruits (Kumar and Ahmed, 2014). Integrated plant nutrient supply (IPNS) is the modern approach of soil nutrient management for sustainable soil health and sustainable quality production of crop. Therefore, an investigation was undertaken to assess the effect organic and inorganic fertilizers on growth, yield and fruit quality of pomegranate cv. Ruby.

## MATERIAL AND METHODS

The investigation was carried out in Midnapore district of West Bengal during the period 2009 to 2012 on nine years old plants of pomegranate cultivar 'Ruby', planted at a spacing of 3 m ×3 m. There were eleven treatments which were replicated three times in randomized block design with four plants in each treatment. Various organic manures and inorganic fertilizers were applied according to different treatments (Table 1). The manures and fertilizers were applied in circular trench at 2 feet away from the trunk, 1 feet wide, 10 cm deep trench in three splits, i.e., in November, January and February (15$^{th}$ of each month) for three consecutive years. Fertilizers were applied after regulating the crop for ambe bahar cropping season (Flowering time January-February, period of harvest June-August) through withholding of irrigation water before flowering (keep all the plants under stress). Sources of N, P and K from inorganic fertilizers were di ammonium phosphate, single super phosphate, muriate of potash, 10:26:26 (N:P:K mixed fertilizers) and organic manures were farm yard manure, neem cake, poultry manure, wood ash and vermicompost. Observations on plant growth, fruit yield, physico-chemical characteristics of fruits, soil organic carbon, N, P and K and foliar N, P and K contents were made. Plant height, girth and plant spread were recorded for three years and means were compared using standard errors of the mean. Organic carbon, available phosphorus and exchangeable potassium were determined in soil before the treatments application at per standard method. Eight pair of leaves from tip of the shoot was sampled as an index tissue for NPK leaf analysis for three consecutive years. The samples were decontaminated

**Table 1.** Treatment details of the experiment

| Treatments | First split (per plant) | Second split (per plant) | Third split (per plant) | Total N, P and K content (g plant$^{-1}$) |
|---|---|---|---|---|
| $T_1$ | DAP: 600 g | SSP: 500g, MOP: 200 g | MOP: 300 g | 108 + 356 + 300 |
| $T_2$ | FYM- 40 Kg, DAP: 600 g and SSP: 500 g | 10:26:26 (N: P: K) 500g, SSP: 500 g and MOP: 200 g | 10:26:26 (N: P: K) 500g, MOP: 300 g & Neem cake 2 kg | 265.6 + 725.6 + 622.4 |
| $T_3$ | Poultry manure 4 kg | FYM 20 kg | - | 29.6 + 20.4 + 32.8 |
| $T_4$ | FYM- 20 Kg, DAP: 600 g and SSP: 500 g | 10:26:26 (N: P: K) 500g, SSP: 500 g and MOP: 200 | 10:26:26 (N: P: K) 500g, MOP: 300 g, Neem cake 2 kg | 241.6 + 711.6 + 592.42 |
| $T_5$ | FYM 20 Kg | Poultry manure 2 kg | Wood ash 2 Kg | 27.2 + 24.8 + 79.4 |
| $T_6$ | FYM- 20 Kg, DAP: 1000 g and SSP: 500 g | 10:26:26 (N: P: K) 500g | 10:26:26 (N: P: K) 500g | 304 + 814 + 290 |
| $T_7$ | FYM- 40 Kg, DAP: 1000 g and SSP: 500 g | 10:26:26 (N: P: K) 500g and MOP: 200 g | 10:26:26 (N: P: K) 500g and MOP: 300 g | 328 + 828 + 620 |
| $T_8$ | FYM 20 Kg | Poultry manure 2 kg | Poultry manure 2 kg | 29.6 + 20.4 + 32.8 |
| $T_9$ | Vermicompost 3 Kg | - | Vermicompost 2 kg | 12.5 + 3.0 + 5.5 |
| $T_{10}$ | FYM- 20 Kg, DAP: 500 g and SSP: 1000 g | 10:26:26 (N: P: K) 500g and DAP: 500 g | 10:26:26 (N:P:K) 500g | 304 + 734 + 450 |
| $T_{11}$ | FYM- 20 Kg, DAP: 300 g and SSP: 250 g | 10:26:26 (N: P: K) 250g, SSP: 250 g and MOP: 100 g | 10:26:26 (N:P: K) 250g, MOP: 200 g and Neem cake 1 kg | 132.8 + 362.8 + 341.2 |

