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Monitoring Land use Land Cover Changes using Remote Sensing and GIS Techniques: A Case Study around Papagni River, Andhra Pradesh, India

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***Abstract*:** In this study, land use land cover (LULC) classifications have been analyzed for Anantapur and Kadapa districts located in the state of Andhra Pradesh, India by using Landsat satellite images of MSS (1973), TM (1992), ETM+ (2001), and IRS RESOURCESAT-II (2012). The study revealed an increase of mining activities, agricultural production, etc. The classification divulges that there was only a minor land cover change observed in the area during 1973-1992 but a major change occurred during 2001-2012. During the period of 1973-2012, water bodies, forest and barren rock was decreased from 3.11 to 1.40%, 58.73 to 29.89, and 0.60 to 0.18% respectively. Land cover change happened due to human activities like mining, scrub, settlement, plantation, cropland was increased substantially from 0.02 to 0.07%, 0.82 to 4.1%, 0.10 to 0.42%, 1.46 to 3.64% and 35.12 to 60.27%, respectively from 1973-2012.

Key Words: ERDAS IMAGINE, Land use land cover (LULC), Landsat images and landscape features, Supervised classification, Temporal changes

In today's world, urbanization is posing a major challenge to the land resources by destructing the natural environment and thereby increasing the urban temperature (Sleeter *et al.,* 2012). Inconsistent increase in population leading to salinization and lower productivity of the soils in the area and built mass, an imbalance in the ecosystem has been observed affecting the biodiversity of the area. The species and forest types are sensitive to agricultural disturbances will get more benefits if land in agricultural zones is spared and prioritized for conservation (Law *et al*., 2015). For example, Chennai floods in India occurred in 2015 is more of man-made disaster rather than a natural disaster. The probable reasons are illegal encroachments on the existing water bodies, excessive dumping of solid waste on river channels and construction of buildings and roads over the man-made drains inhibit the flow of water naturally. Thus, human interventions have modified the Land use land cover [LULC] to such an extent, that changes an ecosystem and environmental processes is taking place at local, regional, and global scale at a very fast pace (Estoque and Murayama, 2011). LULC plays an important role in providing information about the changes on Earth's surface for understanding the relationships between human beings and the natural ecosystem. LULC mapping for large areas with medium to high resolution imagery is still a challenging task and also often unrealistic for large areas due to lack of resources (Beuchle *et al*., 2015). The change in spatial phenomena is difficult to interpret through conventional mapping techniques. LULC parameters and change detection over a period can be determined by using remote sensing and GIS for collecting information at very low cost with good accuracy. Remote sensing data is exceptionally helpful because of its repetitive coverage and continuous information procurement to process LULC classification and helps in keeping up the spatial information which is extremely crucial for monitoring the land use (Hegazy and Kaloop, 2015). Rawat and Kumar (2015) have used aerial photos and Landsat data (TM) to detect the land consumption rate and changes using geospatial techniques. Urban planners and decision makers will get benefited through utilizing the updated LULC maps for monitoring the land use variations and estimating the LULC changes and to conserve water resources thereby predict the future strategies (Karakus *et al*., 2015). In order to understand the reasons and outcomes for the exploitation of natural resources, LULC mapping and monitoring can play a major role in addressing these issues, such as imbalance in ecosystem, controlling global temperatures and through this LULC mapping, a well balanced ecosystem may become a reality. An attempt is made in the present study to produce LULC maps and show temporal changes using ERDAS IMAGINE for the Landsat images such as MSS (1973), TM (1992), ETM+ (2001) and IRS RESOURCESAT-II(2012) (LISS IV Mx) using supervised classification for the portion of Anantapur and Kadapa districts, Pulivendula region, Andhra Pradesh.

MATERIAL AND METHODS

Description of the study area: In the study zone of

Anantapur and Kadapa districts in the state of Andhra Pradesh has 163 villages. The total population of all mandals in the study area was 386682. The Papagni is the major river in the study area, which flows from south to northeast direction. The main tributaries of Papagni River are Madduleru and Mogamureru. Apart from the tributaries some of the small and large streams are originated from the nearby mountains. Other than these water bodies, a few lakes and ponds are also found in the study area. All the tributaries of this area meet with the Papagni River. The types of forests in the study area are of dry deciduous sort. Reserved forest like Redlacheruvu, Ganganapalle, Gorivikanuma, Dorigallu, Lingala, Malakavemula, Elavalakonda, Nigadi, Kokkarajukonda, Gogguvelagala, Velichemela, Tomukunta, Mudupulazuvi, Kadiri, Errappakonda, Mallela south, Kommaddi are some of the reserved forest found in the study area. The study area contains 16 mandals namely Lingala, Nallamada, Kadiri, Gandlapenta, Nambulapulikunta, Mudigubba, Talapula, Chakrayapet, Vempalle, Pendlimarri, Veerapunayunipalle, Thondur, Simhadripuram, Vemula, Pulivendula, and Bukkapatnam covering latitude 14° 0' 0"N to 14° 40' 0"N and Longitude 78° 0' 0"E to 78° 30' 0"E of the study area. The agricultural crops grown in the area are paddy, groundnut, red gram, cotton and bengal gram. The major fruit crops grown here are water melons, papaya, mango, citrus and banana. Some of the commercial crops grown in the study area are turmeric, onion, chilies, coriander, along with vegetables and chrysanthemum etc. The Cuddapah district is rich in minerals. The major minerals found in the district are asbestos, berytis and limestone. The high grade amphibole of asbestos, berytis and limestone are available in large quantities and these minerals are used for manufacture of cement. The major and minor minerals are, mosaic chips, rehmatti, napa slabs, road metal, building stone, marble. Dolomite and Iron Ore are the major minerals found in Anantapur districts. Anantapur gets less precipitation because of its area in the downpour shadow zone of Indian Peninsula. The crops grown here are groundnut, maize, chilies, sunflower, rice, cotton, sesame, and sugarcane. The study area lies in the tropical region where the climate is characterized by very hot summers, mild winters and monsoon rains. The average annual rainfall recorded at IMD observatory at Kadapa is about 783.3 mm and in Anantapur is 381 mm.

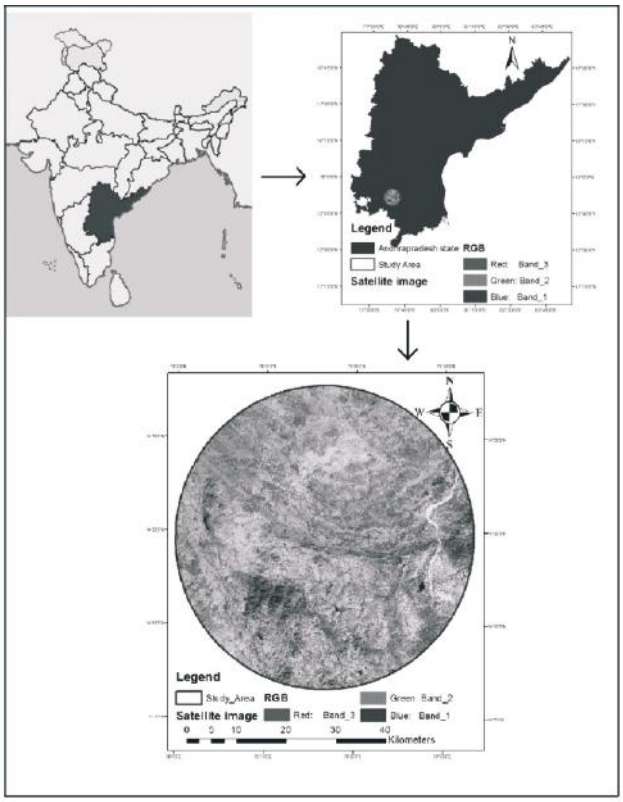

Fig. 1. Boundary of the study area

Land cover classification: Land use refers to usage of land surface for constructing a building and other activities whereas land cover refers to physical nature of earth surface that include forest, bare groundwater bodies, trees etc. Remote sensing data such as Landsat ETM+, TM, and MSS, and IRS Resourcesat II satellite using LISS –IV (Mx) sensor of mix image type has been used for multi temporal mapping. Classification is done based on the remote sensing data for these corresponding years (1973, 1992, 2001 and 2012). To obtain information about land use land cover for the interval 1973-2012, three landsat images and one IRS LISS-IV images have been processed and classified. The satellite images collected for the study area are summarized in Table 1.

Table 1. List of satellite images collected for the study area

Satellite data	Date	Spatial Resolution	Source
Resourcesat II (Path 100, Row 063)	February 2012	5m	NRSC (National remote sensing centre)
Landsat ETM+ (Path 189, Row 032)	February 2001	15m	Global Land Cover Facility (GLCF)
Landsat TM (Path 189, Row 032)	March 1992	30m	Earth Explorer maintained by USGS(United States Geological Survey)
Landsat MSS (Path 189, Row 032)	January 1973	57m	Earth Explorer maintained by USGS(United States Geological Survey)

Digital image-processing software ERDAS Imagine has been used to process, analyses and integrate the digital images. The supervised maximum likelihood classification (MLC) has been used to classify satellite images. The study area is extracted from the satellite image and it is geometrically rectified with respect to survey of India (SOI) Toposheet to eliminate the noise present in the data. To interpret the features properly, these features are verified with SOI toposheet. The study area covers the toposheet of 57J/2, 57J/3, 57J/4, 57J/6, 57J/7, 57J/8 with 1:50,000 scale. The study area falls under Universal Transverse Mercator (UTM) projection system with WGS84 (World geographic system) datum. The resolution of the collected satellite image may vary for each image. The histogram matching is done for sharpening and improving the resolution of the image, so that the features can be identified easily. In supervised classification, by providing templates of each class from the satellite image, the ERDAS software will finds the different zones in the satellite image, which are most similar to the defined classes. Fig. 2 illustrates the detailed methodology for land use land cover classification.

RESULTS AND DISCUSSION

Eight major LULC classes cropland, plantation, forest, water bodies, settlement, scrub, barren rock, and mining were identified. The supervised classification is performed for the entire signature editor created from AOI (Area of Interest). The classification is performed based on the color of the features given as training samples in the satellite image. After supervised classification the classified image is analyzed by comparing the features with ground truth field measured data manually. Finally four different land use land cover maps have been developed for Landsat MSS, TM, ETM+ and IRS-Resourcesat II. The classification results of Landsat MSS(1973) depicts that the features like barren rock (0.60%), forest (58.73%) and water bodies (3.11%) in the study area occupies about 176716.6 ha. These classes are found available in large quantities because there is no human or any other interactions for a considerable span of years, while the cropland (35.12%), plantation (1.46%) , settlement (0.10%), scrub land (0.82%), and mining (0.02%), occupies 106218.4559 ha from the total area of 282935.1 ha. In Landsat TM (1992), the classification results depicts that there is a subtle changes in the area occupied by each features. Majority of study area is covered by forest area 128727.2 ha, and water bodies 6563.77 ha and barren rock 1066.18 ha, contributes 45.49%, 2.31% and 0.37% respectively of the total area. The settlements and mining covers only small portion of area that occupies 520.188 ha (0.18%) and 104.188 ha (0.03%) shows subtle increase in the area within two decades, whereas scrub, plantation and crop lands contributes 3531.188 ha (1.24%), 2283.188 ha (0.80%), 140139.2 ha (49.53%). It can be seen that the features like settlements, mining, scrub, plantation and crop lands is increasing drastically when compared with Landsat MSS 1973 images. The supervised classification of Landsat ETM+ depicts that there is a lot of changes in the year 2001 because of rapid urbanization results in conversion of forest and other agricultural lands to built-up area. This is due to the urban expansion that consuming some of the fertile agricultural lands near to the city or township to urban built-up. The total area covered by plantation, crop lands and settlements estimated at 4137.291 ha (1.46%), 99390.04 ha (35.12%), and 301.04 ha (0.10%) in 1973 has increased to 6848.52 ha (2.42%), 163025.1 ha (57.61%) and 904.154 ha (0.31%), respectively in 2001. It is observed that the portion of mining and scrub occupied in the study area is found to be 160.275 ha (0.05%) and 6194.12 ha (2.18%), respectively for the year 2001. This is due to deforestation, mining activities, industrialization and urbanization. Whereas, the features like barren rock, water bodies and forest covering the total area gets decreasing slowly which contributes 622.521 ha (0.22%), 6220.24 ha (2.19%), and 98960.19 ha (34.97%) respectively for the year 2001. This is due to depletion of

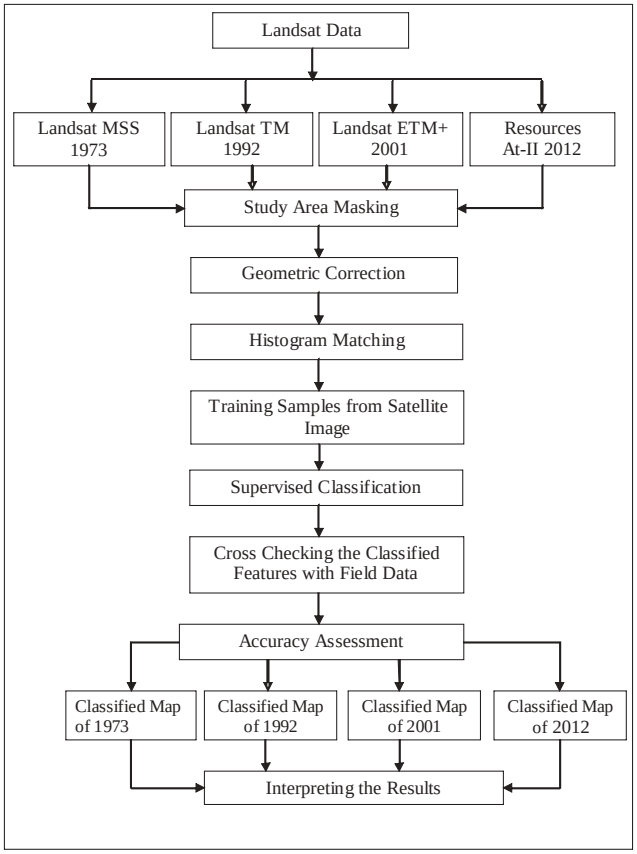

Fig. 2. Flow charts for land use land cover classification

forest, construction of large dams that completely clear half of the forest area and another reason is due to commercial use of timber, and expansion of agriculture. In RESOURCESAT II (2012), the LULC map when compared with the three time periods 1973, 1992, and 2001, shows increase or decreasing level of the features present in the study area. It is observed that forest, water bodies and barren rocks has occupies 29.89%, 1.40% and 0.18% respectively, of the total study area in RESOURCESAT II images. Due to increase in population the establishment of settlements got increased and it is found to be 1208.556 ha (0.42%). The mining, scrub, plantation and croplands get increased to 208.976 ha (0.07%), 11601.996 ha (4.10%) and 10308.696 ha (3.64%), and 170537.996 ha (60.27%), respectively. This is because, most of the farmers clear forest land and used the natural resources to cultivate crops and for various purpose to improve their business lines.

Accuracy assessment: The accuracy assessment is generated for the classified images of MSS, TM, ETM+, LISS IV Mx sensors. To check the accuracy, 360 random samples are generated in ERDAS Imagine and each random point's reference value is verified for accuracy assessment. Landsat satellite image for the years 1973, 1992, 2001, 2012 is used to verify, how many ground truth pixels are classified correctly for the corresponding LULC maps. Different land cover classes have differing producer's and user's accuracy. The overall accuracy, user's accuracy and producer's accuracy are calculated from the generated accuracy error matrix. The accuracy assessment results shows that overall classification accuracy of land use land cover maps of Landsat MSS, TM, ETM+, IRS LISS IV(Mx) images for the year 1973, 1992, 2001, 2012 was 79.44%, 77.50%, 73.89%, 79.17% , respectively. The overall Kappa statistics is found to be 0.7463, 0.7138, 0.6670 and 0.7061. Kappa statistic measures the difference between the true agreement of classified map and random classifier compared to reference data (Haroun *et al*., 2013). The overall accuracy values of each classified image are reported in Table 3.

Table 3. Accuracy assessment for the classified images

Reference Year	Classified image	Overall classification accuracy	Overall Kappa statistics
1973	Landsat MSS	79.44%	0.7463
1992	Landsat TM	77.50%	0.7138
2001	Landsat ETM+	73.89%	0.6670
2012	Resourcesat II	79.17%	0.7061

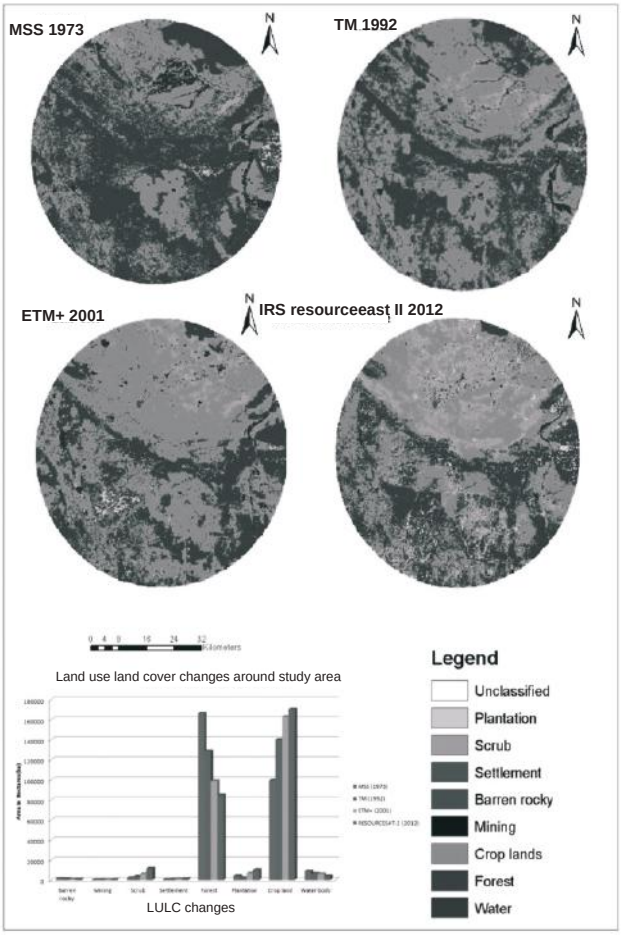

Fig. 3. Land use Land cover classifications and changes for MSS, TM, ETM+, LISS- IV Mx.

Table 2. Comparison between LULC change patterns for the period 1973 to 2012

Land use classes	MSS (1973) (ha)	TM (1992 (ha)	ETM+ (2001 (ha)	RESOURCESAT-II (2012) (ha)
Barren rocky	1707.04	1066.19	622.52	511.12
Mining	69.04	104.19	160.28	208.98
Scrub	2321.04	3531.19	6194.12	11602.00
Settlement	301.04	520.19	904.15	1208.56
Forest	166195.04	128727.20	98960.19	84591.00
Plantation	4137.29	2283.19	6848.52	10308.70
Crop land	99390.04	140139.20	163025.10	170538.00
Water bodies	8814.55	6563.78	6220.24	3966.76
Total area (ha*)	282935.10	282935.10	282935.10	282935.10

To improve the economic status of a particular area the present and past land use land cover data are needed for analyses purpose (Rawat *et al*., 2013). The information obtained from land use land cover change detection can be useful for planning rehabilitation in Anantapur and Kadapa districts, where the major effects have occurred (Iqbal and Khan 2014).

CONCLUSION

The classification results show huge variation in the area occupied by each and every feature in the study area. The overall changes between the three time periods 1973, 1992, and 2001, observed that barren rock, water bodies and forest were found to be occupied at a very higher rate when compared with present year. Whereas in the year of 2012 mining, scrub land, settlement, plantation and crop lands was tremendously increasing due to human activities and urbanization. By observing the landscape changes in the LULC maps of different time periods, we can conclude that urbanization is growing in a very faster way, that create several problems like environmental pollution, accommodation of houses and many infrastructures. The people from rural areas migrate to urban areas because of poverty, unemployment or in search of livelihood. To improve their standard cost of living results in occupying the barren lands and thereby constructing the buildings and industries to satisfy their basic needs. Immediate action is required to avoid such problems thereby reducing the risk of human life and safeguarding the nature to reduce the chance of disaster vulnerability.

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Lignocellulolytic Enzyme Profile of *Pleurotus florida* (Mont.) Singer on Wheat and Paddy Straw

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Abstract: *Pleurotus florida* mean yield harvested was 54.81 kg q^{-1} dry straw on wheat straw and 47.3 kg q^{-1} dry straw on paddy straw. The fungus degraded cellulose, hemicellulose and lignin of both agro- wastes to produce the edible and nutritious mushrooms. Biodegradation of the waste in terms of loss of cellulose, hemicelluloses and lignin showed positive correlation with cellulases i.e. endo-â-1, 4-glucanase (E.C. 3.2.1.91), exo-1, 4-â-glucanase (E.C. 3.2.1.4), xylanase (E.C. 3.2.1.8) and laccase (E.C. 1.10.3.2) activity of the fungus. Minimum activity of endoglucanase, exoglucanase and xylanase was observed during the spawn run period, increased during the formation of pin head and development of the fruiting bodies. *P. florida* showed higher enzyme activity while growing on paddy straw. The culture filtrates (CYM, PDA, MMM) were analyzed for enzyme activity. The linear growth to cover the petriplates and biomass study of *P. florida* was maximum on PDA (90mm) and (19.2g L^{-1}) on 10th day of incubation at 25±2° C, respectively. The *in vitro* protein digestibility of spent wheat straw and rice straw was 59.82% and 58.12% on 100 gram dry matter basis of substrate, respectively.

Key Words: Enzyme activity, *In vitro* protein digestibility of spent straw, Lignocellulosic substrates, *Pleurotus florida*

Cultivation of the oyster mushroom, *Pleurotus* spp has increased greatly throughout the world to constitute the second largest variety of mushroom produced in the World. Its popularity has been increasing due to its ability to colonize a wide spectrum of unfermented, lignino-cellulosic wastes, high yield potential, high nutritional value and purposed to have medicinal properties (Gregori *et al.,* 2007). Oyster mushroom can be grown on various substrates including paddy straw, wheat straw, maize stalks/cobs, vegetable plant residues, bagasse etc. (Hassan *et al*., 2011) and this has been reported to influence its growth, yield and composition (Iqbal *et al.,* 2005; Kimenju *et al.,* 2009; Khare *et al.,* 2010). Due to their fast mycelial growth rate, they colonize the substrates rapidly and so the yield of fruit bodies is also high.

In India, paddy and wheat straw were used for commercial production of oyster mushroom (Jain and Vyas, 2002) and proved to be the best substrates for cultivation of *Pleurotus* species (Bonatti *et al.,* 2004). *P. florida* is able to produce the significant hydrolytic (cellulases and hemicellulases) and oxidative (ligninolytic) extracellular enzymes required to convert insoluble and large components of lignocellulosic materials into the soluble and low-molecular-weight compounds, which can then, be absorbed by the fungi for the purpose of their growth and development of fruiting bodies. The practice of mushroom cultivation is not only to produce a nutritious food but also improves the spent straw quality due to the degradation of cellulose and hemicellulose by mushroom enzymes and hence has been rendered more digestible. Digestibility of the straw is dependent on the depolymerization of its structural carbohydrates. Enzymatic degradation of these macromolecules in the straw would result in degradation and increase the digestibility and availability of the carbohydrate, thereby upgrading the economic value of lignocellulosic wastes (Fazaeli *et al.,* 2004). Present study was focused on the cultivation of *P. florida* by utilizing two different locally available agricultural wastes, and evaluation of cellulolytic, hemicellulolytic, xylanolytic and ligninolytic enzyme activity in cultural fltrates and during the different growth stages of *P. florida* on lignocellulosic substrates.

MATERIAL AND METHODS

Strain and growth conditions: *Pleurotus florida* (PAU-5) was procured from the Culture Collection Bank, Mushroom Research Complex, Punjab Agricultural University, Ludhiana. The strain was maintained and sub-cultured fornightly on Potato-dextrose agar (PDA) slants and stored at 4° C.

Characterization of Cultures

Linear growth and biomass production studies: Linear growth study of *Pleurotus florida* was observed on different agar media i.e. complete yeast extract agar (CYM), potato dextrose agar (PDA) and mushroom minimal media (MMM) at 25+2°C up to 10th day of incubation. Biomass production capability of *P. florida* was also observed in CYM, PDA and MMM broth. Each flask contained 50ml broth medium was inoculated with mycelial agar bit (5 mm dia) and weight of biomass was taken after 10 days of incubation. Wet weighed

biomass was kept at 55°C up to 4 hours and weighed as dry weight by subtracting out the dry weight of filter paper.

Estimation of lignocellulolytic enzyme activity of *P. florida* culture filtrate: *Pleurotus florida* was grown in CYM, PDA and MMM broth for 10 days at 25±2°C to collect the filtrate. The culture filtrates were analyzed for cellulase (endo-â-1, 4-glucanase and exo-1, 4-â-glucanase), xylanase and laccase enzyme activity.

Spawn preparation: Wheat grains were half boiled for 30 min in boiling water until they become soft. Cooled grains were mixed with calcium carbonate (2 %, w/w). Half boiled grains were individually filled (250 g/bag) in a poly propylene bags (13 × 26 cm) and plugged with non absorbent cotton. The grain filled bags were sterilized in autoclave at 15 lb pressure (121^{O}C) for 90 min and allowed to cool at room temperature. Seven days old mycelial discs (5 mm) of *P. florida* were aseptically inoculated in the spawn bags and incubated at 25 ± 2^{O}C and dark chamber for 15 days.

Selection of substrates: Wheat straw and paddy straw (chopped into 2-5 cm long pieces) were wetted for 18 hours, to attain 67.5% moisture level in wheat straw and 65.0% in paddy straw, respectively. The wetted wheat and paddy straw were mixed with spawn @ 10% of dry weight of straw. The spawn mixed in wetted straw was filled in poly bags of size 16×20 inches. Fifteen bags for each of wheat straw and paddy straw were filled, tied from the mouth and incubated at room temperature (24±1°C).

Sample collection: Lignocellulolytic enzymes were estimated during spawn run period, pin head stage, fruiting bodies formation and spent straw during the cultivation of *Pleurotus florida* on wheat and paddy straw. Ten gram sample was homogenized in 100 ml of 50 mM sodium acetate buffer (pH 5.0) for cellulose and hemicellulose assay while ten gram sample was homogenized in 50 mM phosphate buffer (pH 6.0) for laccase assay. Homogenized samples were filtered through Whatman No. 1 filter paper and filtrate was used for enzymatic study.

Enzyme assays: *Pleurotus florida* strain PAU-5 was grown in CYM, PDA and MMM media for 10 days at 25±2°C to collect the filtrate. The culture filtrate was collected and stored at 4°C. Cellulases, xylanases and laccases were assayed as. Cellulases and xylanase were assayed by the method of Sandhu and Kalra (1982) and reducing sugars released was estimated using glucose standard. Laccase (EC 1.10.3.2) was assayed by Dhaliwal *et al.* (1991) method. The units used for cellulases and xylanase is ìg glucose release min^{-1} ml^{-1} and for laccase change in absorbance by 0.001 min^{-1} ml^{-1}. The specific enzyme activity was recorded in U/mg total proteins

***In vitro* protein digestibility of spent straw:** 0.5 gm of sample was taken in 250 ml conical flask and 50 ml of pepsin solution was added, incubated at 37° C for 24 hours and neutralized with about 30 ml of 0.2 N NaOH. Then 50 ml of pancreatin solution was added and incubated at 37° C for 24 hours. An enzyme blank was run simultaneously omitting the protein sample. Few drops of toluene were used to maintain the aseptic conditions in the system. The contents were filtered through Whatman filter paper no. 44. The residues were analyzed for nitrogen content by macrokjeldahl method.

$$(x\text{-}y) \times \frac{0.014 \times V1}{V2 \times S}$$

x = volume of 0.01 HCl used for sample titration; y = volume of 0.01 HCl used for blank titration; V1 =Total volume made; V2 = Volume of aliquot taken; S = Weight of sample taken; % Crude protein = %N *4.38

By using this formula, initial and final nitrogen contents were estimated and then digestibility coefficient was determined by subtracting the residual protein from intial protein on the basis of 100 gram of sample.

RESULTS AND DISCUSSION

Characterization of *P. florida* Cultures

Linear growth and biomass production: Linear growth of *P. florida* was studied on different agar medium up to 10 days of incubation at 25±2° C indicated maximum growth on PDA followed by CYM with minimum on MMM. The biomass was collected on 10th and dried at 55°C for 4 hours to record the biomass dry weight. The biomass was observed maximum in PDA followed by CYM and MMM (Table 1).

Estimation of lignocellulolytic enzyme activity of *Pleurotus florida* culture filtrate: The exoglucanase activity was maximum (1.75 U/mg) in PDA filtrate while it was at par in culture filtrate from CYM and MMM media. The endoglucanase activity was maximum in MMM (2.8 U/mg). Similarly xylanase activity was maximum in MMM (7.9 U/mg). The Laccase activity from both PDA and MMM were at par followed by that on CYM (Table 2).

Cultivation of *Pleurotus florida*: In wheat straw, spawn run was completed between 16-20 days while in paddy straw it took 23-27 days. Pin head started appearing between 20-25 days in wheat straw and 27-31 days in paddy straw. Harvesting was initiated after 28 days in wheat straw and 34 days in case of paddy straw. The mean yield harvested was 54.81 kg q^{-1} dry straw in wheat straw and 47.3 kg q^{-1} dry straw in paddy straw. Average weight of fruiting bodies was 8.2 g on wheat straw and 9.1 g on paddy straw (Table 3).

Estimation of lignocellulolytic enzyme activity: Lignocellulolytic enzymes were estimated during spawn run period, pin head stage, fruiting bodies formation and spent staw during the cultivation of *P. florida* on wheat straw (Table

Table 1. Linear growth of *Pleurotus florida* strain PAU-5 on agar media and biomass production

Medium	Colony diameter (mm/day)					Biomass (g/L)
	Incubation period (days)					
	2d	4d	6d	8d	10d	10d
CYM	10	28	42	60	85	15.7
PDA	12	32	45	58	90	19.2
MMM	08	18	32	52	65	12.2
CD (p=0.05):	Media (Agar) : 0.27 Days : 0.35 Media× Days : 0.61			Broth media (biomass) :1.17		

Incubation period -10 days ;Incubation temp- 25±2°C
Medium- Complete yeast extract medium agar, pH-6.5; Potato dextrose agar medium, pH-6.5
Mushroom minimal medium, pH-6.5

Table 2. Lignocellulolytic enzyme activity of *Pleurotus florida* culture filtrate

Broth	Enzyme activity(U/mg protein)			
	Exoglucanase	Endoglucanase	Xylanase	Laccase
CYM	1.44	1.84	4.2	1.39
PDA	1.75	1.9	5.06	1.45
MMM	1.42	2.8	7.9	1.52
CD (p=0.05)	0.115	0.945	0.164	0.441

Incubation temperature-25+2°C, Incubation time-10 days
Medium used- Potato dextrose agar medium, Complete yeast extract medium, Mushroom minimal medium, pH-6.5
Wavelength-Exoglucanase, endoglucanase and xylanase was 540 nm (Sandhu & Kalra, 1982).
For Laccase 495 nm (Dhaliwal *et al* .,1991)

Table 4. Estimation of lignocellulolytic enzyme activity at different growth stages during cultivation of *P. florida* on wheat straw

Growth Stages	Specific enzyme activity (U/mg protein)			
	Exoglucanas	Endoglucanas	Xylanas	Laccas
Spawn run	0.46	0.96	4.93	5.52
Pin head	0.65	1.73	5.39	4.86
Fruiting body	1.53	2.67	8.6	2.48
Spent straw	0.05	0.25	6.8	0.19
CD (p=0.05)	0.102	0.113	0.128	0.376

Data given is the mean of five replicates
Temperature during the crop= 25-30°C
Size of bag= 16×20 inches
Substrate = 1 kg wet wheat straw/bag
Relative humidity during the crop= 80-88 %

4) and paddy straw (Table 5). Exoglucanase, endoglucanase and xylanase activities showed a gradual rise in enzyme activity with consecutive stages of growth during cultivation of *Pleurotus florida*. These observations can be correlated with slow depletion of cellulose and hemicelluloses component in the vegetative phase and their fast depletion in reproductive phase which further supports the view that cellulose serves as an energy source for the formation of fruit bodies in *Pleurotus* species as suggested by Pandey *et al* (2012). Similar results have also been reported in many other species of *Pleurotus* on various lignocellulosic substrates by Singh *et al.* (2007). After the harvest the enzyme activity was minimum in spent straw. This experiment indicated that every stage of development during the cultivation of *Pleurotus florida* require to break the lignocellulosic substrate to obtain nutrients for its own growth and development as obvious from negligible enzyme activity observed in spent straw. However, the laccase activity showed a gradual decline during the cultivation stages with minimum in spent straw. Elisashvili *et al.* (2003) showed maximum activities of laccase and polyphenol oxidase, during vegetative growth can be directly correlated with degradation of lignin in this stage. It is also reported that high activity of these enzymes during the colonization stage and declined activity during primordia formation.

***In vitro* protein digestibility:** The spent straw (wheat and paddy) after the cultivation of *Pleurotus florida* strain PAU-5 were given treatment with pepsin and pancreatin for 48 hours. The initial protein content in the spent wheat straw was 10.9% and 11.7% in spent paddy straw. The residual protein content after enzymatic treatment was found to be 4.38 and

Table 3. Cultivation of *Pleurotus florida* PAU-5

Substrate	Spawn run (days)	Pin head initiation (days)	First harvest (days)	Fruit bodies (no./q dry weight)	Yield (kg q^{-1} dry straw)	Av. wt. of fruit body (g)
Wheat straw	18 ± 1.51	23 ± 1.51	28 ± 1.25	6680 ± 132.36	54.81 ± 1.69	8.2 ± 0.34
Paddy straw	25 ± 1.36	29 ± 1.07	34 ± 1.36	5190 ± 323.78	47.3 ± 1.80	9.1 ± 0.42

Average of replicates: 15; Dry straw per bag – 1kg; Date of spawning -24 Dec, 2014; Spawn rate- 10% of dry weight of straw; Crop season- Dec –March, 2014-15; Date of termination- 1 March, 2015

Table 5. Estimation of lignocellulolytic enzyme activity at different growth stages during cultivation of *Pleurotus florida* on paddy straw

Growth Stages	Specific enzyme activity (U/mg protein)			
	Exoglucanas	Endoglucanas	Xylanas	Laccas
Spawn run	1.42	1.88	9.6	6.11
Pin head	1.69	3.48	9.48	5.75
Fruiting body	2.45	5.62	11.8	3.87
Spent straw	1.09	2.13	9.53	0.29
CD (p=0.05)	0.647	0.231	0.427	0.225

Data given is the mean of five replicates
Temperature during the crop= 25-30°C
Size of bag= 16×20 inches
Substrate = 1 kg wet wheat straw/bag
Relative humidity during the crop= 80-88 %

4.9 in wheat straw and paddy straw, respectively. The protein digestibility coefficient was calculated in spent wheat and paddy straw was 59.82% and 58.12% on 100 gram dry weight basis, respectively. The presences of highly lignified tissues in rice straw makes a physical barrier and prevents the accessibility of highly digestible tissues to the action of hydrolytic enzyme for rumen micro-organisms (Karunanandaa *et al.,* 1995) and increased digestibility associated with the degradation of structural carbohydrates (Mukherjee and Nandi, 2004).

CONCLUSION

It can be concluded that on agar medium, PDA was the most preferred medium for linear growth of *Pleurotus florida* with minimum growth on MMM. In case of broth medium, the most preferred broth medium was PDA medium followed by CYM. The minimum production of biomass was observed in MMM medium. Higher rate of mycelium run was observed on paddy straw. Pin head started appearing between 20-25 days in wheat straw and 27-31 days in paddy straw. *Pleurotus florida* showed higher enzyme activity while growing on paddy straw. Hence degradation of the components (carbohydrates) happened more efficiently while growing on paddy straw than in wheat straw. The biggest influence on change of enzymatic activity had external conditions; cold shock and mechanical shock. *In vitro* digestibility of spent wheat straw was observed 59.82% and 58.12% in spent paddy straw.

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Extracellular Enzyme System Based Preferential Utilization of Lignocellulosic Agrowastes by *Agrocybe aegerita* (Brig.) Singer

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Abstract: *Agrocybe aegerita* is popular due to its flavor, nutritional and medicinal value. Its commercial cultivation under climatic conditions of Punjab demands the assessment for suitable substrate. During submerged fermentation, no significant difference in CMCase (carboxymethyl cellulase) activity was observed among the three substrates after 28 days of incubation (0.33-0.36U/mg). Substrate utilization ability was significantly higher in respect of wheat straw and sawdust for cellobiose and only wheat straw for hemicellulose after 28 days of incubation. However, FPase (filter paper) activity was found significantly higher on paddy straw and wheat straw substrate than on saw dust, reflecting its major role during mycelial growth. Laccase activity was found low and did not differ significantly among wheat straw and saw dust. In solid state fermentation, without supplementation, cotton sticks were more efficiently utilized by *A. aegerita* with significantly higher activity of CMCase (4.41 U/mg) and Cellobiase (4.28 U/mg) as compared to other substrates. The maximum activity of CMCase, cellobiase, FPase and xylanase activity among the 20% wheat bran supplemented substrates was found on wheat straw and it is significantly higher than all other substrates. However, the lower Laccase activity was observed due to preferential utilization of cellulose and hemicellulose components of the substrates.

Key Words: *Agrocybe aegerita*, Solid state fermentation, Submerged fermentation, Substrate

Agrocybe aegerita (Brig.) Sing. commonly known as black poplar mushroom belongs to the family Strophariaceae. Individualized flavor, high in nutrition and distinctive medicinal values provide sufficient reason for it being suitable for cultivation (Zhao *et al.,* 2003). The whacking prospect of its cultivation in India pertains to the favorable temperatures whole of the year at one place or the other (20^0C-30^0C), ample agricultural waste (600 million tonnes per year) and affordable labor (Sharma and Sharma, 2009). The nutritional properties of *A. aegerita* are conspicuous due to its highest fiber content, which are 0.4-1.4 folds higher than the other analogue species of mushrooms. Its protein content is comparable to that of *Agaricus bisporus* and *Pleurotus ostreatus* and quite higher than the protein content of Lentinus edodes.

The extensive enzymes system in fungi enable them to thrive successfully on wide variety of inexpensive easily accessible lignocellulosic substrates such as lignin, cellulose, hemicelluloses, pectin and other industrial wastes which are not suitable even for animal feed. This enzyme system makes the mushroom species to decay complex organic substrates into low molecular weight soluble substances. Later, without any difficulty it can be assimilated by mushroom mycelium for nutrition. The preference for a particular substrate is decided by the comparative intensity of the activities of different enzyme (Rai and Saxena, 1990; Cavazzoni and Manzoni, 1994). Kempken (2002) reported the selective decomposition of cellulose and hemicelluloses by *A. aegerita*. Wang *et al.* (2000 and 2002) studied the extracellular enzyme activity of nine different enzymes of *A. aegerita* with low activities of Laccase, peroxidase, polyphenol oxidase and tyrosinase and low utilization of lignin and phenolic compounds as substrate in the three strains of *A. aegerita* (T, Ag8 and Ag9).

However, there is knowledge gap in how different substrates content affects lignocellulose utilization *vis-a-vis* enzyme production and mushrooms yield in *A. aegerita*. The little is known about the yield potential, lignocellulolytic enzyme production and substrate utilization when *A. aegerita* is cultivated on different substrates. Keeping in view, the climate conditions and agricultural residues available in Punjab, the present study was carried out to screen *Agrocybe aegerita* for the extracellular lignocellulolytic enzyme production under the submerged and solid state fermentation.

MATERIAL AND METHODS

Agrocybe aegerita strain was procured from Directorate of Mushroom Research (DMR), Solan, Himachal Pradesh, India. It was frequently sub-cultured and maintained on Potato Dextrose Agar (PDA) medium at 25 ± 2ºC.

Preparation of Standard inoculum on agar plates: About 20ml of the molten PDA medium was transferred aseptically in each sterile petri plate and allowed to cool. These petriplates were incubated at 25ºC for two days to check any contamination. A mycelial bit was cut from the culture slant with the help of a L-shaped inoculating needle and was placed on the agar surface, in the centre of the non-

contaminated petriplate such that the mycelial end of the disc touches the surface of the media. The entire process of pouring and inoculation was carried out under aseptic conditions. After inoculation, the sides of plates were sealed with parafilm and were then incubated at 25 ± 2ºC in an inverted position till the growth of the mycelium was completed.

Screening in Basal medium: The enzyme production was carried out in basal medium having the following composition.

Ingredients	**g L^{-1}**
L-asparagine	1.2
KH_2PO_4	2.0
$CaCl_2$	0.2
NH_4Cl	0.5
$MgSO_4.7H_2O$	1.0
$FeSO_4.7H_2O$	0.01
$ZnSO_4.7H_2O$	0.02
$MnSO_4.7H_2O$	0.02
pH	6.5

Basal broth (30 ml) was supplemented with sawdust, wheat straw and paddy straw powder (@ 0.5 g/flask) as inducers for extracellular enzyme production. The medium was autoclaved at 20 psi for 30 minutes. Discs of similar size were cut from the cultured petriplates by the help of a borer and transferred one circular disc in each flask and then incubated at 25º C for four weeks and enzyme activity was measured at regular intervals.

Solid substrates like sawdust, wheat straw and paddy straw powder and finely crushed maize stalks, corn cobs and cotton sticks were filled in “race tubes” (25mm x 198mm) to a height of approx. 130mm and plugged with non-absorbent cotton. The tubes were then sterilized at 20 lbs for 90 minutes in an autoclave. Three replicates were maintained for each substrate. After cooling for two days, each tube was surface inoculated aseptically with the circular mycelia bits of *Agrocybe aegerita* in a way that mycelial surface was in close contact with substrate in the tube. The tubes were then incubated at 25C for four weeks and enzyme activity was measured at regular intervals (7 days).

Extraction of crude enzyme from solid substrate: About 5.5g of mycelium impregnated substrate (wheat straw, paddy straw, sawdust, maize stalks, corn cobs and cotton sticks) in race tube was removed with the help of spatula and dispensed in 20ml of 0.1m citrate buffer for one hour. Then the mixture was centrifuged at 12,000 rpm for 15 min at 4°C. After centrifugation, the extract was used for the estimation of cellulases, Xylanase and Laccase.

Lignocellulolytic activity assay: Carboxymethyl Cellulase activity (EC 3.2.1.4) was assayed with 1% solution of carboxymethyl cellulose as an enzyme substrate in 0.1M citrate buffer of pH 4.8 (Mandels *et al.,* 1976). Cellobiase activity (E.C.3.2.1.21) was assayed with 10mM solution of cellobiose as an enzyme substrate in 0.1M citrate buffer of pH 4.8 (Toyama and Ogawa, 1977). FPase activity was measured according to method of Mandels *et al.* (1976) using strips of 6 x 1 cm size cut from filter paper sheet of Whattman No. 1. Filter paper. Xylanase activity was assayed by standard method of Bucht and Eriksson (1968) using a 1% xylan solution as an enzyme substrate in 0.05 M citrate buffer (pH 4.8). The reducing sugars liberated during the assay reaction were estimated as glucose by using DNS method (Miller, 1959). Laccase activity (E.C.1.10.3.2) was determined by using guaiacol as an enzyme substrate in 0.1 M phosphate buffer (pH 6.0). The total extracellular protein content was determined at regular intervals by method of Lowry *et al.* (1951) for determining the specific activity of the enzymes.

RESULTS AND DISCUSSION

Enzyme activity in submerged fermentation: The CMCase activity was found to be very less during the initial stages of mycelial growth (7 days) but the activity increased (with increase in biomass) as the number of incubation days increased from 7 to 28 days. There was no significant difference in CMCase activity observed among the three substrates after 28 days of incubation (0.33-0.36U/mg) (Table 1).

Table 1. Effect of different lignocellulosic substrates on different enzyme activities of *A. aegerita* under submerged fermentation at 28th day of incubation

Enzymes (µg/min/ml)	Paddy straw	Wheat straw	Saw dust	CD (p=0.05)
CMCase activity	0.33	0.36	0.35	NS
Cellobiase activity	10.70	12.69	12.23	0.78
Filterpaper activity	0.192	0.185	0.066	0.18
Xylanase activity	0.55	1.56	1.11	0.29
Laccase activity Units/ml)	0.046	0.019	0.025	0.11

Data is mean of three replicates
Incubation temperature:25±2°C

Comparable results by Wang *et al.* (2000) of three different strains of *A. aegerita* grown on cotton seed shell and sawdust with decreased activity of CM Case have been recored. Kempken (2002) reported that *A. aegerita* decompose cellulose and hemicelluloses selectively. *A. aegerita* showed high activity in the utilization of cellulose and non-lignin cellulose (Maheshwari *et al.,* 2009).

Cellobiase activity was found significantly higher in respect of wheat straw and sawdust (12.69 and 12.23 U/mg respectively) than on paddy straw after 28 days of incubation. However, FPase activity was found significantly on paddy straw and wheat straw substrate than on saw dust, reflecting its major role during mycelial growth.

Hemicellulose degrading ability of *A. aegerita* on wheat straw (1.56 U/mg) was significantly higher among other substrates and overall proving it as an efficiently utilizable substrate. Laccase activity was found very low and did not differ significantly among wheat straw and saw dust after 28 days of incubation. Similar results were observed by Maheshwari *et al.* (2009) whereby the production of celluloses (Carboxymethyl Cellulase, Filter paper activity, Cellobiase) and Xylanase was studied by different mushroom strains on the Reese mineral medium supplemented with maize residue as carbon source at 7 and 15 days of incubation and exhibited relatively higher activity of all four enzymes at 15th day than that at 7th day of submerged fermentation.

Enzyme activity in Solid-state Fermentation without supplementation: Among the six substrates, cotton sticks were more efficiently utilized by *A. aegerita* showing the highest CMCase (4.41 U/mg) and Cellobiase activity (4.28 U/mg). FPase activity on wheat straw, maize stalks and cotton sticks did not differ significantly but higher among other three agro-substrates.

Hemicellulose was more efficiently degraded by this fungus when grown on paddy straw substrate (6.80U/mg). Laccase activity, however, was found considerably low but paddy straw, corn cobs and cotton sticks showed significantly higher activity at 28th day of incubation. *Agrocybe aegerita* performed well on cotton sticks suggesting its utilization without supplementation would offer significant increment in growth of this fungus (Table 2).

P. betulinus, a brown rot basidiomycete was found to colonize whole volume of wheat straw substrate in first two weeks of inoculation with low initial rate of substrate degradation (Valaskova and Baldrian, 2006). *Agrocybe aegerita* exhibited highest extracellular enzyme activity on cotton sticks and highest hemicellulose activity specifically on paddy straw. Although levels were low, production of cellulases on cotton waste by *P. sajor-caju* was much higher than that on sawdust (Tan and Wahab, 1997). The much higher production of cellulases on cellulosic cotton substrate compared with other substrates reflects the inducibility of the cellulase enzyme complex.

The brown rot fungi are inefficient in degrading lignin comparable to white rot fungi. *A. aegerita* in present study showed low laccase activity. Valaskova and Baldrian (2006) reported that there was no laccase and peroxidases activity detected in brown rot fungus, *P. betulinus* when grown on wheat straw substrate. Saw dust substrate was a poor inducer for all the five enzymes studied because the activity recorded was very low even after 28 days of incubation. The enzymic system of this fungus is capable of utilizing the lignocellulosic substrates used without any supplements. Three main agricultural residues *viz.* wheat straw, paddy straw and saw dust were validated to be a good substrate for cultivation of *A. aegerita,* but accounted with the low production of extracellular enzymes. Overall, among six substrates used for studying extracellular enzymes activity in solid state, cotton sticks represent a promising substrate for cultivation of *A. aegerita.* The nature of the substrate was shown to be important in the production of inducible enzymes.

Enzyme activity in solid-state fermentation with 5%, 10% and 20% wheat bran: Supplementation of wheat bran resulted in increased enzyme activity in all the substrates basal media. Among three substrates, CMCase, cellobiase, FPase and xylanase activity differs significantly and found highest on wheat straw solid medium supplemented with 5% wheat bran whereas laccase activity was found to differ non-significantly (Table 3).

Wheat straw significantly showed enhanced CMCase, cellobiase, FPase and xylanase activity in 10% supplementation. However, laccase activity was found

Table 2. Effect of different lignocellulosic substrates on different enzyme activities of *A. aegerita* without supplementation of wheat bran under solid state fermentation at 28th day of incubation

Enzymes (µg/min/ml)	Wheat straw	Paddy straw	Saw dust	Maize stalks	Corn cobs	Cotton sticks	CD (p=0.05)
CMCase activity	2.65	3.28	0.42	1.57	0.28	4.41	0.26
Cellobiase activity	3.37	0.57	0.57	1.89	0.44	4.28	0.38
Filterpaper activity	1.32	0.97	0.45	1.310	0.195	1.364	0.19
Xylanase activity	5.40	6.80	1.03	2.23	1.16	2.76	0.27
Laccase activity (Units/ml)	0.019	0.045	0.026	0.029	0.043	0.053	0.14

Data is mean of three replicates
Incubation temperature:25±2^{o}C

Table 3. Effect of wheat bran supplementation rate on different enzyme activities of *A. aegerita* using different lignocellulosic substrates under solid state fermentation at 28th day of incubation

Enzyme activity (U/mg)	Wheat straw	Paddy straw	Saw dust	CD (p=0.05)	Wheat straw	Paddy straw	Saw dust	CD (p=0.05)	Wheat straw	Paddy straw	Saw dust	CD (p=0.05)
	5% wheat bran				10% wheat bran				20% wheat bran			
CMCase	6.80	2.95	1.28	0.42	8.85	8.11	1.39	0.23	11.82	10.97	2.11	0.31
Cellobiase	4.77	1.82	1.82	0.23	5.20	2.86	2.86	0.47	8.00	5.32	5.32	1.23
Filterpaper	2.86	2.33	1.76	0.14	5.71	3.66	4.08	0.45	8.88	6.33	6.22	0.56
Xylanase	5.20	3.18	2.18	0.36	7.62	4.00	3.88	0.93	9.29	6.23	4.19	0.44
Laccase	0.093	0.111	0.106	NS	0.125	0.161	0.163	0.25	0.165	0.185	0.193	NS

Data is mean of three replicates
Incubation temperature:25±2°C

higher on paddy straw (0.161 Units/ml) and saw dust (0.163 Units/ml) than on wheat straw which was significantly lower (0.125 Units/ml). The maximum and significant difference of CMCase, cellobiase, FPase and xylanase activity among the 20% wheat bran supplemented substrates was found on wheat straw.

Kapoor *et al.* (2009) reported that CMCase activity was highest followed by Cellobiase (Cbase) and filter paper (Fpase) activity in wheat straw supplemented with cotton seed meal (CSM) and soyabean meal (SBM) in *Lentinus edodes*. They observed that rice bran (RB) was effective in stimulating Cbase activity at early stages but maximum activity was observed on CSM and SBM. FPase activity was also better on SBM and RB supplementation. Altaf *et al.* (2010) *revealed* wide differences among Xylanase production by *Flamulina velutipes and Pleurotus eryngii*. They used different carbon sources xylose, glucose, starch, sucrose, xylan, rice husk and wood straw with maximum Xylanase activity in xylose by *Flamulina velutipes* (5.3 IU/ml) and in starch by *Pleurotus eryngii* (6.83 IU/ml).

However, Laccase activity on all the supplemented substrate did not show significant difference at the rate of 20% but higher relative to 5% and 10% supplementation with wheat bran. The lower Laccase activity seen initially may be due to preferential utilization of cellulose and hemicellulose components of the different substrates.

Similar results were obtained by Wang *et al.* (2002) who found that Laccase activity was very low in the development of *A. aegerita*. Hong and Lang (2007) evaluated ten strains of esculent fungi (*P. citrinopileatus, L. edodes, Flammulina velutipes, A. auricularia, Schizophillum commune, P. ostreatus, A. aegerita, P. eryngii, Pholiota adipose* and *hypsizygus marmoreus*) for their ability to degrade lignin and resulted that *A. aegerita* is capable of degrading lignin. Laccase activity in *Lentinus edodes* (Le-S) appeared at later stages (20-30 days after inoculation) and a very high activity was reported on non supplemented and peanut meal supplemented wheat straw (Kapoor *et al.,* 2009). Results revealed that wheat straw basal medium supplemented with 20% wheat bran was the most efficient substrate for extracellular enzyme production by *A. aegerita* under solid state fermentation conditions. Even the lower wheat bran supplementations (5% and 10%) resulted in higher enzyme activity than the non-supplemented media indicating the efficiency of wheat bran as an inducer for extracellular enzymes.

CONCLUSION

It can be concluded that *Agrocybe aegerita* has rich lignocellulolytic enzymatic system, which confers its potential to degrade biomass for its mycelia growth, primordial formation and fruiting body development. It exhibit extracellular enzymatic activity on variety of agrowastes like wheat straw, paddy straw, saw dust, cotton sticks, maize stalks and corn cobs, Amongst them wheat straw and cotton sticks prove to be plenary into growth cycle of *Agrocybe aegerita.* Supplementation with wheat bran of the substrates was found to be positively correlated with the increase in activity of the enzymes studied suggesting its intrinsic ability to induce extracellular enzymes. The extensive study of these enzymes has led us to a calculable approach which might increase the Biological Efficiency of *Agrocybe aegerita* on commercial scale. However, there is no study so far concerning the yield of this mushroom under climatic conditions of Punjab. Future work on its other biochemical aspects, nutritive values, shelf life and commercialization in Punjab region will be primary objective of further investigation.

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Ecological Survey of Predominant Weed Flora in Bastar Region of Chhatisgarh, India

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Abstract: Bastar region of Chattisgarh was surveyed for the present weed flora and invasion of any re-surging or alien weed species in cropped and non-cropped area. *Cyperus rotundus* and *C. dactylon* registered highest Importance Value Index (IVI) in rice and rice-fallow crop during *kharif* and rabi seasons, respectively in Jagdalpur district. However, *Cassia tora* during *kharif* and *C. dactylon* during *rab*i registered highest IVI in non-cropped area. Out of different weed species in the Bijapur district *C. rotundus* in rice and *C. dactylon* in vegetables registered maximum IVI during *kharif* and *rabi* seasons, respectively. *Cassia tora* during *kharif* and *Parthenium hysterophorus* during *rabi* important weed had highest IVI in non-cropped area. Contrary to above, *Echinocloa colona* in rice and *Leucas aspera* in rice-fallow registered maximum IVI during *kharif* and *rabi* seasons, respectively in Dantewada district.

Key Words: *Cassia tora, Cynodon dactylon, Cyperus rotundus, Echinochloa colona,* Importance value index, *Parthenium hysterophorus*

Import of food grains had always been the entry of alien weed species as evidenced in case of *Parthenium hysterophorus; Eichhornia crassipes*, etc. Invasion of non-native exotic species in alien environments poses a major threat to native plant communities and alerts fundamental structures and functions of eco-systems. It poses one of the most serious threats to biodiversity, causing major changes in vegetation in global level. An invasive alien weed specie whose introduction to the indicative ecosystem causes huge economic loss or alter biodiversity or environmental harm or harm to human health. Directorate of Plant Protection Quarantine and Storage has intercepted five alien invasive weeds namely *Cenchrus tribuloides, Solanum carolinense, Ambrosia trifida, Viola arvensis* and *Cyanoglossum officinale* through the imported wheat to the tune of 6.3 million tons obtained from eleven countries during 2006-07. This wheat has been distributed to non-traditional wheat growing areas including Chattisgarh. Initial control of these alien weeds is of utmost importance to avoid their epidemic spread as has happened in case of *Parthenium hysterophorus.* With this view, an intensive survey was undertaken in the state during 2008-10. The Southern track of Chhattisgarh has been heavily infested by different weed flora throughout the year. The cultivated areas have serious weed problems which reduce the yield of the crops. Some weeds have dominated this region because of congenial environment leading higher intensity. The crops suffer heavily in early growth stage from the weeds. Critical period of crop weed-competition has been identified as 20-30 DAS in upland capable to reduce the yield production by 47 to 92 % (Bhadoria *et al.,* 2000). Weeds are the most omnipresent class of pests that interfere with crop plants through competition and allelopathy, resulting in direct loss to quantity and quality of the product (Gupta, 2004) and indirectly increasing production costs. Therefore, the knowledge of weed species occurrence in crops of the region is necessary to plan and execute a proper and economical weed management schedule.

MATERIAL AND METHODS

Bastar region of Chhattisgarh includes Jagdalpur, Dantewada and Bijapur districts located in the southern area of Chattisgarh. Major soils of this area are entisols and alfisols. Annual rainfall of this region is 1404.4 mm and cropping intensity is 124 %. Rice is the major growing crop of this region (Agriculture Statistics, 2009).

Initially, a grid map of Bastar region was prepared to conduct an effective survey of prevalent weed flora during *kharif and rabi* seasons. During 2008-10, 18 blocks and 509 villages (367 villages in *kharif* and 142 villages in *rabi*) were surveyed in Jagadalpur district, 6 blocks and 63 villages (19 villages in *kharif* and 44 villages in *rabi*) were surveyed in Bijapur district and 5 blocks and 39 villages (29 villages in *kharif* and 10 villages in *rabi*) were surveyed in Dantewada district.

Fields of three farmers from each village were chosen for study. With each farmer, cropped and non-cropped areas were considered and all types of weed species were covered. At each point of survey, observations were taken through quadrate method. Quadrate was dropped randomly at five different places in cropped and non-cropped areas. Total number of all types of weed species occurring in each quadrate was recorded. The weed species

uprooted during the observation were dried at room temperature initially and finally were dried in the oven and dry weight was recorded accordingly for each species of weeds surveyed at different locations. Accordingly, density of weed per sq.m.; dominance, frequency %, relative density, relative dominance, relative frequency and IVI (Importance Value Index) were calculated. Weed dominance can be calculated by multiplying weed density with the dry weight of the weed species. Average values of relative weed density, dominance and relative frequency of individual weeds were used to calculate Importance Value Index (IVI) i.e., IVI = Relative density + Relative frequency + Relative dominance.

RESULTS AND DISCUSSION

In Jagdalpur district, during *kharif* season, 27 weed species in vegetable, 22 in sugarcane and 50 weeds in rice were identified, out of which *Cynodon dactylon, Paspalum conjugatum* and *Cyperus rotundus* were the most dominant weed species observed, respectively, with highest IVI. (Table 1&2). It was also observed that in rice crop, *Cynodon dactylon and Echinochloa colona* registered máximum density per sq.m., however, *Cyperus rotundus* was found to be most frequently occuring weed with máximum frequency % (Table 2). The weed flora observed in rice crop are similiar with the weed flora observed by Duary *et al.* (2015).

During *rabi* season, in the same survey area, 27 weed species in rice, 15 weed species in gram; 29 in vegetable and 30 in rice-fallow were identified. *Ageratum conyzoides in rice, Leucas aspera* in gram, *Cynodon dactylon in vegetable and Commelina bangalensis* in rice-fallow were found to be the most dominating weed species, with highest IVI during rabi season in the cropped areas of Jagdalpur district (Table 3). Frequency and relative frequency of *Commelina benghalensis* was found maximum, however, ecological parameters of *Phyllanthus amarus* were found lowest in the rice crop during rabi season in Jagdalpur district (Table 3).

A total number of 60 weed species during *kharif* season and 52 weed species during *rabi* season were identified in non-cropped area of Jagdalpur district. *Cassia tora* during *kharif* season registered highest density/m^2, frequency, relative density, relative frequency and IVI, followed by *Lantana cámara* and *Cynodon dactylon.* During *rabi season, Cynodon dactylon* registered highest density/m^2, frequency, relative density, relative frequency and IVI, followed by *Lantana cámara* and *Chloris barbata.* On the contrary, *Centella asiatica and Crotolaria spp. recorded the* lowest ecological parameters of weeds during *kharif* and during *rabi* seasons, respectively in non-cropped area.