and dried powder of leaf was used for analyzing total nitrogen by microKjeldhal method, phosphorus by vanado-molybdo-phosphoric yellow colour method and potassium by flame photo-meter method. The fruit yield per plant was calculated by on basis of the total number of harvested fruits from the plant. Fruit size in terms of length and width were recorded with help of vernier callipers and average size was expressed in cm. The colour of arils from randomly selected fruits was observed visually by comparing with colour cards of Royal Horticulture Society, London. The titratable acidity of fruits was expressed as per cent citric acid. TSS of samples was measured by Erma brand hand refractometer and results were expressed as $^0$Brix. Reducing sugars contents of the sample were estimated as per the standard procedures given by AOAC, 1990).

## RESULTS AND DISCUSSION

Pomegranate responded well to both inorganic fertilizer and organic manure application. Results revealed significant differences amongst various growth attributes, fruit yield and fruit quality in pomegranate. Plants grown with $T_2$ (265.6 g N + 725.6 g P + 622.4 g K) through organic and inorganic fertilizers plant$^{-1}$year$^{-1}$ produced maximum annual increment in plant height (16.45 cm), stem girth (20.31 cm) and plant spread towards east-west (20.62 cm) and north-south (21.84 cm) direction. The result was close conformity with the findings of Saraf *et al*. (2004) who also observed that FYM singly or in combination with other inorganic nutrients improved the growth of pomegranate plants.

The various integrated organic and inorganic sources treatment combinations had a significant effect on available soil organic carbon where highest soil organic carbon (24,917.24 kg ha$^{-1}$) was observed in soil when application of 241.6 g N + 711.6 g P + 592.42 g K plant$^{-1}$ ($T_4$) and lowest (12,658.73 kg ha$^{-1}$) was recorded under $T_9$ (12.5 g N + 3.0 g P + 5.5 g K) treatment. The increased organic carbon was due to enhanced root growth, which leads to accumulation of organic residues and direct incorporation of organic matter in soil. Soil pH was significantly varied due to different treatments. Highest soil pH (6.99) was recorded from the plant fertilized with $T_4$ and lowest soil p$^H$ was estimated in $T_{11}$.

The statistical difference in average available nitrogen and phosphorus in soil were significant for three years. The available soil nitrogen and phosphorus reached to a highest level (710.73 kg ha$^{-1}$ and 278.46 kg ha$^{-1}$ respectively) with the 241.6 g N + 711.6 g P + 592.42 g K plant$^{-1}$ ($T_4$). The pooled data on available potassium builds up in soil ranged between 77.6 to 100.6 kg ha$^{-1}$. Average maximum available soil potassium (100.60) was with 328 g N + 828 g P + 620 g K ($T_7$).

The nitrogen content in leaves was significantly affected by all the treatments (Table 5). The maximum amount of nitrogen content in leaves (1.76 %) was in $T_4$ (241.6 g N +

**Table 2.** Nutrient content of organic manures used in the experiment is as follows

| Organic manure used | Percentage | | |
|---|---|---|---|
| | N | P | K |
| FYM | 1.2 | 0.7 | 1.5 |
| Neem cake | 4.8 | 0.8 | 1.2 |
| Poultry manure | 1.4 | 1.6 | 0.7 |
| Wood ash | 0.2 | 3.8 | 2.8 |
| Vermicompost | 2.5 | 0.6 | 1.1 |

711.6 g P + 592.42 g K per plant). This increase in uptake of leaf nitrogen was due to integrated application of nutrients through farmyard manures, di ammonium phosphate single super phosphate, 10:26:26 mixed fertilizers, mutate of potash and neem cake. The leaf phosphorus reached to highest level of 108.66 mg per cent in $T_4$. The leaf potassium content showed significant increase in leaf potassium, where $T_7$ (328 g N + 828 g P + 620 g K) recorded maximum leaf potassium (1.66 %). This increase in leaf potassium of pomegranate may be due to combined use of organic and inorganic sources of fertilizers in integrated manner.