In Bijapur disrict, during *kharif* season, only one crop, i.e. rice was found and surveyed. Thirty weed species in rice were identified during the survey, out of which *Cyperus rotundus* recorded the highest density, dominance, frequency, relative density, relative frequency, relative dominance and IVI, followed by *Echinochloa colona* and *Cyperus iria* (Table 4). Similar weed flora in rice, during *kharif* season was also reported by Kiran and Rao (2013). During *rabi* season, only vegetables grow in Bijapur district. Twenty weed species in vegetable were identified during the survey in its cropped area. *Cynodon dactylon* registered with highest density, dominance, frequency, relative density, relative frequency, relative dominance and IVI, followed by *Cyperus rotundus* and *Leucas aspera* (Table 5). However, ecological parameters of *Celosia argentea*, in rice crop, during *kharif* season and *Cassia tora* in vegetable crop, during *rabi* season were found to be lowest among the total observed weed species in the Bijapur district.

During the survey in non-cropped area of Bijapur district 22 weed species in *kharif* and 25 weed species in *rabi* season were identified. *Cassia tora* during *kharif* and *Parthenium hysterophorus* during *rabi* were the most dominant weeds. They registered highest density/m^2, frequency, relative density, relative frequency and IVI. Second and third most dominant weeds observed during *kharif* season in non-cropped area were *Parthenium hysterophorus* and *Cynodon dactylon,* while *Cynodon dactylon* and *Lantana camara* were the next most dominant weeds observed during *rabi* season. On the contrary,

Table 1. Dominant weed species with highest IVI in different crops of Jagdalpur district during *kharif* '08-10 and *rabi'* 08-10

Season	Cropped area	Dominant weeds
kharif	Vegetable	*Cynodon dactylon; Euphorbia geniculata; Cyperus rotundus*
	Sugarcane	*Paspalum conjugatum; Commelina benghalensis; Portulaca oleracea*
	Rice	*Cyperus rotundus; Cynodon dactylon; Echinocloa colona*
Rabi	Rice	*Ageratum conyzoides; Commelina benghalensis; Cyperus rotundus*
	Gram	*Leucas aspera; Melilotus alba; Medicago denticulata*
	Vegetable	*Cynodon dactylon; Chloris barbata; Cyperus rotundus*
	Rice-fallow	*Commelina bangalensis; Ageratum conyzoides; Cyperus rotundus*

Table 2. Ecological parameters of different weed species in cropped area (rice) of different villages of Jagdalpur district during *Kharif*

Weeds	Density/m^2	Dominance	Frequency %	Relative density	Relative frequency	Relative dominance	IVI
Aeschynomene indica	0.19	0.22	2.92	0.95	1.20	0.02	2.16
Ageratum conyzoides	0.07	0.08	1.18	0.37	0.49	0.01	0.86
Alternanthera sessilis	0.06	0.05	0.91	0.31	0.37	0.00	0.69
Alysicarpus vaginalis	0.01	0.01	0.14	0.04	0.06	0.00	0.10
Amaranthus viridis	0.23	0.32	3.33	1.11	1.37	0.02	2.50
Astracantha longifolia	0.45	0.54	6.88	2.23	2.82	0.04	5.10
Blumea lacera	0.04	0.05	0.68	0.19	0.28	0.00	0.47
Blumea spp	0.01	0.02	0.23	0.06	0.09	0.00	0.16
Brachiaria ramosa	0.43	0.47	6.83	2.12	2.81	0.04	4.96
Caesulia axillaris	0.06	0.07	0.87	0.28	0.36	0.01	0.64
Calotropis pocera	0.05	0.06	1.05	0.27	0.43	0.00	0.70
Cassia tora	0.08	0.08	1.05	0.38	0.43	0.01	0.81
Celosia argentea	0.79	0.91	5.79	3.87	2.38	0.07	6.31
Chloris barbata	0.81	0.85	3.64	3.96	1.50	0.06	5.52
Commelina bengalensis	0.89	0.92	13.80	4.39	5.67	0.07	10.13
Commelina communis	0.68	1.72	10.16	3.32	4.17	0.13	7.62
Commelina diffusa	0.03	0.04	0.59	0.17	0.24	0.00	0.42
Cyanotis axillaria	0.04	0.04	0.68	0.21	0.28	0.00	0.49
Cynodon dactylon	2.71	3.17	27.43	13.34	11.26	0.24	24.84
Cyperus difformis	0.13	0.16	2.14	0.65	0.88	0.01	1.55
Cyperus iria	1.04	1.21	13.53	5.13	5.55	0.09	10.78
Cyperus rotundus	2.61	3.13	28.93	12.83	11.88	0.24	24.94
Dactyloctenium aegyptium	0.76	0.50	7.15	3.75	2.94	0.04	6.72
Digitaria sanguinalis	0.77	2.18	10.43	3.77	4.28	0.17	8.22
Dinebra retroflexa	0.11	0.19	1.18	0.53	0.49	0.01	1.03
Echinochloa colona	2.71	3.27	26.51	13.31	10.88	0.25	24.44
Echinochloa crusgalli	0.45	0.41	6.74	2.21	2.77	0.03	5.01
Eclipta alba	0.18	0.14	2.60	0.89	1.07	0.01	1.96
Eleusine indica	0.15	0.16	2.00	0.72	0.82	0.01	1.55
Euphorbia geniculata	0.47	0.54	7.56	2.31	3.10	0.04	5.46
Euphorbia hirta	0.55	0.70	6.92	2.71	2.84	0.05	5.60
Gandarlata (local name)	0.01	0.03	0.09	0.05	0.04	0.00	0.09
Gompherina celosides	0.06	0.07	1.00	0.30	0.41	0.01	0.71
Heliotropium indicum	0.13	0.10	1.96	0.64	0.80	0.01	1.45
Ischaemum rugosum	0.32	0.33	4.92	1.56	2.02	0.03	3.60
Leucas aspera	0.07	0.21	1.05	0.36	0.43	0.02	0.80
Mimosa pudica	0.50	0.64	8.02	2.45	3.29	0.05	5.79
Parthenium hysterophorus	0.62	1.32	6.10	3.04	2.51	0.10	5.64
Paspalum conjugatum	0.30	0.35	4.51	1.47	1.85	0.03	3.35
Portulaca oleracea	0.04	0.05	0.64	0.20	0.26	0.00	0.46
Sida acuta	0.08	0.08	1.23	0.38	0.50	0.01	0.89
Trianthema portulacastrum	0.02	0.02	0.27	0.09	0.11	0.00	0.20
Sida acuta	0.08	0.08	1.23	0.38	0.50	0.01	0.89
Trianthema portulacastrum	0.02	0.02	0.27	0.09	0.11	0.00	0.20
Urochloa platiginea	0.28	0.44	4.15	1.36	1.70	0.03	3.10
Wild rice	0.22	0.27	3.37	1.07	1.38	0.02	2.47

Table 3. Ecological parameters of different weed species in cropped area (Rice) of different villages of Jagdalpur district during *Rabi*

Weeds	Density/m^2	Dominance	Frequency %	Relative density	Relative frequency	Relative dominance	IVI
Ageratum conyzoides	0.96	1.00	13.16	9.46	10.62	0.19	20.26
Amaranthus spinosus	0.11	0.22	1.71	1.03	1.38	0.04	2.46
Ameranthus viridis	0.15	0.15	2.50	1.45	2.02	0.03	3.49
Argimone mexicane	0.05	0.07	0.92	0.52	0.74	0.01	1.27
Astracantha longifolia	0.48	1.38	4.34	4.75	3.50	0.26	8.52
Blumea spp	0.08	0.18	1.18	0.78	0.96	0.03	1.77
Brucharia remosa	0.25	0.22	3.03	2.48	2.44	0.04	4.96
Celosia argentia	0.09	0.10	1.45	0.88	1.17	0.02	2.07
Chinopodium alba	0.15	0.23	2.11	1.45	1.70	0.04	3.19
Chloris barbeta	0.28	0.34	2.76	2.79	2.23	0.06	5.08
Cichorium intybus	0.04	0.04	0.39	0.36	0.32	0.01	0.69
Commelina bangalensis	0.77	0.92	14.61	7.60	11.78	0.17	19.56
Commelina communis	0.56	0.50	4.47	5.53	3.61	0.09	9.23
Cynodon dactylon	0.83	0.98	9.74	8.11	7.86	0.19	16.16
Cyperus difformis	0.20	0.13	1.97	1.96	1.59	0.02	3.58
Cyperus rotundus	0.92	1.10	9.74	9.04	7.86	0.21	17.11
Cyprus iria	0.41	0.49	4.61	4.03	3.72	0.09	7.84
Dactyloctenium aegyptium	0.26	0.61	1.71	2.53	1.38	0.12	4.03
Digitaria sanguinalis	0.23	0.45	2.37	2.22	1.91	0.09	4.22
Echinochloa crusgulli	0.23	0.28	2.37	2.22	1.91	0.05	4.19
Echinocloa colona	0.25	0.16	3.03	2.43	2.44	0.03	4.90
Eclipta alba	0.35	0.42	3.29	3.46	2.65	0.08	6.20
Eupbhorbia hirta	0.25	0.16	3.42	2.48	2.76	0.03	5.27
Gomphrina spp.	0.03	0.03	0.39	0.26	0.32	0.01	0.58
Heliotropium indicum	0.07	0.04	0.66	0.67	0.53	0.01	1.21
Ischaemum rugosum	0.11	0.10	1.84	1.03	1.49	0.02	2.54
Leucas aspera	0.18	0.22	2.50	1.81	2.02	0.04	3.87
Medicago indica	0.49	0.82	5.92	4.81	4.78	0.16	9.74
Melilotus spp.	0.24	0.25	2.89	2.33	2.34	0.05	4.71
Mimosa pudica	0.16	0.46	2.24	1.60	1.80	0.09	3.49
Parthenium hysterophoras	0.11	0.10	1.18	1.03	0.96	0.02	2.01
Phyllanthus niruri	0.04	0.07	0.66	0.41	0.53	0.01	0.96
Physalis minima	0.15	0.42	2.37	1.45	1.91	0.08	3.44
Solanum xanthocarpum	0.04	0.02	0.66	0.36	0.53	0.00	0.90
Spilanthes calva	0.14	0.24	2.37	1.40	1.91	0.04	3.35
Spilanthus acmell	0.43	0.58	3.55	4.19	2.87	0.11	7.16
Tridax procumbense	0.07	0.08	1.18	0.67	0.96	0.02	1.64

Solanum xanthocarpum during *kharif* and *Chloris barbata* during *rabi* recorded the lowest IVI and considered as least dominant weed species. Ananda *et al.* (2010) also reported the similar weed species in non-cropped area.

In Dantewada district, during *kharif* season, 27 weed species in rice were identified during the survey in cropped area. Out of them, *Echinocloa colona Cyperus irria* and *Ageratum conyzoides* were three dominant weed species registered with highest density, dominance, frequency, relative density, relative frequency, relative dominance and IVI in rice crop (Table 6). *Malvastrum coromadalian was the least dominant weed species as its* ecological parameters were found to be the lowest amongst the 27 weed species in the rice crop of Dantewada district.

During the survey in rabi season of cropped area in Dantewada district, 5 weed species in rice-fallow were

Table 4. Ecological parameters of different weed species in cropped area (rice) of different villages of Bijapur district during *kharif*

Weeds	Density/m2	Dominance	Frequency %	Relative density %	Relative frequency %	Relative dominance %	IVI
Aeschynomene indica	0.11	0.18	1.82	0.57	0.65	0.02	1.24
Astracantha longifolia	0.47	0.52	7.27	2.48	2.59	0.06	5.13
Blumea spp	0.51	0.55	7.27	2.67	2.59	0.07	5.33
Brucharia remosa	0.29	0.25	5.45	1.53	1.94	0.03	3.50
Celosia argentia	0.11	0.12	1.82	0.57	0.65	0.01	1.23
Chloris barbeta	0.65	0.78	9.09	3.44	3.24	0.09	6.76
Commelina banghalensis	0.36	1.19	4.55	1.91	1.62	0.14	3.67
Commelina communis	1.24	3.25	22.73	6.49	8.09	0.39	14.97
Cynodon dactylon	0.58	0.41	10.91	3.05	3.88	0.05	6.99
Cyperus difformis	0.40	0.50	6.36	2.10	2.27	0.06	4.42
Cyperus rotundus	3.42	2.80	51.82	17.94	18.45	0.33	36.72
Cyprus iria	1.75	1.54	17.27	9.16	6.15	0.18	15.49
Dactyloctenium aegyptium	0.65	0.75	7.27	3.44	2.59	0.09	6.11
Echinochloa colonum	2.95	3.36	45.45	15.46	16.18	0.40	32.04
Echinochloa crusgulli	0.47	0.56	7.27	2.48	2.59	0.07	5.14
Eclpta alba	0.25	0.32	3.64	1.34	1.29	0.04	2.67
Eupbhorbia geniculata	0.29	0.61	3.64	1.53	1.29	0.07	2.89
Eupbhorbia hirta	0.55	0.48	7.27	2.86	2.59	0.06	5.51
Gomphrina celosiodes	0.25	0.29	3.64	1.34	1.29	0.03	2.66
Heliotropium indicum	0.18	0.43	2.73	0.95	0.97	0.05	1.98
Ischaenomum indicum	0.62	1.32	10.91	3.24	3.88	0.16	7.28
Leucos aspera	0.44	0.50	4.55	2.29	1.62	0.06	3.97
Malvastrum coromadalian	0.25	0.72	4.55	1.34	1.62	0.09	3.04
Mimosa pudica	0.18	0.34	2.73	0.95	0.97	0.04	1.97
Parthenium hysterophorus	0.44	0.52	8.18	2.29	2.91	0.06	5.26
Paspalum conjugatum	0.55	0.49	5.45	2.86	1.94	0.06	4.86
Phyllanthus maderaspatesis	0.25	0.59	4.55	1.34	1.62	0.07	3.02
Physalis minima	0.29	0.25	4.55	1.53	1.62	0.03	3.17
Sida accuta	0.18	0.30	2.73	0.95	0.97	0.04	1.96
Sorghum halepense	0.36	0.56	5.45	1.91	1.94	0.07	3.92

identified. According to the IVI values, the dominance of these 5 weed species is in the order of *Cynodon dactylon; Leucas aspera; Cyperus rotundus; Echinocloa colona* and *Cyperus difformis.* Madhavi *et al.* (2010) also reported similiar weed species in non-cropped area.

A total number of 23 weed species during *kharif* season and 7 weed species during *rabi* season were identified during the survey in non-cropped area of Dantewada district. It was observed that *Cassia tora* and *Parthenium hysterophorus* were the most dominant weed species during *kharif* and *rabi* seasons, respectively, as they registered highest density/m^2, frequency, relative density, relative frequency and IVI, while *Xanthium strumarium* and *Ageratum conizoides* were considered as the least dominant weed species with lowest IVI, during *kharif* and *rabi* seasons, respectively.

CONCLUSION

The cultivated area of upland is having serious problem of weed infestation which declines the yield of upland crops. Some weeds spread fast in this region because of favorable environment in crops, forest plantation and natural forest. 509 villages in Jagdalpur district, 63 villages in Bijapur district and 39 villages in Dantewada districts were surveyed during 2008-10 under National Invasive Weed Surveillance Programme. Most dominated weed during kharif in the cropped area of Jagdalpur and Bijapur districts was *Cyperus rotundus* and in Dantewada

Table 5. Ecological parameters of different weed species in cropped area (vegetable) of different villages of Bijapur district during *Rabi*

Weeds	Density/m^2	Dominance	Frequency %	Relative density %	Relative frequency %	Relative dominance %	IVI
Amaranthus spinosus	0.174	0.42	2.31	1.57	2.20	0.14	3.91
Amaranthus viridis	0.051	0.12	0.77	0.46	0.73	0.04	1.24
Argimone maxicana	0.041	0.10	0.77	0.37	0.73	0.03	1.14
Brachiaria ramosa	0.051	0.06	0.77	0.46	0.73	0.02	1.21
Cassia tora	0.051	0.05	0.51	0.46	0.49	0.02	0.97
Commelina banghalensis	0.092	0.22	0.51	0.83	0.49	0.07	1.39
Commelina cummunuis	0.297	0.35	3.85	2.68	3.67	0.12	6.47
Cynodon dactylon	4.687	5.11	32.56	42.24	31.05	1.69	74.98
Cyperus rotundus	1.826	2.57	21.03	16.45	20.05	0.85	37.35
Dactyloctenium aegyptium	0.359	0.27	5.64	3.23	5.38	0.09	8.70
Digitaria sanguinalis	0.195	0.41	2.05	1.76	1.96	0.14	3.85
Echinocloa colona	0.267	0.30	3.85	2.40	3.67	0.10	6.17
Echinocloa crusgalli	0.205	0.21	2.05	1.85	1.96	0.07	3.87
Euphorbia hirta	0.103	0.11	1.79	0.92	1.71	0.04	2.67
Gompherina celosides	0.164	0.20	2.05	1.48	1.96	0.06	3.50
Heliotropium indicum	0.062	0.05	1.03	0.55	0.98	0.02	1.55
Ischaemum rugosum	0.174	0.18	2.56	1.57	2.44	0.06	4.08
Leucas aspera	2.041	2.00	17.69	18.39	16.87	0.66	35.93
Mimosa pudica	0.154	0.09	1.54	1.39	1.47	0.03	2.88
Phyllanthus niruri	0.103	0.12	1.54	0.92	1.47	0.04	2.43

Table 6. Ecological parameters of different weed species in cropped area (rice) of different villages of Dantewada district during *kharif*

Weeds	Density/m^2	Dominance	Frequency %	Relative density %	Relative frequency %	Relative dominance %	IVI
Aeschynomene indica	0.34	0.53	5.26	1.79	2.12	0.07	3.98
Ageratum conyzoides	1.52	1.89	20.00	8.05	8.05	0.27	16.37
Ameranthus spinosas	0.34	0.40	5.26	1.79	2.12	0.06	3.96
Astracantha longifolia	0.55	1.55	5.26	2.91	2.12	0.22	5.25
Blumea spp	0.55	0.57	5.26	2.91	2.12	0.08	5.11
Brucharia remosa	0.76	0.65	7.37	4.03	2.97	0.09	7.08
Cassia tora	0.08	0.12	1.05	0.45	0.42	0.02	0.89
Chloris barbeta	0.29	0.34	3.16	1.57	1.27	0.05	2.88
Commelina banghalensis	0.21	0.24	3.16	1.12	1.27	0.03	2.42
Commelina communis	0.80	0.50	9.47	4.25	3.81	0.07	8.14
Cynodon dactylon	1.68	1.11	17.89	8.95	7.20	0.16	16.31
Cyperus difformis	0.55	1.44	5.26	2.91	2.12	0.20	5.23
Cyperus iria	1.68	1.82	21.05	8.95	8.47	0.26	17.68
Cyperus rotundus	2.69	3.21	41.05	14.32	16.53	0.45	31.30
Dactyloctenium aegyptium	0.46	1.10	7.37	2.46	2.97	0.15	5.58
Echinochloa colona	3.49	3.81	46.32	18.57	18.64	0.54	37.75
Echinochloa crusgulli	0.63	0.56	9.47	3.36	3.81	0.08	7.25
Eclpta alba	0.29	0.34	5.26	1.57	2.12	0.05	3.73
Eupbhorbia hirta	0.29	0.35	4.21	1.57	1.69	0.05	3.31
Heliotropium indicum	0.21	0.56	3.16	1.12	1.27	0.08	2.47
Ischaenomum indicum	0.13	0.16	3.16	0.67	1.27	0.02	1.96
Leucos aspera	0.38	0.89	4.21	2.01	1.69	0.13	3.83
Malvastrum coromadalian	0.04	0.06	1.05	0.22	0.42	0.01	0.66
Parthenium hysterophorus	0.38	0.43	6.32	2.01	2.54	0.06	4.62
Phyllanthus niruri	0.13	0.18	2.11	0.67	0.85	0.02	1.54
Physalis minima	0.13	0.14	2.11	0.67	0.85	0.02	1.54
Sida accuta	0.21	0.22	3.16	1.12	1.27	0.03	2.42

Table 7. Ecological parameters of different weed species in cropped area (rice fallow) of different villages of Dantewada district during *rabi*

Weeds	Density/m^2	Dominance	Frequency %	Relative density %	Relative frequency %	Relative dominance %	IVI
Cynodon dactylon	5.85	3.86	52.31	42.60	41.46	5.77	89.84
Leucas aspera	4.00	4.44	29.23	29.15	23.17	6.64	58.96
Cyperus difformis	0.31	0.33	6.15	2.24	4.88	0.50	7.62
Echinocloa colona	0.86	0.77	12.31	6.28	9.76	1.15	17.18
Cyperus rotundus	2.71	3.06	26.15	19.73	20.73	4.58	45.04

district was *Echinochloa colona.* However, *C. dactylon* dominated the cropped area of the Jagdalpur and Bijapur districts and *Leucas aspera* in the Dantewada district during rabi season. In non-cropped area, during *kharif, Cassia tora* was the most dominated weed in all the three districts, however during rabi, *C.dactylon* was dominated in the Jagdalpur district and *Parthenium hysteroporus* was in the Bijapur and Dantewada districts.

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Nursery Management and Fertilizer Application for Better Weed Control as Well as Higher Yield of *Kharif* Rice

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***Abstract*:** Due to delayed monsoon, farmers often fail to transplant rice seedlings at optimum age and cannot achieve the targeted yield. A field experiment was carried out during *kharif* season of 2013 and 2014 with two types of nurseries viz. improved and recommended practice. The sprouted healthy seeds @ 10 g m^{-2} i.e. 10 kg ha^{-1} and 50 g m^{-2} i.e. 50 kg ha^{-1} were spread over beds of improved and recommended nursery, respectively. Vigorous seedlings produced in the improved nurseries were more efficient to suppress the weed population. Lowest weed population was found with improved seedlings (IS) of 60 days. All the yield attributing characters and yield (5.28 t ha^{-1}) were found highest with IS of 30 days, but no significant difference were found between recommended seedlings (RS) of 30 days and IS of 60 days. No significant yield difference was noticed between 100% RDF and 125% RDF.

***Key Words*:** Nursery management, Nutrient management, Seedling age, Weed population

The *kharif* rice cultivation in West Bengal primarily depends on south-west monsoon rain and facing serious challenges due to monsoon vagaries. During recent past monsoon rainfall has become uncertain and erratic, frequently delayed in onset followed by prolonged mid season break. Rice transplanting requires about 200 mm of accumulated rainfall. In deficient rainfall condition farmers usually retain the rice seedlings in the nursery and transplant older seedlings, which results very poor yield. Majority of the rice production system in India involves two distinct phases viz. nursery and main-field, which are equally important and need good management practices for higher yield. Under higher seeding density intra-seedling competition increases, this results in poor seedling vigour. Vigorous seedlings can be produced with low nursery seeding density alongwith better nutrient management. Seedlings in nursery may enjoy more space and nutrients under low seeding density and can be maintained in the same nursery with minimum competition for longer period even after tillering. With this information, the present investigation was carried out to study the effect of improved seedlings of different age alongwith nutrient management for assured *kharif* rice production.

MATERIAL AND METHODS

The experiment was conducted at BCKV, Kalyani, West Bengal during *kharif* season of 2013 and 2014. Two types of nurseries *viz.* improved and recommended were prepared. Basal dose of 2.5:10:5 g m^{-2} ($N:P_20_5:K_20$) alongwith 2.5 Kg m^{-2} organic matter and 0.5 g m^{-2} Zn was applied during preparation of improved nursery. Whereas, in recommended nursery a basal dose of 2.5:5:5 g m^{-2} ($N:P_20_5:K_20$) alongwith 0.5 g m^{-2} Zn were applied. Then sprouted healthy seeds @ 10 g m^{-2} and 50 g m^{-2} were spread over beds of improved and recommended nursery respectively on same date. In both the cases (recommended and improved) the ratio of nursery area and main-field remained same (1:10). In improved nursery N was top dressed @ 2.5 g m^{-2} at 15 days interval, whereas in recommended nursery one top dressing of N @ 2.5 g m^{-2} at 15 days after sowing (DAS) was done. The experiment was laid out in split plot design with four main-plot factors and three sub-plot factors. Out of the four main main-plot treatments, three were comprised of improved seedlings (IS) produced with special nursery management and another one consisted of recommended seedlings (RS). Improved seedlings (IS) of three different ages *viz.* 30 (IS_1), 45 (IS_2) and 60 (IS_3) days and recommended seedlings (RS) of 30 days were transplanted in the main-field in combination with three levels of fertilizers *viz.* S_1:100%, S_2:75% and S_3:125% of recommended dose of fertilizers (RDF i.e. N: P_2O_5: K_2O@80:40:40 kg ha^{-1}) in sub-plots. Seedlings raised in recommended nursery were transplanted 3-4 seedlings $hill^{-1}$ with 20 cm X 15 cm spacing, whereas seedlings from improved nursery were transplanted 1 seedling $hill^{-1}$ alongwith its tillers with same spacing. Observations like dry matter accumulation,leaf area index, weed population and weed dry weight were recorded in the main-field on 45 DAS, 75 DAS, 90 DAS and 110 DAS for every treatment. Because of the fact that the IS_3 was not transplanted on 45 DAS, so no data was recorded on that day for that treatment. Data like effective tillers, filled grains $panicle^{-1}$, test weight, grain yield and straw yield were recorded at harvest during both the years.

RESULTS AND DISCUSSION

Dry matter accumulation (DMA) and leaf area index (LAI) of rice plant: In main-field Improved seedlings of 30 days (IS_1) produced maximum accumulation of dry matter (512.48, 855.86 and 1265.18 gm m^{-2} respectively at 75, 90 and 105 DAS) followed by IS of 45 days and recommended seedlings (RS). Significantly higher LAI (2.21, 3.02 and 2.42 respectively at 75, 90 and 105 DAS) was recorded with IS_1 followed IS_2. Though the lowest value of DMA and LAI were observed in IS_3 but no significant difference of LAI was noticed between RS and IS_3, whereas, DMA was significantly different (Table 1). The results of this experiment are supported with the findings of Zhao-hui *et al. (*2002).

Fertilizer level also significantly influenced the DMA and LAI of rice. The maximum dry matter accumulation was noticed by applying 125% RDF (419.55, 749.76 and 1110.91 gm m^{-2} respectively at 75, 90 and 105 DAS) followed by 100% RDF and 75% RDF. Similarly maximum LAI was observed in 125% RDF (2.07, 2.69 and 2.23 respectively at 75, 90 and 105 DAS), which was significantly differed from 100% RDF (Table 4). The results of this experiment are in confirmity with the findings of Singh *et al. (*2005).

Weed population: Nursery management and age of seedlings resulted marked variation in weed population and dry weight in main-field. At 45 and 75 DAS, broad leaved weed population were maximum under recommended seedlings (RS) followed by improved seedlings IS_1. The lowest population of broad leaved weeds at 75 DAS was observed under IS_3, which significantly differed from other treatments. The maximum population was recorded by applying 75% RDF followed by 100% RDF and 125% RDF (Table 2).

Similarly in grass weeds, the significantly highest population was observed in recommended seedlings RS followed by IS_1, IS_2 and IS_3. The maximum population was

Table 1. Effect of nursery management, seedling age and fertilizer level on dry matter accumulation and LAI of rice plant (Pooled values of 2013 and 2014)

Treatment	Dry matter accumulation (gm m^{-2})			Leaf area index (LAI)		
	75 DAS	90 DAS	105 DAS	75 DAS	90 DAS	105 DAS
RS	310.50	576.02	841.13	1.86	2.20	1.97
IS_1	512.48	855.86	1265.18	2.21	3.02	2.42
IS_2	410.89	774.86	1029.98	2.07	2.59	2.20
IS_3	294.60	550.94	814.39	1.83	2.15	1.93
CD (p=0.05)	43.76	51.00	78.95	0.05	0.20	0.08
S_1	387.79	690.28	966.49	2.01	2.48	2.12
S_2	339.01	628.22	885.60	1.90	2.30	2.04
S_3	419.55	749.76	1110.91	2.07	2.69	2.23
CD (p=0.05)	12.24	22.34	20.66	0.03	0.06	0.06

RS-recommended seedling of 30 days, IS_1 –improved of 30 days, IS_2 –improved of 45 days, IS_3 – improved seedling of 60 days; S_1:100% RDF, S_2:75% RDF and S_3:125% RDF

Table 2. Effect of nursery management, seedling age and fertilizer level on weed population (pooled values of 2013 and 2014)

Treatment	Broad leaves (number m^{-2})		Grasses (number m^{-2})		Sedges (number m^{-2})	
	45 DAS	75 DAS	45 DAS	75 DAS	45 DAS	75 DAS
RS	2.02	2.20	2.10	2.86	2.94	3.24
IS_1	1.37	1.88	1.74	2.45	2.73	2.75
IS_2	-	1.70	-	1.92	-	1.94
IS_3	-	0.94	-	1.16	-	0.99
CD (p=0.05)	-	0.11	-	0.23	-	0.18
S_1	1.14	1.64	1.33	2.07	1.76	2.19
S_2	1.45	1.93	1.61	2.50	2.13	2.58
S_3	1.00	1.46	1.00	1.72	1.42	1.91
CD (p=0.05)	0.11	0.10	0.28	0.12	0.15	0.11

See table 1 for treatment details

recorded by applying 75% RDF followed by 100% RDF and 125% RDF (Table 2).

In case of sedges, maximum population was observed of recommended seedlings (RS) followed by IS_1, IS_2 and IS_3. The maximum population observed was recorded by applying 75% RDF followed by 100% RDF and 125% RDF (Table 2). Seedlings from improved nurseries due to vigorous growth can check the weed growth. Efficient fertilizer management with higher dose improves the crop growth and suppresses weed population. The results were parallel with the findings of Anitha and Chellappan (2011) and Shukla *et al.* (2015).

Weed dry weight: Dry matter accumulation of weeds in rice field was significantly influenced by age of seedlings and nursery management. Maximum dry weight of broad leaved weeds in main-field at 75 DAS were observed in recommended seedlings (RS) followed by IS_1 (Improved seedlings transplanted at 30 DAS) and IS_2 (Improved seedlings transplanted at 45 DAS). Pooled data also shows that the significantly lowest dry matter accumulation of broad leaved weeds were noticed in IS_3 (Improved seedlings transplanted at 60 DAS). The maximum dry weight was recorded by applying 75% RDF followed by 100% RDF and 125% RDF (Table 3).

Similarly maximum dry weight of grass weeds at 75 DAS in main-field was in RS (1.15 g m^{-2}) followed by IS_1 (1.06 g m^{-2}) and IS_2 (0.98 g m^{-2}). Significantly lower grass weeds' intensity was noticed in IS_3 (0.81 g m^{-2}). The maximum dry weight of the same was noticed when 75% RDF was applied (1.08 g m^{-2}) followed by 100% RDF and 125% RDF which were found significantly different from each other (Table 3).

In case of sedges, at 75 DAS significantly higher dry weight was found in RS (1.22 g m^{-2}) followed by IS_1 (1.09 g m^{-2}), IS_2 (0.98 g m^{-2}) and IS_3 (0.79 g m^{-2}). This is due to the fact that older vigorous seedlings cover the field very quickly and suppress weed growth. The maximum dry weight was recorded in 75% RDF (1.07 g m^{-2}) followed by 100% RDF

Table 3. Effect of nursery management, seedling age and fertilizer level on weed dry weight (pooled values of 2013 and 2014)

Treatment	Broad leaves (gm m^{-2})		Grasses (gm m^{-2})		Sedges (gm m^{-2})	
	45 DAS	75 DAS	45 DAS	75 DAS	45 DAS	75 DAS
RS	1.04	1.11	1.06	1.15	1.09	1.22
IS_1	0.89	1.06	0.95	1.06	1.10	1.09
IS_2	-	1.00	-	0.98	-	0.98
IS_3	-	0.79	-	0.81	-	0.79
CD (p=0.05	-	0.06	-	0.06	-	0.05
S_1	0.83	0.99	0.84	1.00	0.89	1.03
S_2	0.88	1.05	0.95	1.08	0.97	1.07
S_3	0.79	0.93	0.78	0.92	0.84	0.97
CD (p=0.05	0.02	0.03	0.07	0.02	0.04	0.03

See table 1 for treatment details

Table 4. Effect of nursery management, seedling age and fertilizer level on yield and yield attributes (pooled of 2013 and 2014)

Treatment	Effective Tillers m^{-2}	Filled Grains $panicle^{-1}$	Test wt (gm)	Grain Yield (t ha^{-1})	Straw Yield (t ha^{-1})
RS	244.49	127.28	20.75	4.36	8.10
IS_1	277.43	156.78	21.19	5.28	8.31
IS_2	248.57	134.06	21.04	4.78	8.08
IS_3	242.07	109.83	20.75	4.28	7.57
CD (p=0.05)	14.82	13.86	0.04	0.31	0.45
S_1	254.98	133.25	20.94	4.57	8.06
S_2	240.56	125.71	20.91	4.32	7.83
S_3	263.89	137.00	20.95	5.13	8.15
CD (p=0.05)	14.75	7.84	0.04	0.31	0.33

See table 1 for treatment details

(1.03 g m^{-2}) (Table 3). Similar results were found by Roy (2012) and Shukla *et al.* (2015).

Yield and yield attributes: Nursery management, seedling age and fertilizer level significantly influenced the yield attributes and yield of rice (Table 4). IS_1 produced significantly the highest number of effective tillers (277.43) followed by IS_2 (248.57) and RS (244.49). Significantly higher number of grains $panicle^{-1}$ and test weight were recorded with IS_1 followed IS_2. Though the lowest value of yield attributing characters namely, effective tillers m^{-2}, grains $panicle^{-1}$ and test weights were observed in IS_3 but no significant difference was noticed with RS. Similarly maximum grain and straw yield were recorded with IS_1 followed by IS_2 and RS (Table 4.). This may be due to the fact that seedlings experienced better environment in nursery be able to produce sufficient numbers of effective tillers, grains $panicle^{-1}$ and test weight, ultimately results in higher grain yield even when transplanted late. The results of this experiment are in conformity with the findings of Patra *et al.* (2014). Khatun *et al*. (2002) also reported that 45 day old seedlings gave higher yields than seedlings aged 30, 60 and 75 days.

Fertilizer level also significantly influenced the rice yield and yield attributes. The maximum grain yield (5.31 t ha^{-1}) and straw yield (8.15 t ha^{-1}) were recorded by applying 125% RDF, which was significantly different from 100% RDF and 75% RDF. Similarly maximum number of tillers, filled grain $panicle^{-1}$ and test weight were observed in 125% RDF, though the values were at par with 100% RDF. Singh *et al. (*2005) found higher grain yield of rice at higher fertility level in the nursery owing to healthy seedlings, which ultimately showed improved yield attributing characters. Patra *et al.* (2014) found higher grain yield of rice with higher dose of fertilizer, but significant difference was notice with recommended fertilizer level.

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CONCUSSION

It may be concluded from the experiment that lower seed rate alongwith better nutrient management in rice maintain the seedling vigor for longer period. Aged seedlings from such nursery do not reduce the rice yield significantly as compared to recommended seedlings which are transplanted in time. Recommended dose of fertilizer is sufficient for optimum yield of rice when over aged improved seedlings are transplanted.

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Biodigested Slurry of Poultry Droppings Based Biogas Plant as Substrate for Protease Production Using Thermophilic Fungi *Humicola fuscoatra* MTCC 1409 and *Aspergillus* (T-14)

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***Abstract*:** This study was carried out to use biodigested slurry of poultry droppings based biogas plant as a substrate for protease production. Both autoclaved and unautoclaved poultry droppings and biodigested slurry were analysed for protease activity. The unautoclaved biodigested slurry without culture showed maximum protease activity of 108 U/g. After qualitative and quantitative screening of different cultures, *Humicola fuscoatra* MTCC 1409 and isolate *Aspergillus* (T-14) showed maximum potency index(1.81 and 2.75, respectively) and protease activity (225U/g and 270U/g, respectively). Unautoclaved biodigested slurry was better substrate for protease production as *Humicola fuscoatra* MTCC 1409 showed maximum protease activity of 157 U/g and isolate *Aspergillus* (T-14) showed maximum protease activity of 163 U/g in unautoclaved biodigested slurry on 4th day of incubation.

***Key Words*:** *Aspergillus*(T-14), Biodigested slurry substrate, Poultry droppings, Protease, *Humicola fuscoatra* MTCC 1409

Proteases constitute one of the most important groups of industrial enzymes. Proteases belong to the class of hydrolytic enzymes and are grouped into the subclass of the peptide hydrolases or peptidases (EC 3.4) (Barrett and McDonald, 1986). They are capable of hydrolyzing peptide bonds and are found in all living organisms, from viruses to animals and humans (Motyan *et al.,* 2013). Extracellular protease production in microorganisms is strongly influenced by media components, e.g. variation in C/N ratio, presence of some easily metabolizable sugars, such as glucose and metal ions (Beg *et al.,* 2002). Protease synthesis is also affected by rapidly metabolizable nitrogen sources, such as amino acids in the medium. Microbial proteases are predominantly extracellular and can be secreted in the fermentation medium. Fungi elaborate a wide variety of proteases than bacteria. The filamentous fungi have a potential to grow under varying environmental conditions such as time course, pH and temperature, utilizing a wide variety of substrates as nutrients (Haq *et al*., 2006). Thermophiles are a good source of novel catalysts and have more stable enzymes as compared to mesophiles (Li *et al*., 2005). These enzymes are also active at low temperature and develop more rapidly to higher peaks as compared to mesophiles and stability of obligate thermophiles increases with process temperature.

In Punjab, there are around 15,000 poultry farms for the production of broilers, each having capacity varying from 2,000-50,000 birds. So, there is a huge quantity of poultry droppings available that can be used for the production of biogas and thus a large number of biogas plants based on poultry droppings have been installed. Disposal of slurry is a big problem as it is very difficult to transport viscous material to the fields. Also, its direct application forms a layer on the soil surface, which is not desirable. Biodigested slurry from poultry droppings based biogas plants is rich in nutrients like cellulose, hemicellulose, lignin, nitrogen, protein, organic matter and potential microorganisms, which can be utilized for production of value added products like cellulolytic, lignolytic and proteolytic enzymes etc. Therefore, the present paper reports the microbial production of proteases using biodigested slurry of poultry dropping based biogas plant as a substrate.

MATERIAL AND METHODS

Proximate and chemical analysis: Poultry droppings and biodigested slurry (sterilized and non-sterilized) were analyzed for pH, proximate (total solids, volatile solids and ash) and chemical (cellulose, hemicellulose, lignin and silica) composition by the standard methods of AOAC (2000). Nitrogen content was measured by Kjeldahl method (Kjeldahl, 1883).

Qualitative screening: The fungal cultures were screened qualitatively for protease enzyme production by clearance zone method. Different fungal cultures were point inoculated on the petriplates containing skimmed milk medium. The composition of Skimmed milk Agar (gl^{-1}) is: Skimmed milk powder 28.0; Yeast Extract 2.5; Casein 5.0; Dextrose 1.0; Agar 20; pH 7. All ingredients except skimmed milk were autoclaved at 121°C (15psi) for 20min after dissolving in distilled water while skimmed milk was autoclaved at 115ºC,

10psi for 10min only separately. Both were mixed during solidified plate prepration. The solidified plates of Skimmed Milk Agar were point inoculated with fungal cultures and were incubated at 40±2ºC. Plates were flooded with tannic acid (10%) after luxuriant growth of fungi on 3rd day. Then the plates were observed for the formation of clear zone around the colony which represents the production of proteases by the fungus. Potency index was calculated as given below:

$$\text{Potency index} = \frac{\text{Area of clearance zone (cm}^2\text{)}}{\text{Area of colony (cm}^2\text{)}}$$

Quantitative screening: Erlen-meyer flasks of 250ml capacity were dispensed with 50ml of skimmed milk broth (Skimmed Milk Agar without Agar) and were autoclaved. The flasks were allowed to cool and inoculated with 5mm culture bit of fungal cultures. The flasks were then incubated at 40±2ºC for enzyme production. After an incubation period of 5 days, crude enzyme was extracted by centrifugation at 10,000 rpm for 15 minutes at 4°C. The supernatant containing enzyme extract was analysed for protease activity and protein content.

Protease production from biodigested slurry*:* Erlen-meyer flasks of 250ml capacity were dispensed with 25ml of biodigested slurry and 25ml of distilled water was mixed. Half of the flasks were autoclaved at 121°C for 20 min for sterilization, while half of the flasks were left unsterilized. After cooling the media was inoculated with mycelial bits (5mm size) of *Humicola fuscoatra* MTCC 1409 and *Aspergillus* (T-14) separately and were incubated at 40±2°C for different periods of time i.e. 0, 2, 4 and 6 days. After the required period crude enzyme was extracted by centrifugation of slurry at 10,000rpm for 20min. The clear supernant was used for measuring protease activity and protein content by methods given below.

Protease assay: Protease enzyme was determined by the method of Enyard (2008). Enzyme extract was taken in aliquots of 0.1ml in triplicate test tubes and mixed with 0.9ml of distilled water. Five ml of 0.65% casein solution (0.65 g casein in 100 ml potassium phosphate buffer of pH 7.5) was added. The mixture was incubated at 37±2°C for 10 min. After incubation, 5 ml of trichloroacetic acid (TCA- 110mM) was added and the mixture was incubated at 37±2°C for 30 min. To measure protease produced during this reaction, 5 ml of Na_2CO_3 was added followed by immediate addition of 1 ml Folin & Ciocalteu's reagent. Mixture was kept at 37±2ºC for 30 min. The % light absorbance was recorded at 660nm in a UV-VIS spectrophotometer (Hitachi model 2800). A standard curve for protease activity was prepared under same conditions using standard solution of L-tyrosine at a concentration range of 0.1 to 1g. The corresponding enzyme activity was read from the standard curve.

$$\text{Units/ml Enzyme} = \frac{\text{µmole tyrosine equivalents released} \times \text{Total volume of assay}}{\text{Volume of enzyme used} \times \text{Time of assay} \times \text{Volume used in cuvette}}$$

Protein content and specific activity: Total protein contents of the enzyme solution were measured by the method of Lowry *et al.*(1951)**, u**sing bovine serum albumin (BSA) as a standard. The specific protease activity was expressed in terms of enzyme units per mg protein.

RESULTS AND DISCUSSION

Proximate and chemical composition of poultry droppings and biodigested slurry: The unautoclaved biodigested slurry showed maximum protease activity(108 U/g) and autoclaved poultry droppings showed minimum protease activity (54 U/g) (Table 1). The protein content of autoclaved and unautoclaved was found to be 1.23mg/ml and 0.48 mg/ml respectively. This might be because slurry was completely digested after biogas production and proteins could break down in simpler form after digestion. Higher protease activity in unautoclaved biodigested slurry might be due to the fact that autoclaving at such a high temperature might inactivate the protease enzyme.

Fantozzi and Buratti (2009) reported 74.30% volatile solids, 24.82% ash and 47.25 total solids in poultry droppings. Shahariar *et al.* (2013) reported that the pH of poultry droppings was 7.61 and that pH of biodigested slurry was 7.69. Owen *et al.* (2008) reported 20% crude protein in poultry droppings while Adegbola *et al.* (1990) reported 16.5% protein content in poultry droppings.

Oyeleke *et al.* (2010) reported that total solids in poultry droppings to be 86.5%, volatile solids 64.3%, ash% 35.7% and pH of poultry droppings was 6.7 and in biodigested slurry total solids were 23.6 % and volatile solids 55.3%, ash% 44.8% and pH of biodigested slurry 6.9.

Qualitative screening and quantitative screening: Results from Table- 2 indicate that maximum potency index of 1.81 and 2.75 was found in *Humicolafuscoatra MTCC 1409 and Aspergillus* sp. (T-14), respectively, Similarly, maximum protease activity was 225 U/ml and 270 U/ml of *Humicola fuscoatra* MTCC 1409 and *Aspergillus* sp. (T-14), respectively. The intensity of colour gets increased with application of tannic acid on plates. This is supported by Saran *et al.* (2007)as that tannic acid increases the colour intensity of plate, because of the precipitation of unhydrolyzed protein in the plate, thus improving the contrast between the intact zones and the enzymatic lyses zones of the substrate.

Protease production from *Humicola fuscoatra* MTCC

1409*:* Unautoclaved biodigested slurry was found to be better substrate for protease production as maximum protease activity was observed in un auto claved biodigested slurry when inoculated with *Humicola fuscoatra* MTCC 1409 (157 U/g) on 4th day. Protease activity increased with increase in incubation period till 4th day and then start decreasing. Protein content was found higher in autoclaved biodigested slurry (Table 3). Lakshmi *et al.* (2014) reported protease production from *Humicolagrisea* using wheat bran as substrate where 10% of the substrates have given a maximum activity of 961.25 IU after 72 hrs.

Protease production from *Aspergillus* (T-14): Unautoclaved biodigested slurry showed more protease activity than the autoclaved biodigested slurry with isolate *Aspergillus* (T-14) (163U/g). The activity increases upto 4th day and then started decreasing. Protein content was also maximum at 4th day but it was found higher in autoclaved biodiged slurry (Table 4). Radha *et al.* (2011) reported protease production using cheese whey as a substrate from *Aspergillus spp.* Under optimized conditions of pH- 5.0, temperature 32±20°C and incubation period of 5 days. Kamath *et al.* (2010) reported highest protease activity after 120h at 1.5% casein concentration and the amount of liberated tyrosine reached 40.3 mg/g substrate at 28°C.

Table 1. Proximate and chemical analysis of biodigested slurry and poultry droppings

Parameters	Poultry dropping		Biodigested slurry	
	Autoclaved	Unautoclaved	Autoclaved	Unautoclaved
pH	6.9 ±0.02	6.2±0.7	8.9±0.06	8.1±0.05
Total solids	41.30±0.96	38.23±0.40	6.04±0.07	7.46±0.70
Volatile solids	65.86±0.95	63.70±0.76	58.14±0.66	54.35±1.32
Ash	35.55±0.95	37.82±1.08	43.55±1.46	46.41±1.87
Cellulose (%)	15.38±0.80	9.33±0.41	9.40±0.43	6.09±0.90
Hemicellulose (%)	23.87±1.20	18.48±0.80	12.43±0.56	10.07±0.10
Lignin (%)	41.38±0.75	27.49±0.46	22.09±0.88	22.31±1.11
Silica (%)	3.00±0.0.26	1.77±0.17	5.39±0.11	2.75±0.39
Nitrogen (%)	15.98±0.65	14.30±0.85	12.85±0.70	14.54±1.05
Protein (mg/ml)	1.27±0.17	0.61±0.85	1.23±0.02	0.48±0.09
Protease activity (U/g)	39±1.15	61±1.25	85±0.79	108±1.02
Specific activity (U/mg protein)	42±0.94	125±0.80	81±1.39	256±1.2

? The data represents the mean ± standard error
Amount of initial sample taken – 20 g; Autoclaving temperature and pressure - 121°C, 15psi respectively

Table 2. Qualitative and quantitative screening of fungal isolates for protease activity

Name of Culture	Potency index [Size of clearance zone (cm^2)/ size of colony (cm^2)]	Protease activity (U/ml)
Humicolafuscoatra MTCC 1409	1.81±0.23	225±0.74
*Aspergillus*sp. (T-14)	2.75±0.65	270±0.37
*Paceliomyces*sp. (T-26)	1.71±0.74	200±0.97
*Trichoderma*sp. (TS-21)	1.59±0.43	121±78
*Trichoderma*sp. (TS-9)	1.03±0.27	158±1.20
*Trichoderma*sp. (TS-19)	1.14±0.15	116±0.96
*Paceliomyces*sp. (T-17)	1.19±0.81	192±1.18

? The data represents the mean ± standard error
Cultural conditions: Media- Skimmed Milk Media; Incubation temperature - 40°C; Incubation days – 4 days; Flooding - tannic acid 10%; pH – 6.5

CONCLUSION

The biodigested slurry from poultry dropping based biogas plant are rich in protein and nitrogen content which may be utilized as a substrate for protease enzyme production using fungal cultures. *Humicola fuscoatra* MTCC 1409 and *Aspergillus* sp. were the best protease producers on skimmed milk agar. Unautoclaved biodigested slurry was found to produce maximum protease activity at 4th day of incubation. Both autoclaved and unautoclaved biodigested slurry can be utilized for protease production, however unautoclaved biodigested slurry was found to be a better substrate for protease production by fungal cultures.

Table 3. Protease enzyme profile of autoclaved and unautoclaved biodigested slurry inoculated with *Humicolafuscoatra* MTCC 1409

Parameters	Autoclaved biodigested slurry					Unautoclaved biodigested slurry				
	Control	0 Day	2 Day	4 Day	6 Day	Control	0 Day	2 Day	4 Day	6 Day
Protease activity (U/g)	82±0.94	100±0.41	115±0.60	132±1.10	121±0.93	105±1.15	125±1.91	133±0.73	157±0.47	139±0.64
Protein (mg/ml)	1.20±0.11	1.23±0.02	1.27±0.01	1.32±0.01	1.25±0.03	0.45±0.01	0.49±0.01	0.53±0.03	0.55±0.02	0.48±0.01
Specific activity (U/mg)	81±1.50	81±1.17	90±1.37	100±0.60	97±0.91	266±1.03	255±0.96	251±1.06	286±1.10	291±0.61
Nitrogen (%)	16.16 ±0.64	13.98 ±0.50	12.23 ±0.25	11.36 ±0.28	14.42 ±0.11	17.04 ±1.21	19.91 ±1.16	14.85 ±0.56	17.04 ±0.08	17.04 ±0.46

? The data represents the mean ± standard error
Culture conditions: Incubation period-4 days; Slurry concentration-50%; Mycelium bit size-5mm;
pH of autoclaved biodigested and unautoclaved slurry was 8.7.and8.3

Table 4. Protease enzyme profile of autoclaved and unautoclaved biodigested slurry inoculated with fungal isolate *Aspergillus* (T-14)

Parameters	Autoclaved biodigested slurry					Unautoclaved biodigested slurry				
	Control	0 Day	2 Day	4 Day	6 Day	Control	0 Day	2 Day	4 Day	6 Day
Protease activity (U/g)	97±0.82	106±0.80	135±1.78	158±1.25	143±1.32	122±0.93	128±1.51	147±1.04	163±1.04	151±1.01
Protein (mg/ml)	1.25±0.01	1.26±0.02	1.29±0.01	1.32±0.02	1.30±0.01	0.46±0.01	0.50±0.02	0.58±0.01	0.63±0.03	0.56±0.01
Specific activity (U/mg)	77±0.70	84±0.98	105±1.04	120±1.10	110±1.03	265±1.07	257±1.06	254±1.23	259±1.18	270±1.34
Nitrogen (%)	16.16±0.49	13.11±0.31	11.79±0.55	18.35±0.27	14.42±0.14	17.04±0.60	17.48±0.93	14.42±0.58	14.42±0.70	15.29±0.17

? The data represents the mean ± standard error
Culture conditions: Incubation period-4 days; Slurry concentration-50%; Mycelium bit size-5mm;
pH of autoclaved and unautoclaved biodigested slurry was 8.7and 8.4

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Distribution of Bivalves and Gastropods along Ratnagiri coast, Maharashtra, India

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Abstract: Mangroves are one of the most productive ecosystems that densely supports and serve as custodians for juvenile stock. Molluscs are potential source of bioactive compounds and play a crucial role in decomposition of organic matter. The productive molluscan fauna from different habitats have a wide chance of research tofurther explore the ecological value and conservation. In the present work, diversity of bivalve and gastropod from four localities of mangrove habitat along Ratnagiri coast showed that there were 23% bivalve species dominated by *Anadara granosa, Crassostrea cattuckensis, Meretrix meretrix, Saccostrea cucullata,* while 77% gastropod species which includes *Planaxis sulcatus, Littorina scabra, Dostiaviolacea, Cerithium cingulate, Telescopium telescopium, Nodilittorina melanostoma*and *Casidula nucleus*. In the present investigation, about12 genera and 20 species were recorded amongst the Konkan coast.

Key Words: Bivalves, Molluscs, Gastropods, Konkan coast

Among the three major habitats of the biosphere, the marine realm covers 70% of the earth's surface provides largest inhabitable space for living organisms (Spalding, 1997). The organisms thrive not only in the surface waters of the sea, but also in the lower and abyssal depths from coastal to the off shore regions, and from the general oceanic to the specialized niches like blue waters of coral reefs to black smokers of hot thermal vents at the seafloor. Mangroves, ecosystem is ideally situated at the inter-phase betweenthe terrestrial and marine environment. Mangrove ecosystems are one of the biologically diverse and rich inorganic matter and nutrients, and support wide range of flora and fauna (Pawar, 2012). The mangrove ecosystem in Konkan region is the God gift, which help to solve the daily problem of their economic. Edible species of oysters, mussels, clams, cockles, and gastropods provide bread and butter to the local communities (Patole, 2010).

The mangrove mud flat of estuaries act as important nurseries for certain fish, shellfish, oysters, Shrimps, etc. by providing rich andmain food sources, and protection from predation. Mangrove roots and lower parts of trunks provide substrate for oysters and mussels. As the animals are filter feeders, they are confined to microhabitats below mean high water and are usually abundant in areas adjacent to open water (Alvarez-Leon, 1983).The blood clam, *Anadara granosa* and other cockles found in large numbers in mud flats, where it lies partially buried in the sediment (Macintosh and Ashton, 2002). The total number of mangrove inhabiting faunal species in Indian mangroves is 3,111, which include prawns, crabs and molluscs, fish, insects, reptiles, amphibian and mammals (Kathiresan, 2005). An oysters, mussels and clams serve the nutritional needs of the coastal population. As they are, good sources of minerals, protein, and glycogen and easily digestible compared to other animal food (Suryawanshi *et al.,* 2012)..

In India, till today, 5,070 species of molluscs have been recorded of which, 3,370 are from marine habitats (Subba Rao, 1991). 8 species of oysters, 2 species of mussels, 17 species of clams, 6species of pearl oysters, 4 species of giant clams,1species of window pane oyster and other gastropods such as Sacred chank, Trochus, Turbo as well as15species of cephalopods are exploited from the Indian marine region (Venkataraman and Wafar, 2005). It is reported that among the 200 estuaries on the east and west coasts of India, only few have been surveyed for biodiversity. The present work is based to reconnoiter the diversity of the bivalves and gastropods from different localities off Ratnagiri coast.

MATERIAL AND METHODS

Study Area: Study area was divided into four localities to cover entire area of the mangrove along Ratnagiri coast *viz*.is explained in details.

1. Mirya: (Lat.17°01'.16.83" North and Long.73°15'.41.63" East).The open fine sandy beach with intertidal shore of about 15m, having rocks at north and south side. Tide influx result in deposition of sand in rock crevices.

2. Shirgaon: (Lat. 17°01'33.57" North and Long.

73°17'20.52" East).The muddy region with exposed inter-tidal mud flat more than 20m during low tide and is scattered by large mangrove trees. Aprox-1km area occupied by oyster beds spread over on the boulders.

3. Sakhartar: (Lat. 17°02'26.15" North and Long. 73°17'53.94" East). The sandy shore followed by mud flats. Sandy shore covers about 10m during low tide while remaining is muddy area scattered by mangroves. Samples were collected from both the areas.

4. Alawa: (Lat. 16°59'63.62" North and Long. 73°17'42.90" East). The sandy shore with often rocks (surf beaten), about 10m intertidal area exposed during low tide.

Species Collection and Identification: Live animals were collected by hand picking including mangrove associated bivalve and gastropod species during low tide. Five quadrates of nylon rope each 1^{-m^2} was prepared, randomly at each locality just over the bed. Sampling was done twice in each season, post-monsoon, winter and summer from October 2013 to September 2014 at different localities *viz.* Mirya (Sandy area), Shirgaon (Muddy region), Sakhartar (Sandy cum muddy area), and Alawa (Sandy shore with surf beaten rocks). After picking up, they were brought to the laboratory. The shells were brushed to clean the fouling biomass, sand and mud. The animals were preserved in three stages- Firstly; narcotization by using Menthol Magnesium Chloride and then Alcohol or Chloral Hydrate was added drop by drop. In the next step, fixation was carried out in 4 to 10% neutral formalin solution based on specimen's size. Morphological characters of typical animal, especially, lunal, umbo, and operculum and internal parts like teeth, adductor muscles, and hinge wereobservedfor taxonomical identification. The shells wereidentified from Zoological Survey of India, Kolkata. Also using the following references: Annotated checklist of Indian Marine Molluscs (Cephalopoda, Bivalviaand Scaphopoda) Part-1 (Ramakrishna and Dey, 2010).

RESULTS AND DISCUSSION

Gastropods contribute 78% covering of 48 species from 14 families as compared with bivalves, which contribute about 22% including 14 species from 05 families in selected localities of Ratnagiri coast. Bivalve species were recorded higher, 09 species at Mirya with 16 gastropod species. While at Shirgaon, 25 gastropod species was found as higher with 05 species of Bivalves. At Sakhartar locality, 05 bivalve species and 08 gastropod species were recorded, and at Alawa, 06 bivalve species and 22 gastropod species were recorded. Because of the monsoon season, fishermen cannot go off sea for fishing, so in these conditions oysters such as *Crassostrea catuckensis*, *Saccostrea cucullata* and clams viz. *Anadara granosa,* Mussels viz. *Perna viridis* and gastropods play a vital role as food for common people those are living on the coastal region (Table 1).