The maximum fruit yield before monsoon (12.76 kg plant$^{-1}$), total fruit yield (24.10 kg plant$^{-1}$), fruit length (7.76 cm), diameter (8.03 cm) and weight (189.46 g) and maximum juice content (74.61) of pomegranate was obtained with the application of 241.6 g N + 711.6 g P + 592.42 g K plant$^{-1}$. Fruit diameter did not varied significantly in different treatments. These results are conformity with the finding of Dutta Ray *et*

**Table 3.** Effect of various treatments on growth and physical properties of pomegranate fruits cv. Ruby (Means of 2009 to 2012)

| Treatments | Annually increase in plant height (%) | Annually increase in Plant girth % | Annually increase in Plant spread E-W % | Annually increase in Plant spread N-S % | Fruit Weight (g) | Fruit length (cm) | Fruit diameter (cm) | Juice (%) | Colour of the fruit skin | Colour of the aril |
|---|---|---|---|---|---|---|---|---|---|---|
| $T_1$ | 12.20 | 07.28 | 13.22 | 14.30 | 179.08 | 7.26 | 8.00 | 72.70 | Yellow | Ivory |
| $T_2$ | 16.45 | 20.31 | 20.62 | 21.84 | 159.36 | 7.33 | 7.60 | 73.38 | Pink | Deep Pink |
| $T_3$ | 09.14 | 09.39 | 08.51 | 12.92 | 165.11 | 7.36 | 7.66 | 68.22 | Orange | Red |
| $T_4$ | 14.29 | 19.96 | 15.98 | 16.17 | 189.46 | 7.76 | 8.03 | 74.61 | Orange | Pink |
| $T_5$ | 10.67 | 09.02 | 14.14 | 16.48 | 183.34 | 7.36 | 7.96 | 74.17 | Orange Red | Red |
| $T_6$ | 04.51 | 06.88 | 09.92 | 18.58 | 177.60 | 7.66 | 7.76 | 72.14 | Orange | Pink |
| $T_7$ | 10.88 | 05.94 | 11.13 | 09.00 | 178.99 | 7.53 | 7.90 | 72.08 | Orange Red | Pink |
| $T_8$ | 10.48 | 10.53 | 13.83 | 10.38 | 157.11 | 7.10 | 7.50 | 71.11 | Orange | Beige Pink |
| $T_9$ | 11.63 | 07.11 | 09.21 | 07.04 | 169.16 | 7.13 | 7.66 | 68.32 | Orange Red | Pink |
| $T_{10}$ | 08.46 | 09.42 | 14.74 | 11.99 | 166.64 | 7.66 | 7.90 | 71.92 | Orange | Pink |
| $T_{11}$ | 09.65 | 07.84 | 06.78 | 07.88 | 163.05 | 7.50 | 7.73 | 71.16 | Orange | Pink |
| C.D (p=0.05) | 0.61 | 0.70 | 0.60 | 0.68 | 9.09 | 0.40 | NS | 3.82 | - | - |

**Table 4.** Status of soil pH, available organic carbon, N, P, K and leaf N, P, K contents as influenced by application of organic and inorganic fertilizer in pomegranate cv. Ruby (Pooled data for 2009 to 2012)

| Treatments | Soil P$^H$ | Organic Carbon (kgha$^{-1}$) | Availabe Nitrogen (kgha$^{-1}$) | Available $P_2O_5$ (kgha$^{-1}$) | Available $K_2O$ (kgha)$^1$ | Leaf Nitrogen (%) | Leaf Phosphorous (mg %) | Leaf Potassium (%) |
|---|---|---|---|---|---|---|---|---|
| $T_1$ | 6.68 | 18,134.80 | 472.87 | 260.73 | 81.83 | 1.67 | 101.00 | 1.59 |
| $T_2$ | 6.93 | 22,658.95 | 671.54 | 214.34 | 97.03 | 1.51 | 92.00 | 1.55 |
| $T_3$ | 6.91 | 22,865.00 | 637.05 | 225.94 | 90.56 | 1.65 | 87.66 | 1.38 |
| $T_4$ | 6.99 | 24,917.24 | 710.73 | 278.46 | 89.36 | 1.76 | 108.66 | 1.45 |
| $T_5$ | 6.77 | 18,757.10 | 546.79 | 252.27 | 93.23 | 1.52 | 93.00 | 1.58 |
| $T_6$ | 6.52 | 16,209.17 | 480.76 | 246.71 | 86.33 | 1.57 | 99.00 | 1.52 |
| $T_7$ | 6.44 | 19,917.90 | 508.74 | 237.55 | 100.60 | 1.67 | 96.66 | 1.66 |
| $T_8$ | 6.89 | 21,198.40 | 591.38 | 238.16 | 92.70 | 1.45 | 104.66 | 1.65 |
| $T_9$ | 6.78 | 12,658.73 | 404.95 | 239.99 | 88.50 | 1.54 | 103.33 | 1.55 |
| $T_{10}$ | 6.37 | 17,778.40 | 537.00 | 221.06 | 78.26 | 1.66 | 102.33 | 1.62 |
| $T_{11}$ | 6.303 | 21,569.10 | 661.68 | 210.67 | 77.60 | 1.48 | 97.00 | 1.44 |
| C.D (p=0.05) | 0.38 | 1,192.90 | 33.59 | 13.19 | 4.95 | 0.09 | 5.44 | 0.08 |