According to Fig. 1, Family Arcidae, Donacidadae, Mytilidae, Ostridae and Vaneridae contributed 16%, 23%, 15%, 15% and 31% respectively with 14species of 05 bivalve families recorded along the sampling sites. It is observedthat bivalve species sandy as well as mangrove habitats have more diversity (Fig. 3), which indicate that family Veneridae, Donacidadae, Arcidae were dominated along mangrove areas. Gastropods including 48 species from 14 families were recorded from four localities. Family Neritidae and Muricidae contribute more 19% and 17% respectively (Fig. 2). This indicates much more diversity on muddy, mangrove as well as rocky habitats. The Onchidiidae family with 02 species found dominantly in muddy habitats. In addition, Onchidium and Slugs were noticed (Thakur, 2012). According to Fig.3, locality Mirya has both bivalve and gastropod species diversity recorded as compared to the

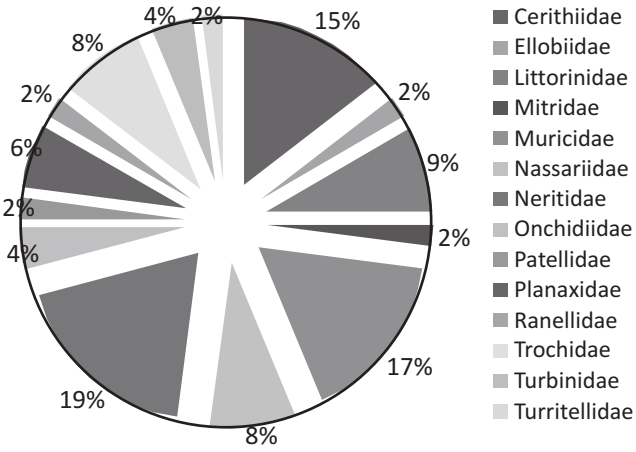

Fig. 1. Diversity of Gastropod families (%)

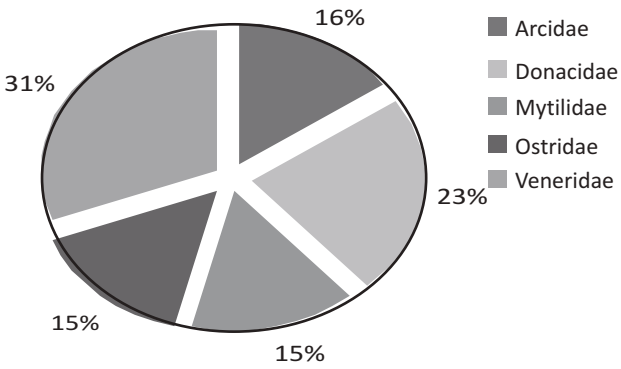

Fig. 2. Diversity of Bivalves families (%)

Table 1. Distribution of bivalves and gastropods among different localities

Families	Species	Mirya	Shirgaon	Sakhartar	Alawa
	Gastropods				
Cerithiidae	*Clypeomorous betilliraeformis*	_	*	_	*
	C. bitasciata	_	*	_	*
	Cerithium traillii	*	_	_	*
	Cerithium spp	*	_	_	*
	C. gennesi	_	_	_	*
	C. bifaciata	_	_	_	*
	Cerithium sp	_	_	_	*
Ellobiidae	*Cassidula nucleus*	_	*	_	_
Littorinidae	*Littorina scabra*	_	*	*	_
	Littoria undulate	_	*	*	_
	Nodilittorina melanostoma	*	_	_	*
	N. vidua	*	_	_	*
Mitridae	*Vexillum ebenus*	_	*	_	_
Muricidae	*Thais blanfordi*	_	*	_	_
	T. lacera	_	*	_	_
	T. tissoti	_	*	_	_
	Morula nodicostata	_	*	_	*
	M.granulate	_	*	_	_
	M. marginatra	_	*	_	_
	Thais hippocastanum	_	*	_	_
	Mancinella bufo	_	_	_	*
Nassariidae	*Nassarius stulatus*	_	*	_	*
	N. pullus	_	*	_	_
	N. jacsonianus	_	*	_	_
	N. vittatus	_	*	_	_
Neritidae	*Nerita albicilla*	*	_	_	*
	N. oryzarum	*	_	_	*
	N. squmulata	_	_	_	*
	N. planspria	*	_	*	_
	N. grayana	*	_	*	_
	N. chameleon	*	_	*	_
	Clithon meticularis	_	*	_	_
	C. smithi	_	*	_	_
	Dostia violacea	_	*	*	_
Onchidiidae	*Onchidium tenerum*	_	*	_	_
	O. tigrinum	_	*	_	_
Patellidae	*Cellana radiate*	*	_	_	*
Planaxidae	*Planaxis sulcatus*	*	_	_	*
	P. nicobarica	*	_	_	_
	Planaxis sp	*	_	_	_
Ranellidae	*Gyranium natator*	*	_	_	*
Trochidae	*Trochus radiates*	*	*	_	*
	Coliostoma speciose	_	*	_	*
	Euchelus atratus	_	_	_	*
	Umbonium vestarium	_	_	*	_
Turbinidae	*Turbo brunneus*	*	_	_	*
	Astralium semicastata	_	_	*	_
Turritellidae	*Turritella duplicate*	_	*	_	_
	Bivalves				
Arcidae	*Arca granosa*	*	_	_	_
	Anadara granosa	*	*	*	_
Donacidae	*Donax incarnates*	*	_	*	_
	D. cuneatus	*	_	*	_
	D. scortum	_	_	*	_
Mytilidae	*Perna viridis*	*	_	_	*
	Modiolus metacalfei	_	_	_	*
Ostridae	*Crassostrea cattuckensis*	*	*	_	*
	Saccostrea cucullata	*	*	_	*
Veneridae	*Gafrarium divaricatum*	*	_	_	*
	Meretrix meretrix	_	*	*	_
	Marcia opima	_	*	_	_
	Dosinia Prostata	*	_	_	*

Note: (_) Absence and (*) Presence

other three localities. Locality Shirgaon has large swampy region with mangroves. Due to this, oysters found in high density and are very useful for local people *viz.* edible and commercial.

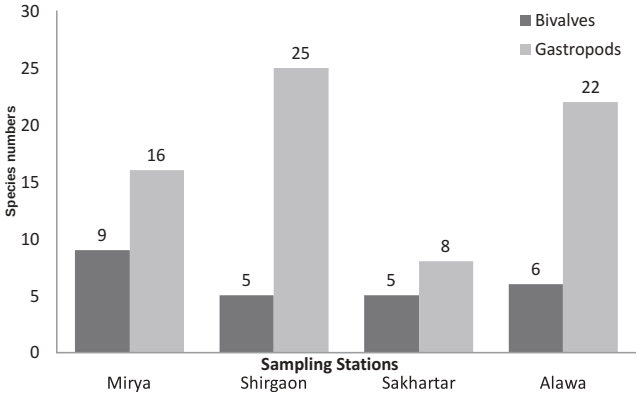

Fig. 3. Distribution of bivalves and gastropods

Diversity of bivalve (22%) and gastropod (78%) molluscs varied significantly at four localities of Ratnagiri coast (Fig.4). The unique characteristics of these ecosystems are the shallowness, high temperature, high oxygen content, and semi-enclosed nature of the habitat. Decomposed litter of the plant from August itself is an important component of nutrient cycling and it harbors large numbers of diverse species. The lowest density was observed in month of July because of Monsoon season. In monsoon, due to self-dilution of the body fluid, the sensitive molluscs were unable to adjust fluctuating osmotic balance. After July, the mortality rate decreased gradually and density increased. It is understood that in July, the salinity and temperature dropped down which made adverse condition for mulluscan survival. The population density was at the peak in the month of November. It was clearly noticed by many researchers that the post monsoon period is the most favorable time for the new inflow of molluscan species. The mangroves support high density of all type of molluscan species particularly, *Telescopium, Potamides, Natica, Nerita*and *Littorina* and other oysters (Rao, 1991; Venkataraman and Wafer, 2005; Jaiswal and Kulkarni, 2005). The *Littorina* spp. was densely found on the trunks, pneumatophores on stilt roots of the mangrove plants. Therefore, mangroves are good harvesting point for variety of molluscan species in winter.

Molluscan communities are good indicators of localized conditions (Rajendra *et al*., 2014). Gastropods, bivalves are generally benthic organisms, and regularly used as bio-indicators for environment (Foeckler *et al.,* 2006). Gastropods and bivalves can produce billions of larvae in the form of planktons that sustains the biotic population and have

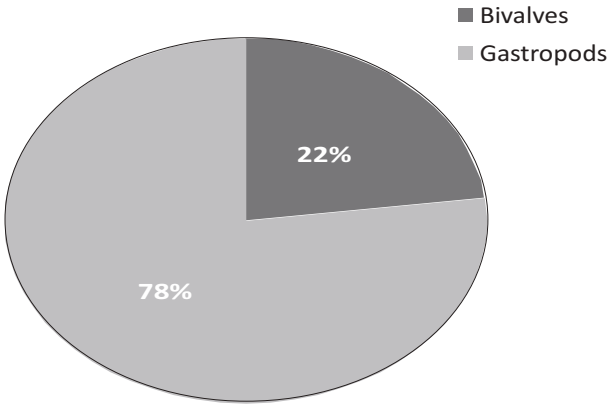

Fig. 4. Molluscan species diversity (%) along Ratnagiri

a great role in food chain. The observation of Gastropods and Bivalves populations in mangrove ecosystem is important to evaluate their condition (Dewiyanti and Karina, 2012). In Malaysia, some of marine bivalve such as *Anadara granosa* is being cultured for commercialization. In Sarawak, mangrove forest covered 173,792 ha of the land, which is suitable for molluscan habitat (Paul, 2012). *Telescopium Telescopium* wasfound in the mud flats of mangroves plants (Suryawanshi *et al*., 2012). In the region of *Nerita* (*Dostia*) *crepidularia, Littorina sp., Cerithidea sp*., were observed in assemblage of oysters on the mud banks, mud flats, mangrove forest, sandy muddy swamps, prop-root sand pneumatophores and mussel were found attached to wherever hard substratum is available such as prop-roots and pneumatophores and oysterbeds (Suresh *et al*., 2012).

Mangroves are providing rich faunal resources from macro faunal communities to microbial diversity. Molluscs can reach high biomass in mangroves ecosystem because of high primary production within the food web, as hiding place from predators, herbivores, detritivores and filter feeders. The numerical abundance and biomass of molluscs can be equally impressive (Sasekumar, 1974). The numerous investigation of mangrove-associated molluscs showed 39 species of gastropods in an Australian mangrove (Camilleri, 1992). 28 species in the Chinese mangrove (Jiang and Li, 1995), 23 molluscs species from the mangrove forest in Hong Kong (Wells, 1990) and 29 species of bivalves from the mangrove root systems on the Atlantic coast of Colombia and Wood boring bivalves are also common in the mangrove forest (Alwarez, 1983). In general, Venkatesan *et al*. (2010) reported numerous surveys of India mangrove molluscs. A total account of 56 species of molluscs including 31 gastropods and 25 bivalves at Sundarban (Dey, 2006).

CONCLUSION

There was a considerable difference within the

study localities. High species diversity was found in a certain locality it could be due to the presence of higher number of different species. The present study revealed that all recorded molluscs are indigenous species at Mirya and Sakhartar have greater commercial value and biodiversity importance. The total number and type of molluscs would be influenced by their habitat and geographical condition. Mirya and Shirgaon probably have suitable habitat to support large number of edible, commercial and ecological molluscan diversity. The gastropods have a significant ecological role to play in the mangrove ecosystems, also rocky habitats is suitable particularly for gastropods. However, very little information is available on the gastropod biodiversity of mangroves. Hence, it is necessary to document the biodiversity of the group of threatened ecosystems and needs an urgent conservation and sustainable utilization of molluscan species.

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Study of Horizontal Zonation of Water Quality Characteristics and Productivity Status of Nanak Sagar Reservoir of Uttarakhand, India

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***Abstract*:** A limnological investigation of the manmade reservoir is necessary to evaluate the potential fish production and to provide information that could be useful in fisheries development planning. In this direction, the present study was conducted on Nanak Sagar reservoir located on Deoha River in the Tarai region of Uttarakhand. The reservoir was divided into three zones *viz*., in Riverine, Transitional and Lacustrine. Fourteen hydrological parameters were analyzed for various seasons such as Monsoon, Post-monsoon and Pre-monsoon from July 2014 to June 2015. The assessment of water quality of the reservoir reflects the uses of water, as well as the condition of the site from where water sample was taken. It is also noteworthy that when intensive sampling has been carried out throughout a reservoir basin to generate a "true" mean for the more common trophic state variables such as nitrogen, phosphorus and silicate concentrations, the volume-weighted mean values have often been statistically indistinguishable from those measured in the different zone. Tropic status of the reservoir was mesotropic in nature found on the basis of hydrological indices. Good status of water quality of this reservoir is essential for the development of culture and capture based fisheries.

***Key Word*:** Reservoir status, Water quality parameters, Zonation

In reservoir ecosystem, climatic and edaphic factors are responsible for energy fixation and nutrient dynamics, thus considered to be of first order importance followed by morphometric factors (basically area, mean depth, irregularity of shoreline) having a significant bearing on productivity. Mean depth (volume/area) of reservoirs is considered to be one of the most important morphometric parameters indicative of the extent of the euphotic littoral zone (Vass and Sugunan, 2008). Reservoirs contribute considerably to the inland fish production of India which has been estimated at 93,000 tonnes (Anon, 2006). Rybakov and Shelekhova (2014) suggested that in shallow and small reservoirs, the reservoir bed may serve as a source of autochthonous nutrient loading as well as evaluate the levels of pollution and its impact on diatom in the riverine zone. However, in Indian reservoirs it has been noticed that the catchment determines the water quality to a larger extent than the basin soil. In majority of Indian reservoirs drastic fluctuations in water level have been observed to impact on fishes, plankton, benthos and periphyton pulses that coincide with the period of least water level and that all the communities are at low ebb during the months of maximum water level and water discharge (Ingole *et al.,* 2014).

Aquatic resources of Uttarakhand include rivers, canal, ponds, reservoirs and upland coldwater bodies. But reservoirs in Uttarakhand hold a major share of fish production of the state. Sharma *et al.* (2005) have reported that the average fish production rate (25 kg ha^{-1}) in the reservoirs of Uttarakhand can be increased up to 200 kg ha^{-1} with proper management of reservoir environment.

There are 6 reservoirs situated in Tarai region of Kumaun in district UdhamSingh Nagar covering a total area of approx 14120 ha., having the congenial water qualities supportive to the tropical fishery of Indian major carps, medium carps, Chinese carps and cat fishes like *Wallago sp., Mystus sp., Channa sp*., *etc*. The average temperature of these reservoirs always remains above 20°C and hence suitable to harbor all the tropical fishes (Verma, 2013). Ingole *et al.,* 2015 studied the fisheries development perspective reservoirs of the Tarai region are Naitaal, Tumaria, Haripura, Baur, Baigul, Dhaura, Nanaksagar, and Sardasagar, which are located at 28°25'– 29° 55'N latitude and 78° 18'–79° 55'E longitude.

The Nanak Sagar is the largest reservoir of Uttarakhand with a catchment area of 570 km^2. The water spread area at full reservoir level (FRL) was 4900 ha, which was reduced to 2202 ha due to sedimentation after thirty five years in year 2007 derived from remote sensing data at same elevation, assessed by Ingole *et al.* (2015).

In the present investigation, horizontal zonation and mapping of Nanak Sagar reservoir water body have been done for the first time. The main purpose of this study was to determine the seasonal variations (monsoon, post- monsoon and pre- monsoon) in hydrological parameters of this

reservoir at selected sampling stations in different zones. Thus, the investigation was attempted to assess the water quality status with a view to elaborate certain aspects of management for the betterment of localities.

MATERIAL AND METHODS

Study Area : The Nanak Sagar reservoir was created by constructing an earthern dam of 19.20 km length across river Deoha and situated (79, 50, 34' E, 28, 57, 20' N) in Udham Singh Nagar district of Uttarakhand. A geographical location map is enclosed given in (Fig. 1).

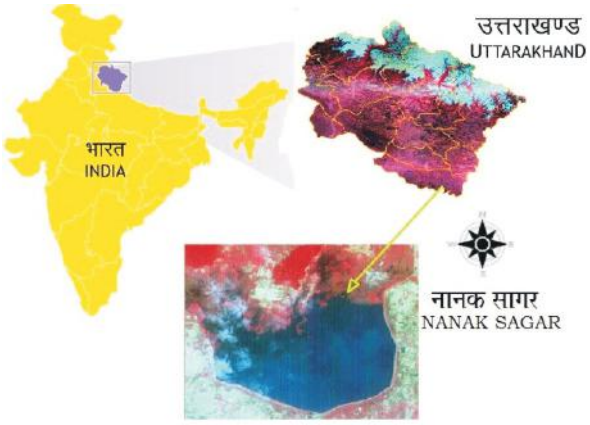

Fig. 1. Geographical location map of Nanak Sagar reservoir

Collection of sample : For this study water samples were taken monthly from fixed twenty sampling station (9:00 am - 01:00 pm) in Nanak Sagar reservoir selected by using Global Positioning System (GPS) GARMIN (ORGEON 550) GPS receiver in different zone (Riverine, Transitional and Lacustrine) of reservoir (Fig. 2, Table 1). Samples were collected in plastic bottles. The survey and mapping were done during monsoon (July-October), post-monsoon (November-February) and pre-monsoon (March-June) season so as to obtain the temporal area of the water body, from July 2014 - June 2015. The water parameters quality including water temperature (digital thermometer, *HM Digital, Inc.*), pH using digital pH meter (HI 98107), Total Dissolved Solid (TDS) using digital TDS (HM Digital, Inc.), water transparency (standard *Secchi disc*), conductivity (conductivity meter *HI98303*), Dissolved Oxygen (DO) was determined by Winkler's titrimetric method, and free Carbon dioxide (CO_2) was estimated by standard titrimetric method using phenolphthalein as an indicator etc. These parameters were estimated on the sampling sites whereas rest of water quality parameters such as turbidity, total alkalinity, total hardness and chloride were tested in the laboratory according to a standard method **(**APHA, AWWA and WPCF, 2005) and nitrate, phosphate and silicate were estimated with the help of UV-VIS Spectrophotometer (Varian). The Statistical Package for the Social Sciences (SPSS, v-16) software was used for the analysis of multi correlation and statistical description.

Fig. 2. Sampling station of Nanak Sagar Reservoir

Table 1. Sampling Station in different zone of reservoir

Zonation	Sampling Station No.
Riverine	3, 4,5,6,7,8,9
Transitional	2,10,11,13,17,18
Lacustrine	1,12,14,15,16,19,20

RESULT AND DISCUSSION

Among various hydrological parameters, Temperature (^{0}C), Transparency (cm), Conductivity **(**µs cm^{-1}), TDS (mg l^{-1}), Turbidity (NTU), pH, DO (mg l^{-1}), free CO_2 (mg l^{-1}), Total Alkalinity (mg l^{-1}), Total Hardness (mg l^{-1}), Nitrate (mg l^{-1}), Phosphate (mg l^{-1}), Silicate (mg l^{-1}) and Chloride (mg l^{-1}) considerably varied seasonally and temporally (Table 2). An annual average of hydrological parameters from selected stations of Nanak Sagar reservoir is showed in Table 3.

Temperature: The optimum temperature of water for survival and growth of fishes is between 26 to 32^0 C (Nelly *et al.,* 2014). Maximum water temperature was 29^{0}C in Riverine zone in monsoon season could be due to high suspended particle found in this zone having property in water column absorb and scatter sunlight and hence determine the extinction of solar radiation and minimum was found (16.9^{0}C) in riverine zone at post monsoon could be due to water come from high altitude region. The recorded annual temperature was 24.8±0.36 ^{0}C. Verma (2013) have reported the average temperature of Tarai reservoirs always remains above 20^{o}C.

Transparency: The annual transparency range estimated was from 134.6 to 144.9 cm; low value in the riverine zone (49.2 cm) during monsoon season, it may be due to high load

Table 2. Hydrological parameter of different seasons and zones of Nanak Sagar reservoir

Parameters	Monsoon			Post-Monsoon			Pre-Monsoon			Annual		
	Riverine	Transitional	Lacustrine	Riverine	Transitional	Lacustrine	Riverine	Transitional	Lacustrine	Riverine	Transitional	Lacustrine
Temperature (^{0}C)	29.0	28.7	28.5	16.9	17.0	17.0	26.1	27.6	28.1	24.0	24.4	24.5
Transparency (cm)	49.2	56.5	65.7	230.5	231.1	232.7	125.3	114.0	109.2	135.0	133.9	135.9
Conductivity (µs cm^{-1})	192	193	193	210	209	205	269	277	281	176	177	175
TDS (mg l^{-1})	136	134	130	65.1	63.7	60.5	90.0	91.7	92.5	96.9	96.3	94.2
Turbidity (NTU)	48.1	47.2	45.9	8.0	7.4	6.8	10.3	10.6	10.1	22.2	21.74	21.0
pH	7.42	7.24	7.15	8.3	8.0	7.9	8.2	8.2	8.0	7.97	7.8	7.70
DO (mg l^{-1})	8.1	8.0	7.8	10.9	10.8	10.6	6.7	6.3	5.9	8.59	8.4	8.13
CO2 (mg l^{-1})	4.1	4.1	4.2	1.9	2.1	2.2	0.2	0.4	0.6	2.08	2.2	2.30
T. Alkalinity (mg l^{-1})	91	94	96	122	120	117	126	126	123	113	113	112
T. Hardness (mg l^{-1})	81	80	78	93	93	91	107.5	110.4	110.9	93.7	94.3	93.5
Nitrate (mg l^{-1})	0.70	0.67	0.64	0.13	0.13	0.11	0.18	0.22	0.21	0.33	0.34	0.32
Phosphate (mg l^{-1})	0.21	0.21	0.19	0.06	0.05	0.04	0.14	0.15	0.14	0.14	0.13	0.13
Silicate (mg l^{-1})	4.2	4.3	4.4	1.7	1.9	2.0	3.4	3.8	3.9	3.1	3.3	3.4
Chloride (mg l^{-1})	20.0	19.0	18.1	9.1	8.3	8.2	13.0	12.9	12.9	14.0	13.4	13.1

of suspended solid and agriculture runoff. The high value of 232.7 cm was found during post monsoon may be due to the settlement of suspended solid in this zone as compared to riverine zone so resulted in high transparency.

Conductivity: The annual variation in electrical conductance range was 220 to 229 µs cm^{-1} with an annual average of 175.94 µs cm^{-1}. It was low in riverine zone (192 µs cm^{-1}) in monsoon season may be because of dilution of water therefore resulted in decrease electrical conductance and high in lacustrine zone (281 µs cm^{-1}) in pre-monsoon season may be due to the high temperature of water with high water evaporation rate (Hayashi, 2004). Olsen (1950) classified water bodies having conductivity values greater than 500.00 µS/cm as eutrophic. According to this criterion Nanak Sagar reservoir water falls under the category of mesotrophic.

TDS: The maximum TDS recorded was 136 mg l^{-1} in the riverine zone during monsoon season, it may be because of high load of suspended solid from catchment area and minimum in lecustrine zone (60.5 mg l^{-1}) during post monsoon might be due to the settlement of dissolved solid in deep and stagnant water. The annual average of TDS was 94.4±1.5 mgl^{-1}.

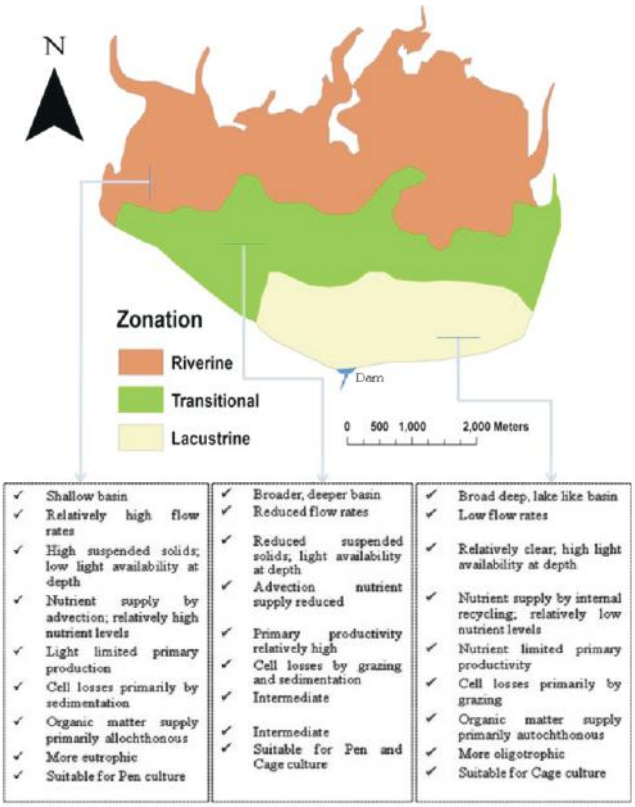

Fig. 3. Horizontal zonation of water quality conditions in Nanak Sagar reservoir (Modified from Thornton *et al*., 1996)

Table 3. Annual average of hydrological parameters on different station of Nanak Sagar reservoir

Station No.	Lat (N)	Long (E)	Temperature (^{0}C)	Transparency (cm)	Conductivity (µs cm^{-1})	TDS (mg l^{-1})	Turbidity (NTU)	pH	DO (mg l^{-1})	CO2 (mg l^{-1})	T. Alkalinity (mg l^{-1})	T. Hardness (mg l^{-1})	Nitrate (mg l^{-1})	Phosphate (mg l^{-1})	Silicate (mg l^{-1})	Chloride (mg l^{-1})
1	28.94419	79.86312	25.3	137.2	224	94	20.77	7.7	8.1	2.3	112	93	0.34	0.13	3.5	13.0
2	28.95096	79.86305	25.2	135.5	227	95	20.89	7.8	8.2	2.3	113	95	0.33	0.13	3.4	13.1
3	28.95854	79.86266	24.4	143.6	220	91	20.62	7.7	8.7	2.1	113	92	0.32	0.13	3.2	12.4
4	28.96471	79.85551	24.3	143.5	222	93	22.23	8.1	8.7	2.0	115	93	0.33	0.13	3.1	14.4
5	28.95842	79.84850	24.7	136.9	224	96	22.59	8.0	8.5	2.1	114	95	0.33	0.14	3.1	14.3
6	28.95754	79.84020	24.7	137.8	225	97	22.60	7.9	8.5	2.2	114	95	0.33	0.14	3.1	14.4
7	28.95775	79.83342	24.8	137.3	225	97	22.64	7.9	8.5	2.1	112	95	0.34	0.14	3.1	14.3
8	28.96011	79.82478	24.3	143.5	223	95	22.36	8.0	8.7	2.0	114	93	0.35	0.13	3.1	14.2
9	28.96273	79.81397	24.3	143.8	223	95	22.05	8.1	8.7	2.1	115	93	0.35	0.14	3.1	14.2
10	28.95168	79.81994	24.5	144.9	223	93	21.90	7.9	8.7	2.1	113	93	0.33	0.13	3.2	13.6
11	28.95093	79.82796	24.8	137.8	225	95	21.96	7.8	8.4	2.2	115	94	0.36	0.13	3.2	13.0
12	28.94448	79.83357	24.8	136.5	224	94	20.99	7.7	8.4	2.2	111	94	0.35	0.13	3.3	12.7
13	28.95131	79.83996	25.1	134.7	228	95	21.11	7.7	8.3	2.2	112	94	0.32	0.13	3.4	13.2
14	28.93941	79.84163	25.3	135.1	228	93	20.96	7.7	8.1	2.3	110	92	0.30	0.12	3.4	13.2
15	28.94001	79.84901	25.2	136.3	229	94	20.96	7.7	8.0	2.3	112	92	0.31	0.12	3.4	13.1
16	28.94678	79.84801	25.3	134.6	228	93	21.18	7.7	8.0	2.3	113	95	0.30	0.13	3.5	13.2
17	28.95247	79.84887	25.1	134.8	228	95	22.27	7.8	8.3	2.2	112	96	0.33	0.14	3.4	13.7
18	28.95226	79.85565	25.0	134.9	228	96	22.31	7.8	8.3	2.2	113	95	0.34	0.14	3.4	13.7
19	28.94603	79.85541	25.2	135.5	229	93	20.99	7.7	8.1	2.3	110	94	0.33	0.12	3.5	13.1
20	28.94062	79.85639	25.2	136.4	229	94	20.82	7.7	8.1	2.3	113	94	0.32	0.12	3.5	13.1

Table 4. Descriptive Statistics of annual average of hydrological parameter (modified from Garg *et al*., 2009)

Parameters	Water quality Range					Trophic Status	References
	N	Minimum	Maximum	Mean	Std. Deviation		
Temperature	20	23.60	24.80	24.3000	0.36850	Meso-thermal	Lee *et al.* (1981)
Transparency	20	128.40	141.10	1.3497E2	3.99396	Eutrophic	Lee *et al*. (1981)
Conductivity	20	173.00	179.00	1.7585E2	1.38697	Mesotrophic	Olsen (1950)
TDS	20	92.00	99.00	95.8000	1.85245		
Turbidity	20	20.60	22.60	21.6200	0.72881		
pH	20	7.70	8.10	7.8200	0.13992	Alkaliphilous	Venkateswarlu (1983)
DO	20	8.00	8.70	8.3650	0.25189		
CO2	20	2.00	2.30	2.1900	0.10208	Soft	Reid and Wood (1976)
Alkalinity	20	110.00	115.00	1.1280E2	1.47256	Productive with rich nutrient	Spence (1964)
Hardness	20	92.00	96.00	93.8500	1.18210	Moderately hard	Sawyer (1960)
Nitrate	20	0.30	0.36	0.3305	0.01605	Meso-eutropic	Vollenweider (1968)
Phosphate	20	0.12	0.14	0.1310	0.00718	Meso-eutropic	Jones and Lee, (1982)
Silicate	20	3.10	3.50	3.2950	0.16051		
Chloride	20	12.40	14.40	13.4950	0.61685	No pollution	Unni (1983)
Valid N (listwise)	20						

Turbidity: Clay, silt organic matter, plankton and other microscopic organisms cause turbidity in natural water **(**Kishor *et al.,* 2005). The annual variation in turbidity ranged from 20.62 to 22.64 NTU with an average of 21.61 NTU. It was maximum in riverine zone (48.1NTU) during monsoon may be due to high runoff from catchment area foremost dissolved in riverine zone than other zone and minimum value was 6.8 NTU in lacustrine zone during post monsoon might be due to low load with early settlements of silt and clay particle, so resulting low turbidity in this zone. Vass and Sugunan (2008) reported high turbidity of Indian reservoirs mainly in the riverine zone during the rainy season.

pH : The pH fluctuated from 7.68 to 8.83 with an average of 7.83. The minimum pH observed was 7.15 in the lacustrine zone during monsoon season; it may be due to gradual dilution of alkaline soil towards the lacustrine zone, while 8.30 pH in the riverine zone during post-monsoon and pre-monsoon may be due to dissolution of atmospheric CO_2. The majority of the Indian reservoirs have moderately alkaline pH (Vass and Sugunan, 2008).

Dissolved oxygen (DO): In the present study, maximum concentration (10.9 mg l^{-1}) was recorded in the riverine zone during post monsoon may be due to high aquatic vegetation, algal growth and moderate temperature. In pre-monsoon minimum DO concentration was found (5.9 mg l^{-1}) in the lacustrine zone may be because of increasing water temperature **(**Naz and Turkmen, 2005) and also clinograde condition (Vass and Sugunan, 2008, Surve, *et al*., 2005). The annual average DO was 8.36 mg l^{-1}.

CO_2 : The free CO_2 ranged from 1.98 to 2.34 mg/l with an annual average of 2.19 mg/l. It was absent or very low (0.2 mg/l) in the riverine zone during pre-monsoon may be due to high utilization by aquatic weed and algae during photosynthesis. High concentration of CO_2 i.e., 4.2 mg/l was recorded in the lacustrine zone during monsoon, it may be due to respiration of organism and absence of photosynthetic activity down to cloudy weather **(**Naz and Turkmen, 2005; Krishnankutty and Chandrasekaran, 2007).

Total alkalinity: The total alkalinity ranged from 64.25 to 146.25 mg l^{-1}, which makes the reservoir as nutrient rich and highly productive water body**.** In the present study, the alkalinity level reduced in the riverine zone (97 mg/l) during monsoon season, it might because of quick dilution of alkaline soil **(**Vass and Sugunan, 2008)**.** Rise in the level of total alkalinity during pre-monsoon in transitional zone (126 mg/l) may be due to a shallow area and increased the rate of organic decomposition and evaporation of water. The annual average of Total alkalinity was 112.78 ppm. Alkalinity also depends on upon nature of bottom deposits (Patil *et al*., 2015).

Total hardness: The hardness was maximum in the lacustrine zone (110.9 mg l^{-1}) during pre-monsoon; it might be due to increased concentration of salt by down the water level to excessive evaporation of water. Minimum value was recorded in the lacustrine zone (78 mg l^{-1}) during monsoon season; it may be due to slow dilution of water through runoff. Nanak Sagar reservoir falls in the category of the moderately hard water body with hardness ranging from 92.36 to 95.80 mg l^{-1}, with an annual average 93.80 mg l^{-1}.

Nitrate: The annual nitrate value ranged from 0.30 mg l^{-1} to

Table 5. Correlation matrix of hydrological parameters for Nanak Sagar reservoir

		Temperature	Transparency	Conductivity	TDS	Turbidity	pH	DO	CO2	Alkalinity	Hardness	Nitrate	Phosphate	Silicate	Chloride
Temperature	Pearson Correlation	1													
	Sig. (2-tailed)														
Transparency	Pearson Correlation	-.543*	1												
	Sig. (2-tailed)	.013													
Conductivity	Pearson Correlation	.062	-.106	1											
	Sig. (2-tailed)	.796	.656												
TDS	Pearson Correlation	.031	-.787**	.377	1										
	Sig. (2-tailed)	.897	.000	.101											
Turbidity	Pearson Correlation	-.302	-.405	.404	.767**	1									
	Sig. (2-tailed)	.196	.076	.077	.000										
pH	Pearson Correlation	-.623**	.032	.396	.483*	.775**	1								
	Sig. (2-tailed)	.003	.893	.084	.031	.000									
DO	Pearson Correlation	-.868**	.175	.150	.379	.563**	.753**	1							
	Sig. (2-tailed)	.000	.461	.528	.099	.010	.000								
CO2	Pearson Correlation	.811**	-.074	-.123	-.429	-.641**	-.796**	-.935**	1						
	Sig. (2-tailed)	.000	.755	.606	.059	.002	.000	.000							
Alkalinity	Pearson Correlation	-.485*	.036	.371	.448*	.534*	.710**	.590**	-.574**	1					
	Sig. (2-tailed)	.030	.881	.107	.048	.015	.000	.006	.008						
Hardness	Pearson Correlation	.532*	-.771**	.435	.707**	.431	.051	-.142	.118	.073	1				
	Sig. (2-tailed)	.016	.000	.055	.000	.058	.831	.550	.621	.761					
Nitrate	Pearson Correlation	-.303	-.051	.358	.446*	.449*	.441	.512*	-.446*	.405	.171	1			
	Sig. (2-tailed)	.195	.832	.121	.049	.047	.052	.021	.048	.076	.472				
Phosphate	Pearson Correlation	-.199	-.463*	.491*	.807**	.750**	.555*	.515*	-.488*	.468*	.577**	.452*	1		
	Sig. (2-tailed)	.401	.040	.028	.000	.000	.011	.020	.029	.038	.008	.045			
Silicate	Pearson Correlation	.792**	-.052	-.264	-.481*	-.705**	-.816**	-.890**	.864**	-.628**	.079	-.469*	-.543*	1	
	Sig. (2-tailed)	.000	.828	.261	.032	.001	.000	.000	.000	.003	.740	.037	.013		
Chloride	Pearson Correlation	-.588**	-.170	.277	.600**	.744**	.825**	.809**	-.867**	.588**	.047	.488*	.569**	-.764**	1
	Sig. (2-tailed)	.006	.472	.237	.005	.000	.000	.000	.000	.006	.843	.029	.009	.000	

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).
a= Listwise N=20

0.36 mg l^{-1} with an average of 0.33 mg/l. It was maximum in the riverine zone (0.70 mg l^{-1}) during monsoon season, primarily it could be due to agricultural runoff as well as fast mixing in this zone, which is also a rich source of nitrogen applied as fertilizer. The minimum value of nitrate was observed in the lacustrine zone (0.11 mg l^{-1}) during post monsoon, it may because of high utilization by algal groups and a low source of formation. It may also be the beginning of stratification cycle, the phytoplankton community was mainly using nitrate as nitrogen source (Francisco *et al.,* 2001).

Phosphate: The maximum value was estimated in the riverine zone (0.21 mg l^{-1}) during monsoon, it may be due to first as well as fast assorted agricultural runoff in this zone and minimum in the lacustrine zone (0.04 mg l^{-1}) during post monsoon may be due to high utilization by phytoplankton community and low silted water. The annual range of phosphate was 0.12 to 0.14 mg l^{-1} with an average 0.13 mg l^{-1}.

Silicate: The least silicate content was observed in the riverine zone (1.7 mg l^{-1}) during post monsoon and highest 4.4 mg l^{-1} in the lacustrine zone during monsoon season with an annual average of 3.28 mg l^{-1}. Tzong Wu and Chou (2003) indicated that enrichment with silicate gave rise to a greater enhancement in phytoplankton biomass, mainly of diatoms, than did enrichment with nitrogen or phosphorus.

Chloride : The value of chloride concentration in the present reservoir was highest in the riverine zone (16.4 mg l^{-1}) during the pre-monsoon season may be due to decreasing in water level and decompose a large amount of organic matter **(**Patil *et al.,* 2013). Lowest concentration 7.8 mg l^{-1} in the lacustrine zone during monsoon season might be because of slow mixing of domestic sewage or agricultural runoff in this zone. The annual average was 11.46±0.62 mg l^{-1}. The desirable limit of chloride concentration in drinking water is 250 mg/l. As per these criteria the chloride values of this reservoir lies in the acceptable limit as well as suitable for culture based capture fisheries by Sharma *et al.*, 2012.

Trophic status: Trophic status of the Nanak Sagar reservoir is under the category of Mesotrophics on the basis of different indices given by some investigators (Table 3).

Correlation analysis : In present study, the results showed that water temperature was positively correlated with CO_2 (R^2= 0.81, p<0.01), T. Hardness (R^2= 0.53, p<0.05) and Silicate (R^2= 0.79, p<0.01) and had significantly negative correlation with transparency, pH, DO (R^2=-0.86, p<0.01), alkalinity, nitrate, phosphate, chloride and vice-versa (Table 5). Transparency significantly positive correlate with pH, DO and alkalinity whereas significantly negative with TDS (R^2=-0.78, p<0.01), turbidity, hardness (R^2=-0.77, p<0.01), phosphate and chloride. The electric conductivity positively correlated with all other parameters except for CO_2 and silicate. TDS positively correlated with turbidity (R^2= 0.76, p<0.01), pH, alkalinity, hardness (R^2= 0.70, p<0.01), phosphate (R^2= 0.80, p<0.01) and chloride (R^2= 0.60, p<0.01) while had significantly negative correlation with CO_2 and silicate and vice-versa.

Turbidity correlated positively with pH (R^2= 0.77, p<0.01), DO (R^2= 0.56, p<0.01), T. alkalinity (R^2= 0.53, p<0.01), Total Hardness, phosphate (R^2= 0.75, p<0.01) and chloride (R^2= 0.74, p<0.01). It had negative correlation with CO_2 (R^2= -0.64, p<0.01) and silicate (R^2= -0.70, p<0.01). pH was positively correlated with DO (R^2= 0.75, p<0.01), alkalinity, phosphate and chloride (R^2= 0.82, p<0.01), while negatively correlated with CO_2 (R^2= -0.79, p<0.01) and silicate (R^2= -0.81, p<0.01). DO was positively correlated with alkalinity (R^2= 0.59, p<0.01), nitrate, phosphate and chloride (R^2= 0.80, p<0.01) and had significantly negative correlation with CO_2 (R^2= -0.93, p<0.01) and silicate (R^2= -0.89, p<0.01) vice-versa. CO_2 was positively correlated with silicate (R^2= 0.86, p<0.01) while negatively correlated with alkalinity, nitrate, phosphate and chloride (R^2= -0.86, p<0.01). T. alkalinity was positively correlated with T. Hardness (R^2= 0.73, p<0.01), nitrate, phosphate and chloride (R^2= 0.58 p<0.01). It was negatively correlated with silicate (R^2= -0.62, p<0.01). T. Hardness correlated positively with phosphate (R^2= 0.57, p<0.01) and while negatively correlated with transparency. Nitrate was positively correlated with phosphate (R^2= 0.45, p<0.05) and chloride, while negatively correlated with silicate (R^2= -0.46, p<0.05). Phosphate was positively correlated with chloride, while negatively correlated with silicate (R^2= -0.54, p<0.05). Silicate correlated negatively with chloride (R^2=-76, p<0.01).

CONCLUSION

The study suggests the good status of water quality. The water of this reservoir is found to be suitable for culture based capture fisheries. Cultural practices like pen and cage culture can be carried in late monsoon (mid week of September) to the early pre-monsoon (mid week of April) season in the riverine and lacustrine zone.

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Parashi (*Cleistanthus collinus* Roxb.)-A Multipurpose Plant of Ethno-botanical Importance in South West Bengal of India

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***Abstract*:** Primary data regarding ethno-botanical importance of Parashi (*Cleistanthus collinus*) were collected from the tribal (mainly Santhal and Lodha) villages of the Jhargram Division, Paschim Medinipur District and recorded. Every part of the parashi plant has its importance for the human and animals. The species finds a great scope to establish as a multipurpose tree in agroforestry system. The traditional knowledge and confirmation of the active ingredient established its importance as an insect repellant in the paddy fields, especially to control rice case worm (*Nymphula depunctalis*).

***Key Words*:** Parashi, *Cleistanthus collinus*, Ethno-botanical importance, Insect repellant, Transect walk, Stratified random sampling

Parashi (*Cleistanthus collinus*), a small glabrous multipurpose tree is an extremely toxic plant for human beings due to the presence of three toxic organic active ingredients viz. Diphyllin, Cleistanthin-A and Cleistanthin-B (Anuragh 2012). Water decoction of the leaves is used for suicidal purpose in southern parts of India. But for the local tribal people of the Paschim Medinipur district, parashi is very useful for them for its toxic properties. Mainly the farmers are utilizing this plant for toxic property as a natural insecticide in paddy crop. But review of the literature revealed that the plant is in data deficient category as per the IUCN Red List of Threatened Species ™ (Citation: World Conservation Monitoring Centre, 1998). There is uncertainty about the endemic status of the species. Documentation about conservation importance and utilities of the plant is very rare. So the present study was carried out (1) to assess the population dynamics in the wild and to generate data regarding multipurpose ethno-botanical importance and utilities of the plant, (2) to establish its importance as natural insecticide to reduce chemical load in the environment and (3) to explore the potentiality as an agroforestry species after artificial regeneration to avoid the collection from the wild.

MATERIAL AND METHODS

The species availability study in the wild is conducted in the Sal coppice (*Shorea robusta*) dominated forest areas of Knakrajhore beat, Bhulaveda Range of West Bengal and Jharkhand border in-between 22º 42´ 42.9´´ to 22º 39´ 28.6´´ N latitude and 086º 33´ 46.1´´ to 086º 38´ 25.4´´E longitude. Altitudinal range of the area was 187–328m amsl. The primary data regarding ethno-botanical importance were collected from the forest fringe tribal (santhal and lodha) villages of the Belpahari and Bhulaveda Ranges of the Jhargram Division, West Bengal (Fig. 1). The forest is mainly Sal coppice forests which varied from Northern Tropical Dry Deciduous Forests to Dry Peninsular Sal forests (As per Champion and Seth's revised classification). The soil of the study area is characterized by rocky new and older alluvium intercalated with sandy and clayey layers along with coarse angular pebbles, lateritic capping and lateritic gravels (Working Plan Officer and Divisional Forest Officer, 2014). From the Mineralogical point of view, the soils have oxides of iron deposited around quartz (Working Plan Officer and Divisional Forest Officer, 2014). The N_2, P_2O_5 and K_2O content varies from 0.5-0.75%. The organic matter content is also low and the soil is slightly acidic having $_pH$ of 5.5 to 6.5 (Working Plan Officer and Divisional Forest Officer, 2014) .

Vegetation sampling: To know the availability of the plant in the forest, sampling was carried out by belt transects method in the month of November, 2015. Map reading of the study area was done before drawing the transect. Our total transact length was 10.05 Km and this line was divided into thirty one 300 m segments with a 25 m gap in between them to ensure sample independence. Area of the each belt was 300 x 10 m^2= 3000 m^2. As the working area topography was undulated, GPS and eye estimation method was used for length measurement. Coordinates were marked using GPS (GARMIN etrex 30) at every 325 m interval; on the mid line of the belt transact. The coordinates then imposed in the Google map and prepared GPS map of the study area. To correct the error of undulation at the time of vegetation analysis, we have chosen 3 strata of elevation for stratified random sampling viz. 187 m (low level strata), 219 m (mid level strata) and 328 m (high level strata) (Tables 1). Collected samples were preserved as herbarium.

Ethno-botanical study: Field survey were conducted in Bhulaveda Range, Jhargram Division in the month of April, 2015 to May,2015 and September, 2015 to mid November, 2015 and interviewed the people of all strata in the tribal villages by followed stratified random sampling method. Stratification done among the groups of local healers, village old man, tribal and non tribal farmers, livestock farmers, women and new age farmers (Table 3). For stratified random sampling method, transects were laid in three strata of elevation to know the Parashi (*Cleistanthus collinus)* plant population in the forest of Kankrajhor beat, Bhulaveda Range of Jhargram Division, Paschim Medinipur district. Transects were named with first two letters of the respective mouzas of the forest areas (Am- Amjharna/24 and Amlasole/25, Ka-Kankrajhor, Ma-Makarbhula and Kadamdiha).

RESULTS AND DISCUSSION

Transect wise results and analyses of the plant population are presented in Table 2.

Transect Am: Total eleven transects were laid in the Amjharna/24 and Amlasole/25 forest areas. Total parashi plant recorded in these transects were 413, with the highest number of individuals (66) and density (0.022) found in Am-3 transect. Lowest number (15) of parashi plants were identified in the transact Am-8, having lowest density (0.005). Otherwise they were uniformly distributed to some extent. The plant density ranged from 0.005 to 0.022, with a mean density of 0.013, highest among the three sampling elevation of the transects. The mean density of the plants in this transect is the addition of the other two (0.013= 0.008 + 0.005) i.e. Transect Ka and Ma..

Transect Ka: Total nine transects were laid in the Kankrajhor-27 forest areas. Total parashi plant recorded in these transects were 122, with the highest number of individuals (23) and highest density (0.008) found in Ka-6 transect. Lowest number (2) of parashi plants were identified in the transect Ka-5, having lowest density (0.001). The plant density range in this transect is 0.001 to 0.008, with the mean density of (0.005), lowest than the other two class of transect.

Transect Ma: Total eleven transects were laid in the Makarbhula-49 and Kadamdiha-50 forest areas. Total parashi plant recorded in these transects were 254, with the highest number of individuals (48) and highest density (0.016) found in Ma-5 transect. Lowest number (3) of parashi plants were found in the transect Ma-7, having lowest density (0.001) also. The plant density ranged in this transect was 0.001 to 0.016, with the mean density of (0.008), lower than the transect Am, but higher than the transect Ka.

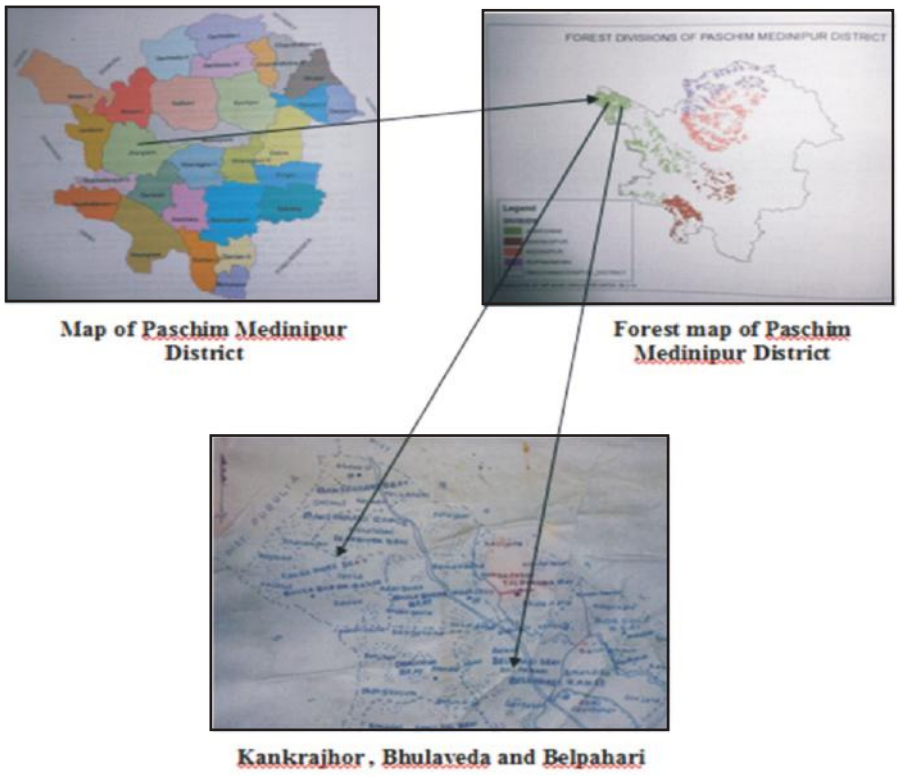

Fig. 1. Map of the study area
(Map Source: 3rd Working Plan, Paschim Medinipur District)

Table 1. Strata wise GPS data of the study area

Date	Survey Type	Elevation	Altitude Type	Place	GPS Location	
					Starting	End
05/11/2015	Transect	328 m	Highest	Amjharna and Amlasole Mouza of Kankrajhor Beat	N22º42´42.9´´ E 086º33´46.1´´	N22º41´57.9´´ E 086º34´59.9´´
06/11/2015	Transect	187 m	Lowest	Kankrajhor Mouza of Kankrajhore Beat	N22º41´47.1´´ E 086º35´06.8´´	N22º40´54.8´´ E 086º36´50.4´´
07/11/2015	Transect	219 m	Medium	Makarbhula and Kadamdiha Mouza of Kankrajhor Beat	N22º40´54.0´´ E 086º37´09.2´´	N22º39´28.6´´ E 086º38´25.4´´

All together including 3 stages viz. herb, shrub and trees there were 789 individuals (Parashi plant), counted in 31 transects. The results of the study could not be compared because no such study has been performed earlier. From the transect analysis, it has been found that, the highest mean density (0.013), highest number of individuals (413) and wide range of plant density (0.005-0.022) are found in the transect Am **(**Amjharna/24 and Amlasole/25), which is situated in the highest altitude (328 m), among the 3 strata. In the mid altitude (219 m) of transect Ma, the number of individuals (254), density range (0.001–0.016) and mean density (0.008), all are medium. The total number of individuals (122), density range (0.001 to 0.008) and mean density (0.005), all are lowest in the lowest altitude (187 m) among the three strata of our study. The reason behind this is that at the highest altitude, biotic interference is less, most of the collection of the leaves by the farmers (for natural insecticide in the paddy field and as fodder for goats) is done from the lowest altitude. *Eupatorium odoratum* has extensively encroached the lowest to medium altitude of the study area. Clearing of forest land of lowest altitude by the forest fringe villagers for the plantation of Mango (*Mangifera indica*) and Jamun (*Syzygium cumini*) was found common, also the encroachment of forest land for paddy and pulse farming was common. Grazing by the goats (*Capra aegagrus hircus*) mainly in the lowest and then in the medium altitude is another reason for higher interference. Analysis of Google map imagery after imposing the GPS reading and transect tract, also supported the fact that vegetation density is medium in the medium altitude and lowest in the lowest altitude of our study area. Google map imagery also supported the encroachment in lowest altitude for crop cultivation. These findings support and certify the availability of Parashi (*Cleistanthus collinus)* plant in particular and vegetation density as a whole in the forest areas of Kankrajhor Beat, Bhulaveda Range of Jhargram Division.

Parashi plant as insecticide : Being a rain-fed area kharif paddy cultivate here in this region of Paschim Medinipur District and the tribal farmers harvest the leaves of the Parashi (*Cleistanthus collinus)* plants from the forest in between July – October (Kharif season) for application in the field to control rice insect pests. For fodder, fuel wood and other purpose the leaves are harvesting throughout the year. Local people mainly utilize the plant leaves, when there is attack from the rice case worm (*Nymphula depunctalis*). As soon as the farmers find the symptoms of leaf rolling in the field, they apply the parashi leaves, which acts as a repellant. After harvesting, the leaves are broadcasted as such in the standing paddy water. The rotting of leaves started 5-7 days after application, then the standing water changes into black colour and hence become effective as an insecticide. The black aqueous degradation extract of the plant leaves is responsible for the insecticidal property. The toxic principles in the leaf are arylnapthalene lignan lactones – Diphyllin and its glycoside derivatives Cleistanthin A and B (Anuragh, 2012). But these toxic principles, arylnapthalene lignans, are detected in acetone extracts but, are not seen or are present in minimal amounts in aqueous extracts (Parasuraman *et al*., 2009). On spectroscopic analysis of aqueous extracts of fresh *C. collinus* leaves, the major phyto-constituents detected are 3-O-methyl-d-glucose, benzenetriol (pyrogallic acid), 1,6- anhydro-â-D-glucopyranose (levoglucosan), heptacosane, 2-hydroxy-7-methoxy-4,5-diphenyl-5 hindeno [1.2-d] pyrimidine and eicosane (Parasuraman *et al*., 2009) . Parashi is not only found effective against rice case worm, but other paddy pests are also controlled by its application. Bharti *et al.* (2011) also found same type of results.

Establishing the plant leaves as a fodder source: As per the ethno-botanic study local tribal (santhal, lodha) and non tribal villagers are using this species as goat fodder from time immemorial (Table 3). Not only stall feeding, the goats are also browsing the parashi leaves from the forest at initial stage of growth. But still now toxicity has been reported, but goats avoided the fruits of the plant. Though trial on rats, cats, mice and monkeys recorded that Cleistanthin A and B act as anti-neoplastic agent, which affect at the cellular level (Bharti

et al., 2011), but no toxicity has been reported in case of goat. Fodder from the Parashi (*Cleistanthus collinus*) is not fed to the cows, as well as not fed by the cows also. So, there may be some detoxification enzymes in goat's digestive track, which detoxify the effect of Diphyllin, Cleistanthin A and B. Further study is required in this regard.

Table 2. Transact wise plant population analysis

Date	Elevation	Sampling	Transect	Number of plants	Density = Number	Mean
05/11/ 2015	328 m	Amjharna-24 and Amlasole-25 Mouza	Am-1	39	0.013	0.013
			Am-2	45	0.015	
			Am-3	66	0.022	
			Am-4	37	0.013	
			Am-5	34	0.012	
			Am-6	35	0.012	
			Am-7	24	0.008	
			Am-8	15	0.005	
			Am-9	34	0.012	
			Am-10	39	0.013	
			Am-11	45	0.015	
Total				413	0.14	
06/11/2015	187 m	Kankrajhor-27 Mouza	Ka-1	15	0.005	0.005
			Ka-2	12	0.004	
			Ka-3	7	0.003	
			Ka-4	19	0.006	
			Ka-5	2	0.001	
			Ka-6	23	0.008	
			Ka-7	9	0.003	
			Ka-8	13	0.004	
			Ka-9	22	0.007	
Total				122	0.041	
07/11/2015	219 m	Makarbhula-49 and Kadamdiha-50 Mouza	Ma-1	28	0.009	
			Ma-2	19	0.006	0.008
			Ma-3	25	0.008	
			Ma-4	7	0.003	
			Ma-5	48	0.016	
			Ma-6	24	0.008	
			Ma-7	3	0.001	
			Ma-8	27	0.009	
			Ma-9	44	0.015	
			Ma-10	13	0.004	
			Ma-11	16	0.005	
Total				254	0.084	

Table 3. Ethnobotanic knowledge recorded by interview method

Sample strata	Ethno botanical knowledge	
	Plant parts	Use
Tribal (Santhal, lodha) and non tribal farmers	Leaves	Natural insecticide in the paddy field, fodder
Livestock farmers	Leaves	Fodder for goats
Local healers	Fruits	Suicidal purpose
	Twig and stem	As a tooth brush
Village old man	Twig and stem	As a tooth brush
	Leaves	Insect repellant
Women	Dried stems	Fuel wood
	Dried stem with dried leaves	Roof material, fencing material
	Leaves	Fodder for goats
New age farmers	Leaves	Natural insecticide in the paddy field, fodder

Fig. 2. Parashi plants

Fresh plant leaves are not toxic to the human beings, animals and insects. Only degradation extract is effective as an insecticide and time is needed to spread and mix active ingredient in plant's cell sap to get insecticidal activity. So it is clear that concentration of active ingredient is determining criteria here. It seems that here in the field condition the heat from the sunlight and heat produced from the degradation system itself converting the aqueous extract to concentrated decoction stage to become aqueous leaf extract affective as an insecticide. Fresh leaf juice (50%) and alcoholic extract (50%) is moderately effective to prevent insect pest on rice with some extent to adverse effect (Bharti *et al*., 2011).

Besides the above utility, plants are also used for fencing in the farm land and home land, for thatching the roof of the tribal villages, which shows its great potential as a MPT (Multi Purpose Tree) in agroforestry system of this red and lateritic zone. Parashi' is such a multipurpose tree that all parts of the plant (leaves, twigs, stems) are useful in day to day lives of the human beings, except fruits.

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Carbon Mitigation Potential of Biomass and Soil under Different Density of *Eucalyptus camaldulensis* in Arid Region of India

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***Abstract*:** This paper investigates the potential of additional carbon sequestration by silvicultural management practices, as a part of climate change mitigation strategies. Plantation of forests using fast growing species has been adopted as an option for sustainable supply of tree products and also for reducing the pressure on natural forest in many countries. Thus development and implementation of adaptation strategies is necessary to assess the likely impacts of projected climate change on existing forests and afforested areas to enhance the resilience of forests to climate change. The research results revealed that the total carbon stock both in biomass and soil organic carbon increased with increase in planting density and clearly showed that the number of trees per hectare plays an important role in total carbon production by contributing to the increasein the removal and storage of carbon from the atmosphere directly. Hence, it can be concluded that the tree density and carbon stock are linearly correlated to each other. Research findings of this study will help in achieving the set of seven criteria established by Rio conference in 1992 to meet the needs of society, and provision of legal, institutional and economic framework for forest conservation and sustainable management, and also will help in achieving the one of the best silviculture practices for sustainable management of forests.

***Key Words*:** Carbon stock,CO_2 Mitigation, Multipurpose species, Soil organic matter, Tree density

Forests and tree vegetation outside forests play an important role in climate change mitigation by absorbing atmospheric CO_2 and turning it into biomass. Terrestrially carbon plays an important role in global carbon cycle as CO_2 source and sink, and is stored above ground in biomass and underground in biomass and soil (Chauhan *et al.,* 2010.2012). It stores about 60 percent of above ground and 40 percent of below ground terrestrial organic carbon (IPCC, 2001), and vegetation biomass can reduce reliance on fossil fuels, to mitigate greenhouse gas (GHG) emissions (Losi *et al.*, 2003; Phat *et al*., 2004; Chotchutima *et al*., 2013).

The debate on the atmospheric build up of GHGs and their role in global warming by Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) in 1997, in Kyoto, Japan, concluded in insisting participating countries to reveal approaches for reducing GHG concentrations in the atmosphere. Reducing anthropogenic emissions of CO_2andenhancing carbon sinks in the biosphere through reforestation and afforestation could be an effective approach to accomplish carbon reduction targets. Government of India's target of bringing 33 percent of geographical area under forest cover can be achieved through afforestation and reforestation practices. The mitigation potential of afforestation policy in India for the forest sector was assessed (Chaturvedi *et al*., 2010), considering two scenarios which could mitigate5.2 $GtCO_2$and 3.96 $GtCO_2$under rapid afforestation and moderate afforestation rate scenario, respectively over the period of 2010–2030. The aggregate mitigation potential is estimated to be approximately 3.2 $GtCO_2$and 1.8 $GtCO_2$over the baseline in scenario-2020 and scenario-2030, respectively resulting that rapid afforestation under scenario 2020 will lead to an incremental of 1.4 $GtCO_2$ mitigation potential over scenario2030 (Kishwan*et al*., 2011).

India has a large afforestation programme of over 1.32 Mha per annum, and under 'Green India Mission' and 'Compensatory Afforestation Fund Management and Planning Authority' (CAMPA) more area is likely to be afforested (FSI, 1989-2009). Plantation of forests using fast growing species has been adopted as an option for sustainable supply of tree products and also for reducing the pressure on natural forest in many countries (Widyorini *et al*., 2009). Thus development and implementation of adaptation strategies is necessary to assess the likely impacts of projected climate change on existing forests and afforested areas to enhance the resilience of forests to climate change (Ravindranath *et al*., 2011).

The aim of the present study is to assess the potential of additional carbon sequestration by silvicultural management practices, as a part of climate change mitigation strategies. Therefore, it is necessary to understand the carbon storage and sequestration in tree

biomass and soil under different spacing regimes since, limited studies are available on CO_2 mitigation potential under different spacing regimes in arid region. These data can be used to assess the actual and potential role of tree density in capturing atmospheric CO_2.

MATERIAL AND METHODS

The present study was carried out in the spacing trial plot of *Eucalyptus camaldulensis*plantation, raised by Tamil Nadu Forest Plantation Corporation (TAFCORN) during the period 2006 to 2012, located at Arimalam Forest Range in Pudukottai district of Tamil Nadu representing 10.2572° N latitudes and 78.8861° E longitudes, lies at an elevation of 216 ft above mean sea level with average temperature ranging between 33.5°-42.2°C and 1043.31 mm annual rainfall (Fig. 1).