**Table 5.** Effect of various treatments on fruit yield, date of harvest and chemical composition of pomegranate fruits cv. Ruby (Pooled data for three years from 2009 to 2012)

| Treatments | Fruit yield (kg/plant) before monsoon | Total fruit yield/ Plant/ year (kg)* | Date of 1st harvest | Date of peak harvest | TSS (°Brix) | Acidty (%) | Reducing sugar (%) | TSS/acid ratio |
|---|---|---|---|---|---|---|---|---|
| $T_1$ | 9.77 | 19.33 | 18-May | 30-May | 13.63 | 0.31 | 11.65 | 43.00 |
| $T_2$ | 6.76 | 13.15 | 21-May | 03-Jun | 14.06 | 0.34 | 11.71 | 41.01 |
| $T_3$ | 7.09 | 14.89 | 20-May | 13-Jun | 13.46 | 0.33 | 11.27 | 40.44 |
| $T_4$ | 12.76 | 24.10 | 26-May | 10-Jun | 13.60 | 0.29 | 10.97 | 46.41 |
| $T_5$ | 9.70 | 19.02 | 22-May | 02-Jun | 13.63 | 0.32 | 10.96 | 42.20 |
| $T_6$ | 8.02 | 14.41 | 21-May | 05-Jun | 13.43 | 0.36 | 10.80 | 37.00 |
| $T_7$ | 8.46 | 16.50 | 22-May | 13-Jun | 13.66 | 0.35 | 10.75 | 38.28 |
| $T_8$ | 4.91 | 9.78 | 22-May | 13-Jun | 13.30 | 0.38 | 10.47 | 34.36 |
| $T_9$ | 8.47 | 19.13 | 21-May | 10-Jun | 13.90 | 0.32 | 11.25 | 43.03 |
| $T_{10}$ | 8.19 | 14.80 | 24-May | 08-Jun | 13.43 | 0.39 | 10.63 | 34.44 |
| $T_{11}$ | 9.59 | 15.16 | 23-May | 15-Jun | 13.26 | 0.37 | 10.33 | 35.56 |
| CD (p=0.05) | 0.45 | 0.91 | | | NS | 0.02 | 0.60 | 2.18 |

*al*. (2014). Ghosh *et al*. (2012) also reported an increase in the physical characteristics of pomegranate with the application of inorganic and organic manure combinations.

General appearance of the fruit rind colour and aril colour is concerned, fruits from $T_2$ (265.6 g N + 725.6 g P + 622.4 g K) had the pink colour and deep pink, respectively. Date of 1st harvest and date of peak harvest of the fruits were 18th May and 30th May respectively, recorded as early in $T_1$ and late in $T_4$.

The highest total soluble solids (14.06°Brix) and reducing sugar (11.71 %) were recorded maximum in $T_2$. Lowest TSS (13.3°B) and reducing sugar (10.47%) were measured from the fruits of $T_8$ (29.6 g N + 20.4 g P + 32.8 g K) plants. Total soluble solids of mature fruits due to different treatments were found statistically non-significant. Dutta Ray *et al*. (2014) was observed that fruits of the plants treated with 300g nitrogen + 1kg neem cake plant$^{-1}$ recorded highest total soluble solids (12.29º Brix) and reducing sugar (9.78%). Minimum acidity content and maximum TSS/acid ratio were estimated from the fruits of ($T_4$).