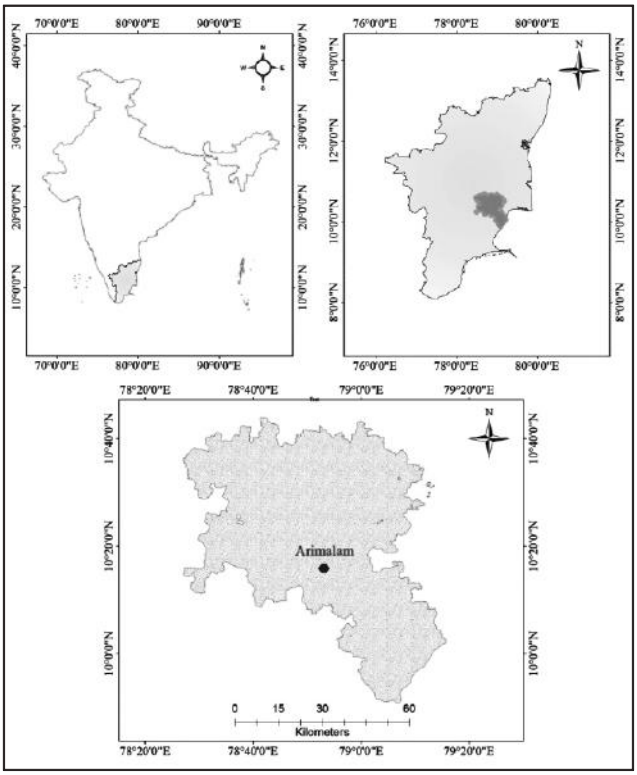

Fig.1. Location map of study area

Experimental design and treatments: The seedlings were planted in the field using a randomized block design with three blocks in 2006. Each block had seven experimental plots (seven different spacing). The total area of the each plot was 648 $m^2$and the spacing between seedlings was 3×3 m, 3×2 m, 3×1.8 m, 3×1.65 m, 3×1.5 m, 3×1.35 m and 3×1 m.

Biomass calculation for carbon stock: In November 2012, five trees were randomly selected from each plot with total of 105 samples (3 blocks × 7 plots × 5 trees) for carbon estimation excluding trees along borders to avoid the edge effect. Trees were felled and separated into foliage, branches and stem from different spacing of 6 year old plantation. The above ground utilizable biomass (total wood, stem wood and branches wood) was measured at rotation age. Using the ratio 0.27 of below ground biomass to above ground biomass in Indian context, total biomass was estimated in ton ha^{-1} (Kaul *et al*., 2009).

The soil samples from different spacing of 6 year old plantation in the identified area were collected from 0-30 cm depth at 0.5 m distance away from the tree base. Five sampling points were randomly selected from each plot with total of 105 samples (3 blocks × 7 plots × 5 trees) for soil organic carbon and bulk density excluding soil samples from borders to avoid the edge effect. Because the input of organic matter is largely from aboveground litter, forest soil organic matter tends to concentrate in the upper soil horizons, with roughly half of the soil organic carbon of the top 100 cm of mineral soil being held in the upper 30 cm layer. The carbon held in the upper profile is often the most chemically decomposable, and the most directly exposed to natural and anthropogenic disturbances (IPCC, 2003). Therefore, Soil samples were collected from the top 30 cm because it is the depth where most changes are expected to occur as a result of the microbial activities and root of plants. Plantation leaf litter of an area of 0.5 m **×** 0.5 m, at each sampling point was removed prior to sampling and a pit 30 cm wide, 30 cm deep and 30 cm in length was dug out.

All the collected soil samples were brought to the laboratory and processed as per standard procedure described by Jackson (1967) prior to laboratory analyses. The bulk density (BD) of the soil was measured by collecting a known volume of soil with a metal core after drying in an oven at 105°C and weighing the soil. Organic carbon was determined by Walkley and Black's rapid titration method as described by Tandon (1999) and the soil organic carbon pool was estimated as per Ravindranath (2003).

$$\text{Soil mass (ton ha}^{-1}) = \frac{[\text{Area (10,000 m}^2) \times \text{Depth (m)} \times \text{Bulk Density} \times 10^3 \text{grams kg}^{-1}]}{1000 \text{ kg ton}^{-1}}$$

$$\text{Soil organic carbon (ton ha}^{-1}) = \frac{\text{Soil mass (ton ha}^{-1}) \times \text{Soil organic carbon (\%)}}{100}$$

Accounting biomass carbon stocks: Wood specimens were collected from the randomly selected sampled trees for estimating the carbon content by using ash method. The ash content (inorganic elements in the form of oxides) left after burning was weighed and carbon was calculated by using the following equation (Negi*et al*., 2003).

Carbon % = 100 – (Ash Weight + Molecular Weightf02 (53.3) in C6H12O6)

Carbon (C) = Biomass x Carbon %

Carbon Sequestration = Carbon x 3.67

Statistical analysis: The observed data were statistically analyzed as per the layout using AGRES version 3.01 software. Wherever, the effects exhibited significance the critical difference (CD) was calculated at five percent level of probability.

RESULTS AND DISCUSSION

Carbon stock potential: The total carbon stock both biomass and soil (per hectare) was significantly influenced by spacing and increased with closer spacing (Table 1). The statistical comparison of C content in woody stem and soil organic carbon of eucalyptus planted at the different spacing varied from 11.27 to 17.01%, and maximum biomass carbon stock (Above ground level and Below ground level) was observed in closer spacing (3333 trees ha^{-1}) with the values53.01 and14.31 $tonha^{-1}$, respectively followed by T_5, T_6, T_2, T_4 T_3 and the minimum was observed in wider spacing (1111 trees ha^{-1}) with the values 37.72, 10.18 $tonha^{-1}$, respectively. The resultsindicated that the biomass production level both above and below ground increased with increase in planting density (Nagar *et al*., 2015), and clearly showed that the number of trees per hectare plays an important role in total biomass production (Nagar *et al*., 2015), by contributing to the increase in the removal and storage of carbon from the atmosphere directly. Aboveground measurements of the carbon stock (and, by implication, carbon sequestration) are direct derivatives for above ground biomass measurements, assuming that 50 percent biomass is made up of carbon (Nair, 2011). Hence, it can be concluded that the tree density and carbon stock are correlated to each other linearly. The soil organic carbon also significantly varied among different spacing regimes, maximum SOC (26.15 ton ha^{-1}) was observed in closer spacing (3333 trees ha^{-1}) and the minimum (14.02 ton ha^{-1}) was recorded in wider spacing (1111 trees ha^{-1}). The result of ANOVA indicates that total carbon stock was significantly different at 0.05 level. Total carbon stock both biomass and soil was recorded highest (93.48 ton ha^{-1}) in closer spacing (3333 trees ha^{-1}) and lowest (61.92 ton ha^{-1}) was in wider spacing (1111 trees ha^{-1}).

CO_2 mitigation potential: Mitigation potential was worked out with respect to carbon content of wood both above and below ground level and soil organic carbon pool. The total carbon stock was significantly different at 0.05 level among different spacing regimes (Table 1). The CO_2 mitigation potential of biomass (both above and below ground level) and soil was observed maximum (194.35, 52.47 and 95.88$tonha^{-1}$, respectively) and the minimum (138.27, 37.33 and 51.38 ton ha^{-1}, respectively) was recorded in wider spacing (1111 trees ha^{-1}). Total CO_2 sequestration was observed maximum (342.71 ton ha^{-1}) in closer spacing (3333 trees ha^{-1}) and minimum was in wider spacing. Figure 2 and 3 shows strong relation between spacing regimes and CO_2 mitigation potential of biomass and soil organic carbon respectively under different density. It indicates that total

Table 1. Carbon stock of *Eucalyptus camaldulensis* at different spacing regimes (ton ha^{-1})

Spacing regimes	Carbon stock			Total carbon	CO_2sequestration potential			Total CO_2seq.
	AGB	BGB	SOC		AGB	BGB	SOC	
T_1 (3.00 m × 3.00 m)	37.72 ^{d}	10.18 ^{d}	14.02 ^{f}	61.92 ^{e}	138.27 ^{d}	37.33 ^{d}	51.38 ^{f}	226.98 ^{e}
T_2 (3.00 m × 2.00 m)	43.23^{c}	11.67^{c}	18.10^{d}	73.01^{d}	158.50^{c}	42.79^{c}	66.35^{d}	267.64^{d}
T_3 (3.00 m × 1.80 m)	42.94^{c}	11.59^{c}	16.51^{e}	71.04^{d}	157.40^{c}	42.50^{c}	60.53^{e}	260.43^{d}
T_4 (3.00 m × 1.65 m)	43.21^{c}	11.67^{c}	24.07^{b}	78.95^{c}	158.42^{c}	42.77^{c}	88.23^{b}	289.42^{c}
T_5(3.00 m × 1.50 m)	49.54^{b}	13.38^{b}	19.79^{c}	82.71^{c}	181.61^{b}	49.03^{b}	72.56^{c}	303.21^{c}
T_6 (3.00 m × 1.35 m)	49.38^{b}	13.33^{b}	25.63^{a}	88.34^{b}	181.01^{b}	48.87^{b}	93.95^{a}	323.84^{b}
T_7 (3.00 m × 1.00 m)	53.01^{a}	14.31^{a}	26.15^{a}	93.48^{a}	194.35^{a}	52.47^{a}	95.88^{a}	342.71^{a}
Mean	45.58	12.31	20.61	78.49	167.08	45.11	75.55	287.75
CD (p=0.05)	3.14	0.85	1.54	4.31	11.52	3.11	5.64	15.82

*Significant differences in mean values are indicated by different letters and same alphabets represent statistically at par group.

Note: AGB – Above Ground Biomass; BGB – Below Ground Biomass; SOC – Soil Organic Carbon (0-30 cm).The results of the study were comparable to the study carried out in Central Apennines, reporting that the dense forests accumulate more biomass carbon than others (Chao, 2007). Adoption of silvicultural management practices affects the growth and yieldof different tree species through the interactions between biological processes and environmental conditions. Thus different management practices indicates substantial potential for carbon accumulation in different spacing regimes and can play a significant role in obtaining carbon credits for international conventions.

carbon stocks at closer spacing can be sequestrate done and half time more CO_2as compared to wider spacing regimes because closer spacing having more number of trees, hence produces more biomass per hectare both above and below ground level, leaf litter, organic matter and microbial activity compare to wider spacing.

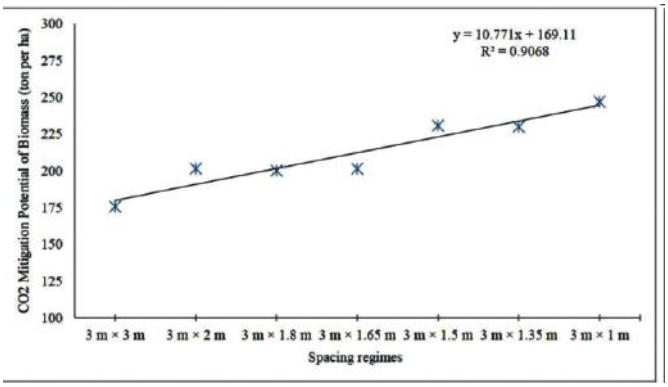

Fig. 2. Correlation between biomass both above and below ground level and spacing regimes in *Eucalyptus camaldulensis* plantation

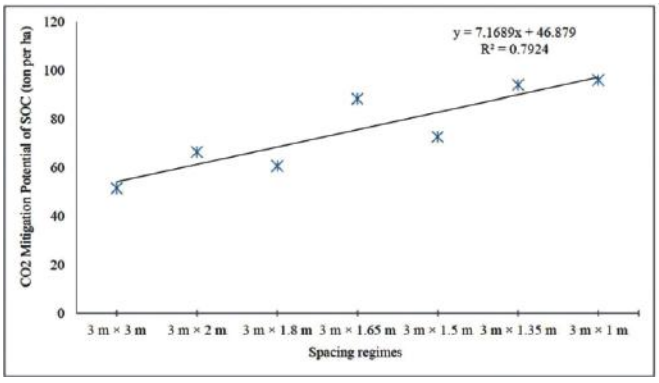

Fig. 3. Correlation between soil organic carbon (SOC) and spacing regimes in *Eucalyptus camaldulensis* plantation

The results of the study revealed that silvicultural management practice such as tree density can also play a significant role in mitigating green house gas (GHG) emission through storage of carbon from the atmosphere as maximum biomass production level, carbon stock and CO_2 mitigation potential both above and below ground was recorded in higher density.

CONCLUSION

The study provides an insight, that adoption of better management practices can enhance above ground and below ground carbon (biomass and soil carbon); and improve soil quality and productivity in the wooded areas. Moreover, enhancement of forest or plantations carbon stocks can be achieved by increasing the carbon density or by increasing the pool of carbon stored in a given forest or wooded area. Thus, the study results concludes that tree density as a silvicultural management practice can be an alternative option to capture carbon flux by reducing atmospheric CO_2 and may be helpful in achieving carbon reduction targets through enhancing C sinks and reduced anthropogenic CO_2emissionsin the biosphere.

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Rainfall-runoff Modeling using Artificial Neural Networks (ANNs) and Multiple Linear Regression (MLR) Techniques

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***Abstract*:** Runoff prediction has an important role in hydrology, water management, flood prediction and socio-economical concern. The effective flood management is always of great apprehension in the field of hydrology and water resources engineering. The present study shows the comparison of various training algorithms available for training multi-layer perceptron (MLP) in artificial neural networks (ANNs) and multiple linear regressions (MLR) for modeling the rainfall-runoff process. Gamma test (GT) is one of the non-linear modeling tools whereby an appropriate combination from input parameters can be investigated for modeling the output data as well as establishing a smooth model, to develop and evaluate the applicability of the MLP and MLR models by way of training and testing of developed models during monsoon period (June to September). The ANN models were trained using multi-layer perceptron with various types of algorithm namely Momentum, Quickprop, Delta-Bar-Delta, Conjugate Gradient and Levenberg Marquardt. The performance of the models were evaluated qualitatively by visual observation and quantitatively using different performance indices viz. root mean square error (RMSE), correlation coefficient (r), coefficient of efficiency (CE).

Key Words: Artificial Neural Networks (ANNs), Multi-layer perceptron (MLP), Multiple linear regressions (MLR), Gamma test (GT)

The occurrence of rainfall-runoff is very difficult processes which may be extremely non-linear and exhibit both spatial and temporal variations. The hydrologic response of basin to rainfall, evaluations of runoff data and river catchment yield, are of vigorous significance for hydrological investigation for the purpose of watershed managements, water resources planning, design of storage structure, pollution control, flood forecasting, and many other applications. Most of Indian basin and river catchments are less gauged and normally the inadequate discharge data are accessible with the apprehension state and central agencies. Under such conditions rainfall-runoff model can be established to simulate the accepted hydrological processes for estimate the catchment runoff. The input parameter was most important role in any types of hydrological modeling such as rainfall-runoff, sediment, evaporation, infiltration etc. One of the major areas of research interest in water resources management is predicting the future rainfall-runoff.

In past decade ANN model was widely used in field of water resource and development and hydrology. The startup period of studying ANNs presentation in hydrology occurred throughout the *1990s*.The study deliberated as the first paper on neural network submission in hydrologic modeling by Daniell (1991) and many studies have recognized that the ANNs are brilliant tools to model the compound rainfall–runoff process and can achieve better than the other modeling procedures (Dawson and Wilby, 1998; Rajurkar *et al.* 2002; Rajurkar *et al.,* 2003; Kumar *et al.,* 2005; Chen and Adams, 2006; Shamseldin *et al.* 2010; Machado *et al.,* 2011; Chen *et al.,* 2013; Shrivastav *et al.* 2014; Behmanesh, and Ayashm, 2015; Chandre and Mayya, 2015; Chandwani *et al.,* 2015 and Singh *et al.,* 2016). Conventional multiple linear regression (MLR) approaches have also been extensively used in daily rainfall-runoff modeling, water level forecasting at gauging stations, real time flood forecasting and warning (Dawson and Wilby, 1999;Bisht *et al*., 2010; Asati and Rathore, 2012). Chakravartia *et al.* (2015) compared Artificial Neural Network (ANN) technique and conduct laboratory experiment for the generation of rainfall runoff data using rainfall simulator for estimating observed runoff data. Ghorbani (2016) studied were artificial neural networks (ANNs), support vector machines (SVM) rating curve (RC) and multiple linear regression (MLR). Sedighi *et al*. (2016) studied the performance of the artificial neural network (ANN) using hyperbolic tangent and sigmoid) and support vector machine (SVM) models to predict the rainfall–runoff process prejudiced by snow water equivalent (SWE) height. ANN using the hyperbolic tangent function and sigmoid transfer function had superior prediction capability than the other models. Patel *et al*. (2016) studied multiple linear regression based technique in determining the rainfall-runoff relations. In this study following objectives; (a) to investigate the

techniques of ANNs and MLR for modeling the complex rainfall–runoff process, (b) evaluate the investigated learning algorithms methods available for training the ANN rainfall–runoff models for the Arpa River.

MATERIAL AND METHODS

The daily rainfall and runoff data during the monsoon (1 June to 30 September) period from 2001-2007 for Arpa River were recorded from Ghatora station of Central Water Commission (CWC) and the data were obtained from Divisional office of CWC Raipur, Chhattisgarh, India. The Ghatora station of Arpa River is located in Bilaspur district of the Chhattisgarh state in India at latitude of 22 33'29.16'' N and longitude of 82 6'41.20'' E and having elevation of 246 m from mean sea level (MSL). The drainage area of Arpa River is approximately 3035 km^2 and all drainage area lies under toposheet-64J0. The location of study area is shown in Fig. 1. The seven years data set are divided into two phases, first phase is training and second is testing. The models are trained using the five years data from 2001 to 2005, and the testing of the models was done using the two years data from 2006 to 2007 for validation of developed models.

Model Development: Five different types of ANN rainfall–runoff models have been developed and are represented (Table 1) that differ in the manner of the training algorithms employed to ?rst classify the input–output data into three categories before developing separate feed-forward MLP type ANN models trained using back propagation algorithm (BPA).

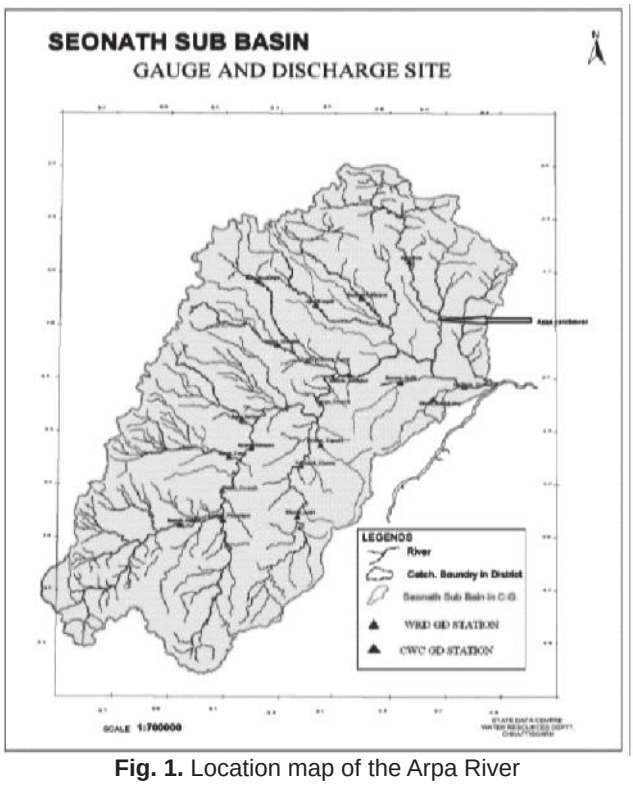

Fig. 1. Location map of the Arpa River

Table 1. Details of various types of the learning algorithms

Model	Algorithm	Learning rule description
ANN-1	Momentum	Gradient and Weight Change (Momentum)
ANN-2	Conjugate Gradient	Second Order method for Gradient
ANN-3	Levenberg Marquardt	Improved Second Order method for Gradient
ANN-4	Delta Bar Delta	Adaptive Step Sizes for Gradient plus Momentum
ANN-5	Quickprop	Gradient and Rate of Change of Gradient

The statistical parameters of rainfall and runoff data are shown (Table 2) which indicates that the rainfall and runoff show significant skewed distribution. The ratio between the standard deviation and mean is high.

Table 2. Statistical parameter of data set for training and testing data of Arpa river

Statistical parameters	Training data set		Testing data set	
	R_t	Q_t	R_t	Q_t
Mean	6.28	46.65	4.02	41.30
Standard deviation	14.08	81.62	9.16	42.02
Coefficient of Skewness	4.10	7.71	3.63	4.81
Maximum	127.10	1248.37	65.01	425.20
Minimum	0	0	0	4.01

Model Input Selection: In order to simulation runoff by ANNs, variables R_t, R_{t-1}, R_{t-2}, R_{t-3}, R_{t-4}, Q_{t-1}, Q_{t-2}, Q_{t-3} and Q_{t-4} were considered as input variables. Identifying best input combination is the most important step of any modeling. As indicated the complexities of the model including the higher number of inputs, more data for training model, a model with greater parameters, may have less prediction error; however, it not necessarily ensure fewer errors at the test phase. In this condition, there is an optimal condition in which prediction errors are minimizing at the test phase.

Also GT was used for finding the finest input combination of input variables. Different combinations of input variables were explored to assess their influence on the runoff simulation (Table 3). Gamma test predicts the minimum achievable modeling error before the modeling. Suppose 'n' is the variables influencing on occurrence of a phenomenon; 2^n-1 meaningful combination would be established from the input variables. As indicated in Table 3, out of 9 parameters, R_t, R_{t-1}, Q_{t-1} had the highest influence on runoff discharge. Moreover, eliminating the parameters R_{t-3}, R_{t-4}, Q_{t-4} decreased the gamma value. Eliminating other remained variables had an identical influence on increasing the gamma value. To

Table 3. Identifying the most effective variable based on GT

Different combinations	Mask	Gamma	SE	V_{ratio}
All	111111111	0.0322	0.014	0.128
R_t	011111111	0.0501	0.012	0.200
R_{t-1}	101111111	0.1142	0.015	0.457
R_{t-2}	110111111	0.0393	0.015	0.157
R_{t-3}	111011111	0.0257	0.010	0.103
R_{t-4}	111101111	0.0317	0.0115	0.135
Q_{t-1}	111110111	0.0381	0.013	0.152
Q_{t-2}	111111011	0.0347	0.019	0.139
Q_{t-3}	111111101	0.0345	0.019	0.150
Q_{t-4}	111111110	0.0252	0.018	0.100

determine the best input combination in modeling, various combinations of input parameters were assessed using GT so as to identify the most appropriate combination among the remained variables to predict the runoff discharge. Some of these combinations along with Gamma values are shown in (Table 4). The results showed, the best input combination of the variable is when using R_t, R_{t-1}, R_{t-2}, Q_{t-1}. The Small value of gamma indicates that the data with provided combination might possibly provide better results in modeling.

Table 4. Determination of the best combination

Different combinations	Mask	Gamma	SE	V_{ratio}
R_t, R_{t-1}, R_{t-2}, Q_{t-1}, Q_{t-2}, Q_{t-3}	111001110	0.0376	0.00955	0.1507
R_t, R_{t-1}, R_{t-2}, Q_{t-1}, Q_{t-2}	111001100	0.0298	0.00587	0.11949
R_t, R_{t-1}, R_{t-2}, Q_{t-1},	111001000	0.0241	0.00324	0.11357
R_t, R_{t-1}, Q_{t-1}	110001000	0.0329	0.011821	0.1319
R_t, R_{t-1}, Q_{t-1}, Q_{t-2}, Q_{t-3}	110001110	0.0347	0.00966	0.1391
R_t, R_{t-1}, Q_{t-2}, Q_{t-3}	110000110	0.0304	0.00709	0.1219

Model performance

The performance of ANN model is assessed by the satisfying the defined objective function of the model. Also, to test the applicability of the model for hydrologic problem following.

Root mean square error (RMSE) : The root mean square error compares difference between predicted and observed values and gets the information on short term performance. It is a positive value ranging from 0 to . The RMSE is zero for perfect fit and increased values indicate higher deviation between predicted and observed values. It is determined by following relationship:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(Q_o - Q_p)^2}{n}} \quad \text{.....(1)}$$

where, Q_o is i^{th} observed values of daily runoff, Q_p is predicted values of daily runoff and n is the number of observations.

Correlation coefficient (r): The Correlation Coefficient (r) is an indicator of degree of closeness between observed and predicted values. If observed and predicted values are completely independent, the r will be zero (Mutreja, 1992). The correlation coefficient is determined using the following equation:

$$r = \left[\frac{\sum_{i=1}^{n}\{(Q_o - \bar{Q}_o)(Q_p - \bar{Q}_p)\}}{\sqrt{\sum_{i=1}^{n}(Q_o - \bar{Q}_o)^2}\sqrt{\sum_{i=1}^{n}(Q_p - \bar{Q}_p)^2}}\right] \text{.....(2)}$$

where Q_0 is average of the observed daily runoff series and Q_p is average of predicted daily runoff series.g statistical criteria are also applied.

Coefficient of efficiency (CE) : The Coefficient of efficiency is developed by Nash and Sutcliffe in 1970. Nash-Sutcliffe coefficient of efficiencies range between - to 1. Similarly CE value equal to zero indicates that the model predictions are equal to mean of observed data series. The Coefficient of efficiency is determined by using the following equation:

$$CE = 1 - \frac{\sum_{i=1}^{n}(Q_o - Q_p)^2}{\sum_{i=1}^{n}(Q_o - \bar{Q}_o)^2} \text{.....(3)}$$

RESULTS AND DISCUSSION

ANN Model Results: The ANN model trained using Momentum learning algorithm (ANN-1 model) performed the worst while the performances of the ANN models trained using Conjugate Gradient, Levenberg Marquardt, Delta-Bar-Delta and Quickprop (ANN-2, ANN-3, ANN-4 and ANN-5 models, respectively) were comparable (Table 5). The ANN-2 model obtained the best RMSE, r and CE statistics of 18.70, 0.93 and 0.90 respectively; similarly the ANN-3 model obtained the best RMSE, r and CE statistics of 11.98, 0.97 and 0.96 respectively; ANN-4 model obtained the best RMSE, r and CE statistics of 17.10, 0.93 and 0.92 respectively and ANN-5 model obtained the best RMSE, r and CE statistics of 19.22, 0.92 and 0.92 respectively during the testing period. The ANN model trained using Levenberg Marquardt learning algorithm the best outperformed all other models. The ANN-3 model obtained the best statistics results during testing period. Thus, it can be said that when the overall performance is considered, the ANN model trained using Levenberg Marquardt learning algorithm performed the best, the ANN model trained using Momentum learning algorithm performed the worst, and the performance of the ANN model developed using Conjugate Gradient, Delta-Bar-Delta and Quickprop learning algorithms was moderate. The qualitative performance was evaluated by visual observation Fig. 2 to 6.

MLR Model Results: The best RMSE, r and CE statistics of 26.66, 0.80 and 0.85 respectively during the testing period. The qualitative performance of developed model was judged by observed and predicted daily runoff graph and scatter

Table 5. Statistical performance evaluation measures from various ANN models

Model	Networks	Training			Testing		
		RMSE	R	CE	RMSE	r	CE
ANN-1	4-15-1	43.94	0.85	0.79	19.94	0.89	0.89
ANN-2	4-16-1	31.10	0.93	0.89	18.70	0.93	0.90
ANN-3	4-4-1	20.46	0.97	0.95	11.98	0.97	0.96
ANN-4	4-11-1	24.41	0.93	0.93	17.10	0.93	0.92
ANN-5	4-13-1	36.06	0.90	0.85	19.22	0.92	0.92

plots as shown in Fig 7. The runoff graph shows that while predicting both high and low runoff indicates that MLR models have high deviation between observed and predicted daily runoff. The MLR model was having high accuracy during low flow. Some researchers have reported that the ANN rainfall–runoff models trained using popular BPA do not perform well in predicting low magnitude flows (Jain and Srinivasulu, 2006). In order to compare the performances of ANN models trained using different learning algorithms namely Momentum, Quickprop, Delta-Bar-Delta, Conjugate Gradient and Levenberg Marquardt in predicting magnitude flows, a close examination of the statistical results was carried out. For this, selected error statistics (RMSE, r and CE) were calculated from the ANN-1, ANN-2, ANN-2, ANN-3, ANN-4, ANN-5 and MLR models for the data corresponding to low and high magnitudes of flow (Table 6).