It is concluded that application of 241.6 g N + 711.6 g P + 592.42 g K/plant/year through three split doses (November, January and February) was good approach for production of high yield and good quality pomegranate fruits before monsoon starts in laterite zone of West Bengal.

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# Differences in Peer-Relationship among Adolescents across Socio- Economic Variables

**Rupika Chopra, Shakuntla Punia and Santosh Sangwan**

*Department of Human Development and Family Studies, CCSHAU, Hisar -125 004, India*
*E-mail: rupikachopra90@gmail.com*

***Abstract:*** The present study was undertaken on 460 adolescents of 11th and 12th standard i.e., 112 studying in university and 348 studying in government school. Results highlighted that adolescents studying in school had good peer-relationship as compared to adolescents studying in university environment and significant differences were observed in peer-relationship across educational institute. Bullying level was also significantly different across caste and annual income.

***Keywords*:** Bullying, Peer–relationship, Victimization and Pro–social behavior

Peers are the one with whom adolescents identify, learn, fight, discover new enterprises and learn about themselves. Rothon *et al.* (2011) defined peer as a small group of similarly aged, fairly close friends, sharing the same activities. Peer groups are networks of interacting individuals who spend time together and share activities. As the children enter adolescence, the quality of peer-relationship starts changing. The adolescents start identifying themselves with small gang and get involved in bullying and victimization. Originally it was thought that relatively few teenagers were bullied and victimized, however findings suggest that approximately one in five teenagers are chronically exposed to ongoing peer torment in the U.S.A. that consists of physical hitting, pushing, verbal threatening, insult, relational attacks such as ignoring, shunning and spreading rumors (Storch *et al.,* 2005). Direct bully victims exhibit a wide range of maladjustment, which includes internalizing problems, peer rejection, lack of close friendships, acceptance of deviance, less supportive and uninvolved parents, less optimal temperament, negative emotionality and reactive aggression. Quality of peer–relations are the product of family environment and family values which differ across the socio–economic status of family. The present study was therefore an attempt to access the status of peer–relationship and further to delineate the socio-economic factors influencing the same.

The study was conducted in Hisar district, Haryana state on two groups of adolescents, one having transition from school to university atmosphere and another continuing their 11th and 12th in the same school atmosphere at the age group of 16-17 years. To draw the rural sample, three villages namely Neoli Kala, Behbalpur and Mangali were randomly selected. Adolescents from College of Home Sciences and Agriculture of CCS HAU, Hisar were included in study to represent urban sample. In total 348 adolescents from rural and 112 adolescents from urban area constituted the sample for present study. Peer-Relationship Questionnaire (PRQ) for children developed and standardized by Rigby and Slee (1993) was used to assess the peer- relationship. SPSS Programme was run to analyze the data. Descriptive statistics was used to describe the background information and main variables under the study.

**Personal profile of respondents:** Personal profile refers to the information with regard to school and university adolescents' with personal variables are given in table 1.

**Peer-relationship of adolescents across gender:** The level of bullying is low as 94.60% adolescents were involved in bullying to a lower level (Table 2). Similar pattern of bullying behavior was seen in both males (91.30%) and female adolescents (96.80%). Only 8.2 per cent males and 2.8 per cent female adolescents were involved in bullying to moderate level depicting that comparatively bullying behavior was present to a slightly higher level in males. More than 1/3rd (78.70%) adolescents were being victimized by others at lower level, while 21 per cent of adolescents were being victimized to moderate and high level. Rothon *et al.* (2011) study also strengthen the present results who reported that the boys and girls equally reported bullying and Papafratzeskakou (2008) found non–significant differences between boys and girls in terms of victimization. Victimization was lower in females as results show that 72.20 per cent of male adolescents and 83 per cent of female adolescents were being victimized by others at lower level, whereas, more than 1/4th (26.20%) of male adolescents and 15.90 per cent of female adolescents were being victimized by others at moderate level.

**Table 1.** Personal profile of adolescents across educational institute

| Educational institutes/Personal variables | School (n=348) | University (n=112) | Total (n=460) |
|---|---|---|---|
| Adolescent's age (mean) | 16.66±06.44 | 16.58±06.43 | 16.58±06.43 |
| Sex | | | |
| Male | 131 (37.80) | 52 (46.00) | 183 (39.80) |
| Female | 216 (62.20) | 61 (54.00) | 277 (60.20) |
| Ordinal position | | | |
| 1st born | 116 (33.40) | 38 (33.60) | 154 (33.50) |
| 2nd born | 96 (27.70) | 41 (36.30) | 137 (29.80) |
| Up to 4 | 111 (32.00) | 33 (29.20) | 144 (31.30) |
| >4 | 24 (06.90) | 01 (00.90) | 25 (05.40) |
| Academic achievement (mean) | 61.88±09.75 | 76.61±16.52 | 65.01±12.98 |
| Academic achievement | | | |
| Poor (3rd division) | 32 (09.20) | 14 (12.40) | 46 (10.00) |
| Average (2nd division) | 89 (25.60) | 06 (05.30) | 95 (20.70) |
| High (1st division) | 226 (65.10) | 93 (82.30) | 319 (69.30) |
| Academic class | | | |
| 11th | 169 (48.70) | 54 (47.80) | 223 (48.50) |
| 12th | 178 (51.30) | 59 (52.20) | 237 (51.50) |

Note: Figures in parentheses indicate percentages

Moving towards pro-social behavior, the majority of adolescents (85.9%) displayed pro-social behavior with their peer-group irrespective of gender. The study by Guzman *et al.* (2005) did not find any gender differences among teenagers in pro-social behavior. This indicates that adolescents had good pro-social behavior with their peers and bullying as well as victimization was present to a lower level, which means that on the whole good peer - relationship was seen among adolescents.

**Comparison of peer-relationship of adolescents across socio-economic variables**: Significant differences were observed in mean scores of adolescents for bullying, victimization and pro-social skills against educational institutes (Table 3). Comparatively bullying and victimization was slightly higher in university, whereas, pro-social behavior was higher in school adolescents. Some researchers speculate that the transition from school to university atmosphere can cause stress that might promote bullying behavior, as students attempt to define their place in the new social structure. Changing from one school to another often leads to an increase in emotional and academic difficulties (Hankin *et al.,* 2007); bullying may be another way that young people deal with the stress of a new environment. The differences were significant differences in bullying behavior against caste ($F_{(2,457)} = 2.33$, $p< 0.05$) and annual income ($F_{(2,457)} = 4.51$, $p< 0.05$). Further pro-social behavior was found

**Table 2.** Peer - relationship of adolescents across gender

| Gender/Aspects of peer- relationship | Male (n=183) | Female (n=277) | Total (n=460) |
|---|---|---|---|
| Bullying | | | |
| Low (6 – 12) | 167 (91.30) | 268 (96.80) | 435 (94.60) |
| Moderate (13 – 18) | 15 (08.20) | 08 (02.80) | 23 (05.00) |
| High (19 – 24) | 01 (00.50) | 01 (00.40) | 02 (00.40) |
| Victimization | | | |
| Low (5 – 10) | 132 (72.20) | 230 (83.00) | 362 (78.70) |
| Moderate (11 – 15) | 48 (26.20) | 44 (15.90) | 92 (20.00) |
| High (16 – 20) | 03 (01.60) | 03 (01.10) | 06 (01.30) |
| Pro – social behavior | | | |
| Low (4 – 8) | 10 (05.50) | 17 (06.20) | 27 (05.90) |
| Moderate (9 – 12) | 16 (08.70) | 22 (07.90) | 38 (08.20) |
| High (13 – 16) | 157 (85.80) | 238 (85.90) | 395 (85.90) |

Note: Figures in parentheses indicate percentages

better in school adolescents (M = 14.52) as compared to university adolescents (M = 14.00). This may be due to rich traditional values of Indian culture, especially in rural areas as the maximum respondents of the present study were from rural area. Rural areas still have closely knitted emotional ties as majority of the families are medium sized. Living together requires pro-social skills for survival. Results revealed that adolescents belonging to general caste category (M = 7.9) were reported to have more involvement in bullying as compared to their counterparts *i.e.* scheduled caste (M =

**Table 3.** Comparison of peer - relationship of adolescents across socio – economic variables

| S. No. | Socio – economic variables | | | | |
|---|---|---|---|---|---|
| 1. | Aspects of peer-relationship | Family structure | | | |
| | | Nuclear Mean±SD | | Joint Mean±SD | Z value |
| (a) | Bullying | 07.62±02.25 | | 07.67±02.60 | 0.53 |
| (b) | Victimization | 08.55±02.72 | | 08.22±02.56 | 1.51 |
| (c) | Pro – social behavior | 14.34±02.56 | | 14.29±02.45 | 0.42 |
| 2. | | Educational institute | | | |
| | | School Mean±SD | | University Mean±SD | |
| (a) | Bullying | 07.49±02.19 | | 08.08±02.82 | 2.31* |
| (b) | Victimization | 08.27±02.63 | | 08.98±02.71 | 2.50* |
| (c) | Pro – social behavior | 14.52±02.20 | | 14.00±02.63 | 2.06* |
| 3. | | | Family size | | |
| | | Small Mean±SD | Medium Mean±SD | Large Mean±SD | F value |
| (a) | Bullying | 08.01±02.54 [a] | 07.52±02.34 [a] | 07.60±02.23 [a] | 1.55 |
| (b) | Victimization | 08.91±02.84 [a] | 08.30±02.59 [a] | 08.43±02.72 [a] | 1.91 |
| (c) | Pro – social behavior | 14.63±02.06 [a] | 14.39±02.36 [a] | 14.00±02.52 [a] | 1.36 |
| 4. | | | Caste categories | | |
| | | Scheduled caste | Backward caste | General | |
| (a) | Bullying | 07.31±02.08 [a] | 07.67±02.31[ab] | 07.91±02.67[b] | 2.33* |
| (b) | Victimization | 08.20±02.59 [a] | 08.66±02.52 [a] | 08.41±02.91[a] | 1.18 |
| (c) | Pro – social behavior | 14.56±02.24[a] | 14.38±02.11 [a] | 14.22±02.63 [a] | 0.76 |
| 5. | | | Number of siblings | | |
| | | One to three | Four to six | Seven to nine | |
| (a) | Bullying | 07.60±02.37[a] | 07.77±02.41 [a] | 07.78±02.05 [a] | 0.18 |
| (b) | Victimization | 08.40±02.71[a] | 08.65±02.50[a] | 08.11±02.85[a] | 0.34 |
| (c) | Pro – social behavior | 14.40±02.30[a] | 14.39±02.30 [a] | 13.89±02.30[a] | 0.21 |
| 6. | | | Annual income | | |
| | | Low (Rs. 20,000 – up to | Medium (Rs. 2,00,001 – | High (Rs.4,00,001 – | |
| (a) | Bullying | 07.51±02.20[a] | 08.50±02.91[b] | 08.36±04.25[ab] | 4.51* |
| (b) | Victimization | 08.43±02.66[a] | 08.78±02.90[a] | 07.27±01.62[a] | 1.46 |
| (c) | Pro – social behavior | 14.44±02.33[b] | 14.24±01.80[ab] | 13.09±03.62[a] | 1.94 |

*Significant at 5% level
Means in the same row that do not share superscripts differ at $p < 0.05$ using Duncan multiple difference comparison

7.31) and backward caste (M = 7.67). Within the group comparison highlighted that adolescents belonging to schedule caste and general category were significantly different from each other. The group of adolescents formed on the basis of number of siblings did not differ significantly from each other in any of the sub aspects of peer–relationship. Turning towards socio-economic status, there were significant differences between three groups in bullying behavior. Adolescents having annual family income ranging from Rs. 2,00,00 to Rs. 4,00,000 and Rs. 4,00,001 to Rs. 6,00,000 were more involved in bullying (M = 8.50 and M = 8.36) as compared to adolescents having annual income Rs. 20,000 to up to Rs. 2,00,000 (M = 7.51). The adolescents of lower and higher income groups differed significantly from each other for their pro – social behavior.

Significant differences were observed in peer-relationship of adolescents across educational institute. Bullying was significantly different across caste and annual income of adolescents. The staff of the school should be vigilant towards the bullying and victimized behavior among students and provide counseling to curb the negative social behavior. Intervening in bullying among younger children and assessing both bullies and victims of bullying for risk factors associated with suicide, may have significant benefits as children enter the developmental stage when suicide risk begins to rise. Bullying often takes place in areas hidden from adult supervision. Cyberspace has become such an area. At the same time, young people may also use social media and new technologies to express suicidal thoughts that they are unwilling to share with their parents and other adults. Both

bullying prevention programs and suicide prevention programs need to learn how to navigate in this new world.

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