During testing the ANN-3 model having best values of statistics RMSE, r and CE of 09.54, 0.92 and 0.95 for low magnitude flows. It was concluded that ANN-3 model trained using Levenberg Marquardt learning algorithms having best performing results during low magnitude flow. Similarly during high magnitude flow the ANN-5 model was found network (4-13-1) best results of statistics of RMSE, r and CE of 23.50, 0.99 and 0.99 respectively. After the analyzing the

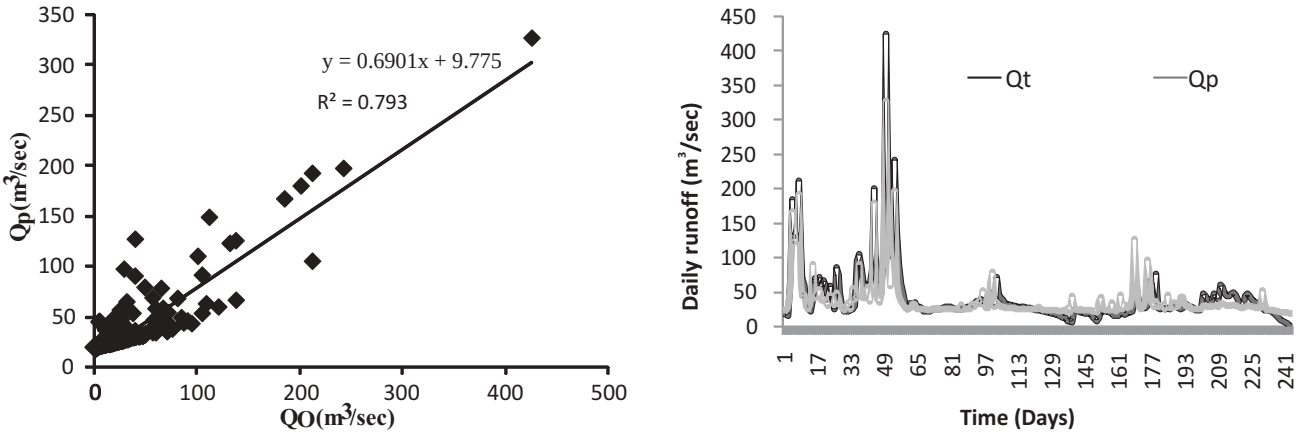

Fig. 2. Comparison of observed (Q_o) and predicted (Q_p) daily runoff and their corresponding scatter plot during testing period for ANN-1 model

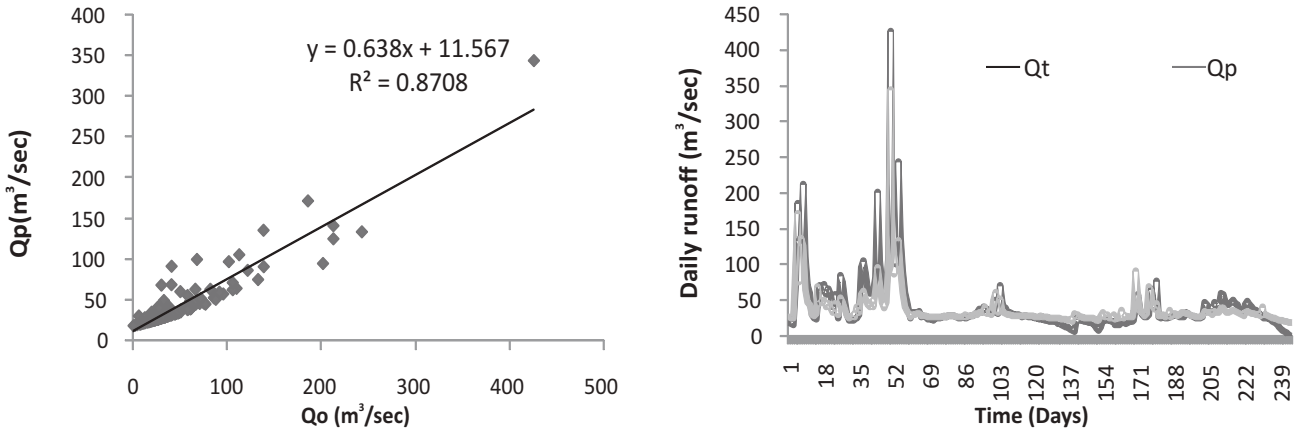

Fig. 3. Comparison of observed (Q_o) and predicted (Q_p) daily runoff and their corresponding scatter plot during testing period for ANN-2 model

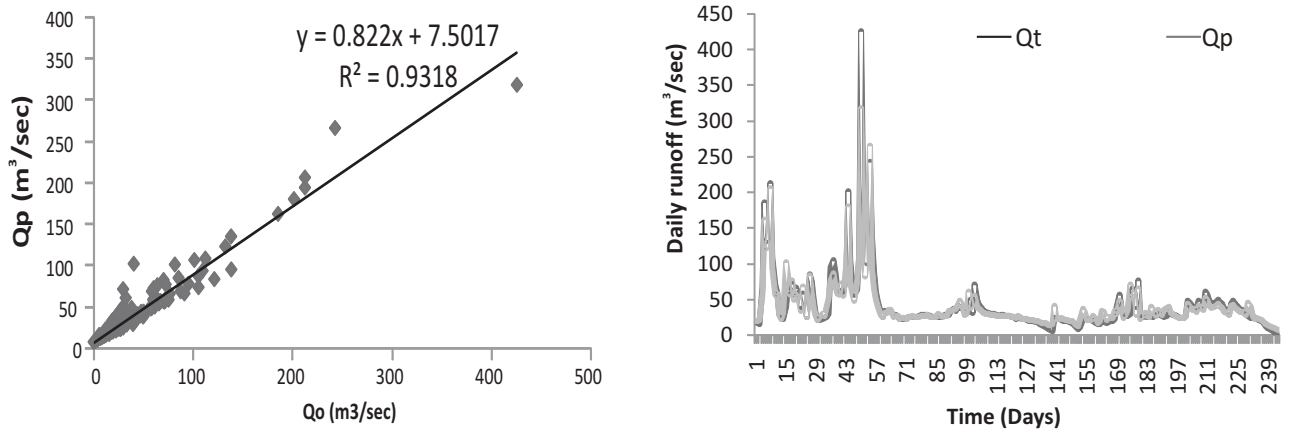

Fig. 4. Comparison of observed (Q_o) and predicted (Q_p) daily runoff and their corresponding scatter plot during testing period for ANN-3 model

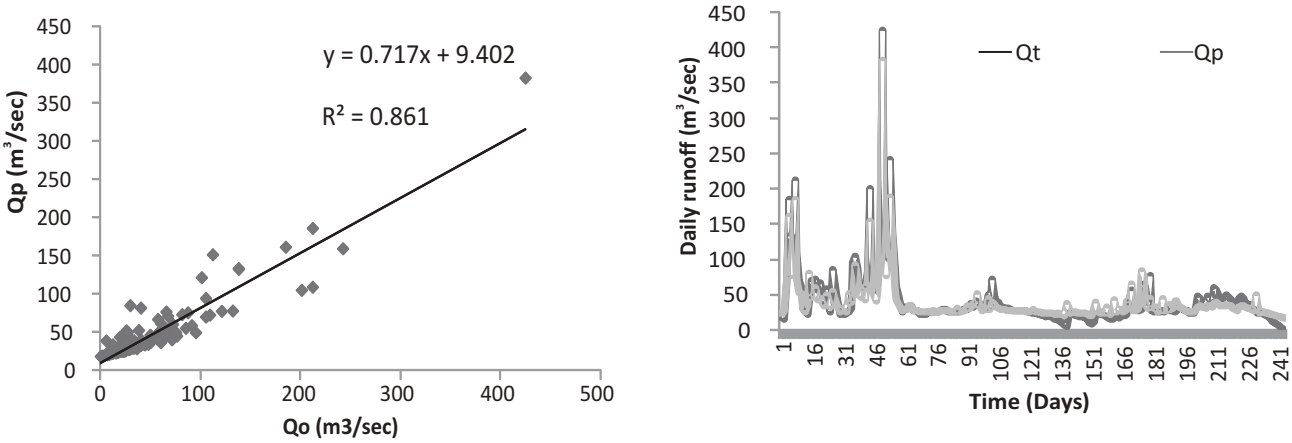

Fig. 5. Comparison of observed (Q_o) and predicted (Q_p) daily runoff and their corresponding scatter plot during testing period for ANN-4 model

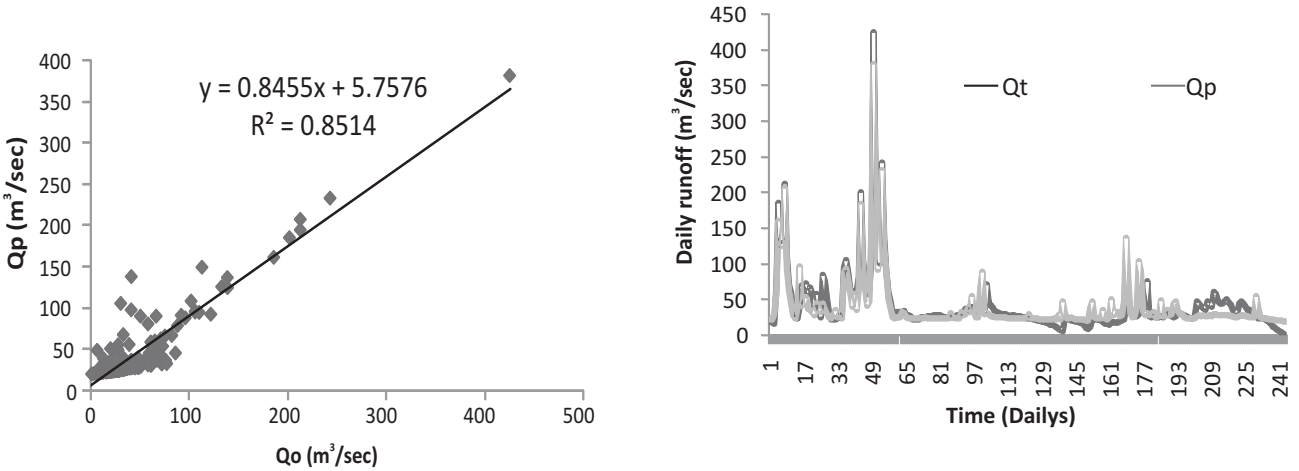

Fig. 6. Comparison of observed (Q_o) and predicted (Q_p) daily runoff and their corresponding scatter plot during testing period for ANN-5 model

Table 6. Statistical results for low and high magnitude flows

Model	Training			Testing		
	RMSE	r	CE	RMSE	r	CE
Low magnitude flows						
ANN-1	27.54	0.66	0.61	17.47	0.68	0.87
ANN-2	22.49	0.72	0.74	13.39	0.85	0.90
ANN-3	16.57	0.85	0.86	09.54	0.92	0.95
ANN-4	18.34	0.82	0.83	13.4	0.84	0.91
ANN-5	27.84	0.64	0.61	15.96	0.76	0.88
MLR	32.12	0.63	0.59	20.15	0.72	0.81
High magnitude flows						
ANN-1	179.61	0.78	0.82	63.39	0.89	0.94
ANN-2	115.52	0.92	0.92	84.10	0.92	0.89
ANN-3	65.39	0.98	0.98	35.31	0.96	0.98
ANN-4	84.58	0.96	0.96	71.55	0.94	0.92
ANN-5	128.08	0.90	0.92	23.50	0.99	0.99
MLR	192.21	0.66	0.78	91.41	0.68	0.79

results both during training and testing, ANN-3 model was best in low magnitude flow, but during high magnitude flow the ANN-5 model was the best. For all magnitude flows during both training and testing data sets by the ANN models trained using Quickprop learning algorithm over the one trained using the popular Levenberg Marquardt during high magnitude flow.

Figure 8 to 9 indicate the deviation of observed and predicted runoff during low magnitude flow and high magnitude flow for ANN-3 and ANN-5 models respectively.

CONCLUSIONS

The Momentum learning algorithm is not suitable in training the ANN rainfall–runoff models for the Arpa river. The predictive capability of the Levenberg Marquardt learning algorithm trained ANN rainfall-runoff models were much superior to those trained using all learning algorithm. The ANN models performed better than MLR models in runoff

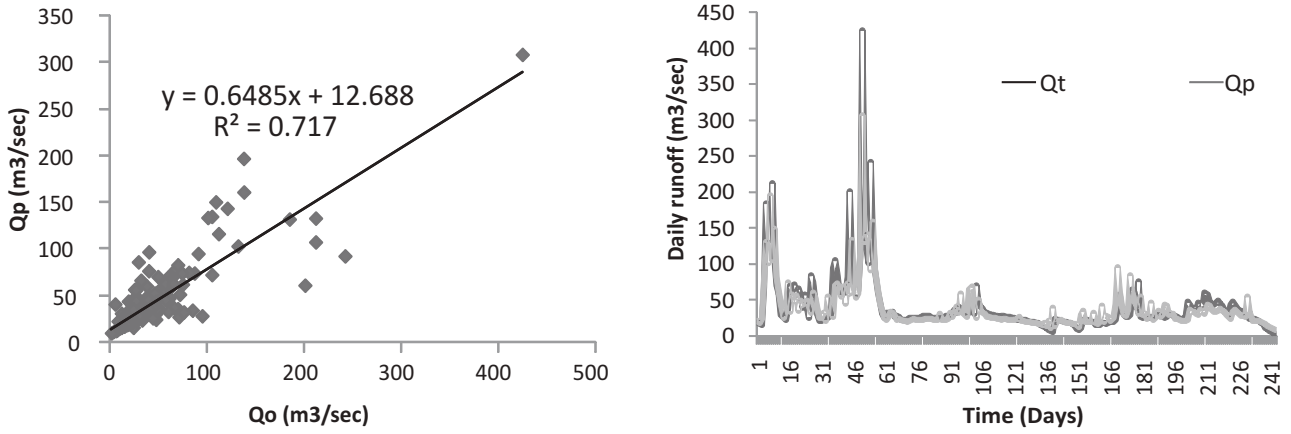

Fig. 7. Comparison of observed (Q_o) and predicted (Q_p) daily runoff and their corresponding scatter plot during testing period for MLR model

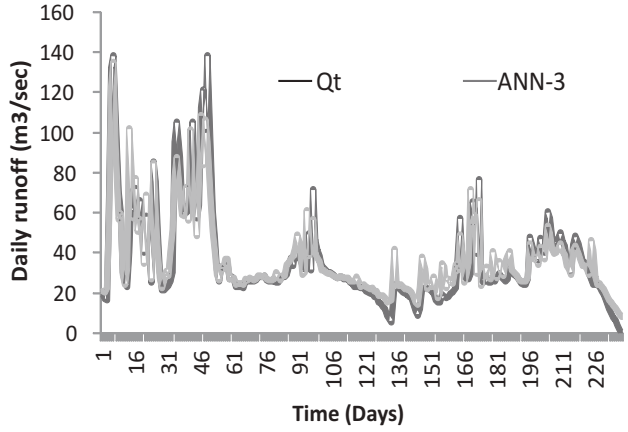

Fig. 8. Observed and predicted runoff during low flow magnitude

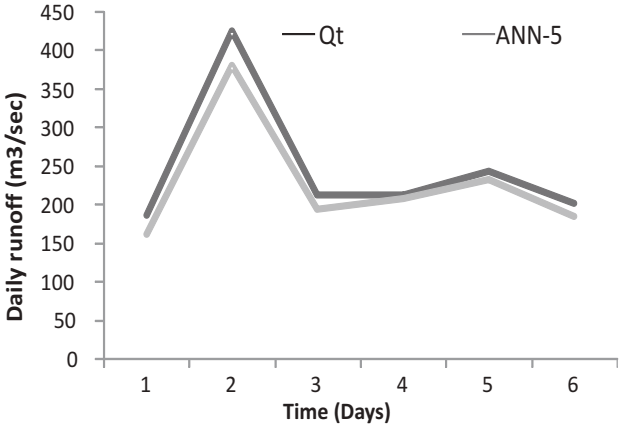

Fig. 9. Observed and predicted runoff during high flow magnitude

prediction for Arpa River. It is advantageous to perform an error analysis of the results for varying magnitudes of flows (such as low, and high) in order to properly examine the robustness and predictive capability of the ANN models. Further, the performances of various ANN models need to be evaluated using a wide variety of standard statistical performance evaluation measures rather than relying on a few global error statistics, such as correlation coefficient and efficiency, normally employed that are similar in nature to the global error minimized at the output layer of an ANN. The models presented in this paper only applied on data from one station. Further studies using more sample data from various areas are required to strengthen these conclusions.

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Physico-chemistry and Phytoplankton Characteristics of Two Tropical Rivers in Ebonyi State, Southeast Nigeria

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***Abstract*:** The physico-chemistry and phytoplankton characteristics of two tropical rivers; Idumayo and Oyilo-Adada in Ebonyi State, Southeast Nigeria were studied. Mean values of physico-chemical variables measured showed water temperature (31.55°C), conductivity (121.13µS/cm) and TDS (84.75 mg/L) to be higher in Idumayo river, while pH (7.01) was lower compared to Oyilo-Adada. Transparency (1.7m) was higher in Oyilo-Adada River while dissolved oxygen was lower (3.60 mg/L) than in Idumayo. Nitrate concentrations were higher (0.02 mg/L) in Idumayo River compared to Oyilo-Adada (0.01 mg/L). However, mean values of phosphate in Oyilo-Adada (0.20 mg/L) were higher than that of Idumayo (0.19 mg/L) River. Monthly variation in transparency, DO and phosphate concentrations of the study sites were significant ($p<0.05$). Five phytoplankton division made of ninety eight (98) species with 836 and 1,981 individuals from Idumayo and Oyilo-Adada rivers, respectively were identified. Phytoplankton abundance varied significantly ($p<0.05$) at the two rivers. Diversity of Chrysophyta was higher in Idumayo compared to Oyilo-Adada river. From the findings, the rivers are yet unpolluted, so the water quality should be maintained to sustain the productivity of the ecosystem.

***Key Words*:** Nigeria, Physicochemical variables, Phytoplankton, Rivers, Species composition

Water is critical to society's welfare, it is vital for ecosystem stability, energy production, recreation, transportation, waste disposal, agriculture and industrial development (Kenneth and Peter, 1999). Nigeria is richly endowed with vast expanse of inland freshwater and brackish ecosystems (FAO, 1973). Their full extent cannot be accurately stated as it varies with season and from year to year depending on seasonal and annual variations in rainfall. However, these water resources are spread all over the country from the coastal region to the arid zone of the Lake Chad Basin.

Freshwater including rivers and lakes cover about 3,221,500 ha (Pongswat *et al*., 2000*)*. The total surface area of water bodies in Nigeria, excluding deltas, estuaries and miscellaneous wetlands suitable for rice cultivation but not necessarily suitable for fish cultivation, is estimated to be about 14,991,900 ha or 149,919 km^2 and constitutes about 15.9% of the total area of Nigeria (Pongswat *et al*., 2000*)*. So, freshwater resources in Nigeria have a total cover of about 15 hectares (Ita, 1993).

Rivers serve as habitat for large diversity of flora and fauna. However, the landscape worldwide is constantly changing due to rechannelization for agriculture, urbanization, navigation and dam construction purposes. The watershed and nutrient rich floodplains or wetlands around some rivers support intensive agricultural activities throughout the year. These roles are vital to sustainable socio-economic development of nations, which also makes it critically important to properly manage these rivers and their wetlands (Castree, 2008).

Riverine wetlands are responsible for most of the observed variations in water quality of associated streams or rivers. This may be linked to increased human activities such as crop cultivation, mining (where there are mineral deposits), dumping of refuse, use of herbicides/pesticides, fertilizer application, animal grazing, which can lead to the seepage of nutrients and/or hazardous chemicals into rivers. These can alter the water quality and biological diversity of the ecosystem.

Phytoplankton is often used as indicators of water quality (Davies *et al.,* 2009). The species composition, biomass, relative abundance, spatial and temporal distribution of these organisms could be an expression of the environmental health or biological integrity of a particular water body (Ekwu and Sikoki, 2006), and these could be affected by ambient nutrient concentrations (Agouru and Audu, 2012), light penetration, temperature, water current and salinity (Spodniewska, 1974). There is no existing literature on the physico-chemistry and phytoplankton characteristics of Idumayo and Oyilo-Adada rivers. Therefore, this study was carried out to compare the physico-chemical and phytoplankton characteristics of the two rivers, identify the response of different species to changes in environmental variables. The study will enhance the understanding of the functionality of the rivers and the health of the riparian ecosystem. It will also provide information that will improve understanding on the relationship between

water quality variables and phytoplankton communities.

MATERIAL AND METHODS

Idumayo (6° 2' 13" N, 8° 0' 28" E), and Oyilo-Adada (6° 0' 25" N, 8° 5' 15" E) Rivers are in Onicha and Ikwo Local Government Areas, respectively of Ebonyi State, Nigeria. The two rivers lie within the Guinea savannah region and they experience distinct rainy and dry seasons with large wetlands which support intensive agricultural activities on the catchment areas. The rivers run into the Cross River system through long undulating channels. The major activities around the rivers are cultivation of staple food crops such as rice, yam, cassava, cocoyam and vegetables. The rivers also provide water for domestic use and for small scale irrigation farming by the riparian population in the dry season.

Methodology: Water samples for physico-chemical variables and phytoplankton analysis were collected from the study sites from September, 2014 to April, 2015. Water temperature, conductivity, Total Dissolved Solid (TDS), and pH were measured *in situ* using Hanna thermometer, conductivity (Model HI98303), TDS (Model HI98108) and pH (Model HI96107) meters, respectively. Transparency was measured using seechi disc. Samples for dissolved oxygen analysis were collected in BOD bottles and fixed at the sites using Winkler's reagent and determined in the laboratory using titration method while samples for nitrate (NO_3-N) and phosphate (PO_4-P) were collected and analyzed in the laboratory using methods according to AOAC(2003). Water samples were collected before midday and all the parameters were measured in triplicate.

Phytoplankton samples were collected at midday by towing a plankton net of 45µm mesh size horizontally in water, pooled and fixed in 4% buffered formalin and identified to species level using the taxonomic keys of (Prescott, 1982; Botes, 2003;Nwankwo, 2004;APHA, 2005) with an Olympus microscope (Model BHTU BH-2) at X400 magnification.

The phytoplankton characteristics of the rivers were evaluated through the abundance and diversity of the Divisions identified from the sites. Abundance was expressed as the number of individuals per litre (ind/L) according to Ovie (1993) while diversity was estimated using Shannon-Wiener diversity index.

Variations in physico-chemical variables were expressed in simple mean and standard error. The physico-chemical and phytoplankton characteristics of the rivers were subjected to a one way analysis of variance (ANOVA) and values were considered significant at $p<0.05$. ANOVA was performed using Statistical Package for Social Science version 17.0

RESULTS AND DISCUSSION

Variation in the mean values of physico-chemical variables (Table 1) between the study sites showed no significant difference during the study period. This could be due to the geographical locations of the sites which lie within the same local biome with similar weather pattern. Water temperature (31.55°C), conductivity (121.13µS/cm) and TDS (84.75 mg/L) were higher in Idumayo river while pH (7.01) and Transparency (0.16 m) were lower compared to Oyilo-Adada but did not vary significantly between the two sites. This could be attributed to the constant mixing of water due to water movement along the river channels which is a typical feature of a lotic system. However, the observed variations in water temperature in the study sites could be due to difference in the sampling time or seasonality as this variable is strongly linked to meteorological variable in tropical waters (Aoyagui and Bonecker, 2004). The higher conductivity recorded in Idumayo may be an indication of more dissolved substances (salts). The comparatively lower pH recorded at Idumayo could be attributed to higher level of organic acid from decayed rice paddy from the riparian rice farm which leached into the river to increase the organic acid content of

Table 1. Mean with standard error, minimum and maximum values of physico-chemical characteristics of the study sites

Physico-chemical variables	Idumayo river			Oyilo – Adada river		
	Mean	Min.	Max.	Mean	Min.	Max.
Water temperature (°C)	31.55^a±1.04	27.10	37.20	30.04^a±0.77	26.00	33.50
Conductivity (µS/cm)	121.13^a±25.69	55.00	240.00	94.25^a±19.52	45.00	190.00
Total dissolved solid (mg/L)	84.75^a±15.47	12.00	186.00	61.25^a±12.35	27.00	117.00
pH	7.01^a±0.23	6.00	7.90	7.45^a±0.24	6.50	8.60
Transparency (m)	0.16^a±0.03	0.04	0.25	0.17^a±0.03	0.08	0.28
Dissolved oxygen (mg/L)	3.70^a±0.28	2.60	5.00	3.60^a±0.34	2.50	5.00
Nitrate (NO_3-N) (mg/L)	0.02^a±0.00	0.01	0.04	0.01^a±0.00	0.003	0.02
Phosphate (PO_4-P) (mg/L)	0.19^a±0.07	0.01	0.40	0.20^a±0.07	0.01	0.46

NB: Mean values with the same superscript at the same row are not significant

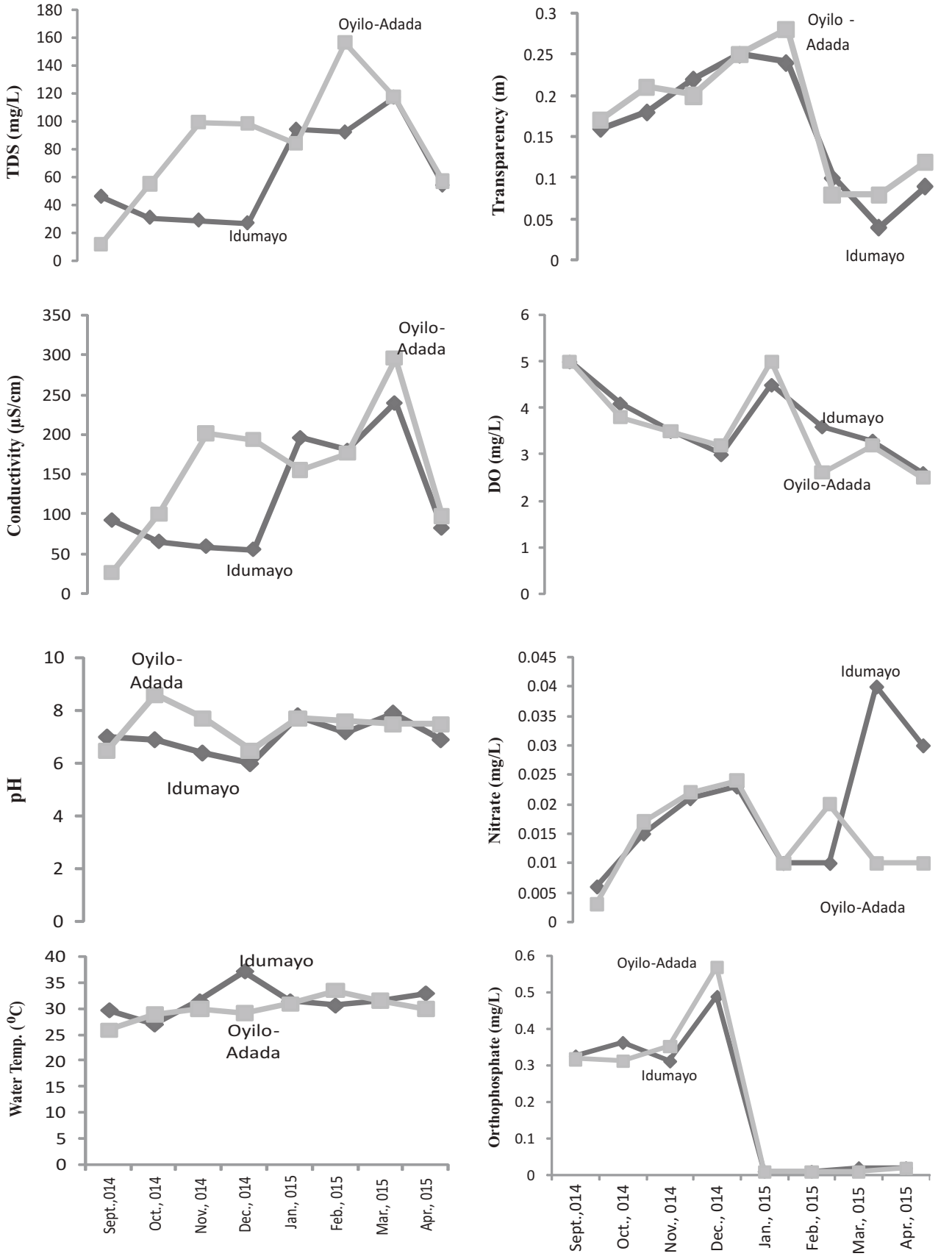

Fig. 1. Monthly variations in physico-chemical variables of the study sites

the water. Lauridsen *et al*. (1998) have attributed decrease in natural water pH to decomposition of organics which release more carbondioxide (del Giorgio *et al*., 1991) that increase the organic acid content of the waters. Transparency was generally low for the two studied rivers and this could be due to frequent human activities within the rivers which constantly unsettles and maintain the suspension of sediments. Mean dissolved oxygen was higher (3.70 mg/L) in Idumayo river than Oyilo-Adada. High dissolved oxygen levels were recorded in September and January, which coincides with the period of high water level, increased water turbulence, low water temperature and cold harmattan weather (January). These factors enhance air-water mixing and can increase DO level according to Nwonumara and Okogwu (2013). Boyd (1979) had also reported increased dissolved oxygen level of river channel at low water temperature. Nitrate concentrations were higher (0.02 mg/L) in Idumayo River compare to Oyilo-Adada (0.01 mg/L) while mean phosphate value in Oyilo-Adada (0.20 mg/L) was higher than that of Idumayo (0.19 mg/L) River. Low levels of nitrate lend credence to unpolluted status of the rivers although the phosphate levels were relatively high. High phosphate levels could be attributed to the breakdown of leachate of glyphosate based herbicide formulations (Forlani *et al.,* 1999), which are commonly applied to eliminate weeds in rice paddies proximally close to the rivers.

Phytoplankton Composition

Species composition of the study sites are showed in Table 2. Five phytoplankton divisions comprising ninety eight (98) species with 77, 670ind/L and 178, 290ind/L from Idumayo and Oyilo-Adada rivers, respectively were identified during the study period (Table 2). All the phytoplankton divisions including Chrysophyta (65, 700ind/L; 31, 320ind/L), Dinophyta (58, 950ind/L; 10, 170ind/L), Chorophyta (43, 020ind/L;24, 210ind/L), Cyanobacteria (10, 170ind/L;9, 540ind/L) and Rhodophyta (450ind/L,0ind/L) were more abundant in Oyilo-Adada compared to Idumayo rivers, respectively (Table 3, Fig.2).The result showed that species abundance of phytoplankton in Oyilo-Adada river was higher than that of Idumayo (Table 3). On the other hand, species diversity of Chrysophyta, Dinophyta, and Chlorophyta were higher in Idumayo river than in Oyilo-Adada river (Table 3). ANOVA result showed that difference in the abundance of Chrysophyta, Dinophyta and Chlorophyta were significant ($p<0.05$) between the study sites.

The species composition of the study sites showed high similarity among individuals identified. This could be attributed to the geographical location of the rivers. The rivers lie within the same ecoregion and therefore share similar meteorological and environmental characteristics and as a

Table 2. Phytoplankton species composition of the study sites

Phytoplankton divisions IdumayoOyilo-Adada	Species composition	Total abundance (ind/L)	
Chrysophyta		31, 320	65, 700
	Achnanthes lanceolata	**	
	Actinoptychus splendens	***	
	Amphipleura pellucida		***
	Asterionellopsis glacialis	**	
	Biddulphia laevis	**	
	Chaetoceros capense	***	
	Chaetroceros constrictus	***	
	Chaetoceros diversus		***
	Chaetoceros didymus	***	***
	Chaetoceros cf lorenzianus	***	
	Chlorobotrys regularis		**
	Cocconeis pediculus		**
	Coscinodiscus centralis		**
	Coscinodiscus granii	**	**
	Coscinodiscus stellaris	***	***
	Cyclotella meneghipian		***
	Denticula elegans		**
	Diceras phaseolus	**	**
	Ditylum brightwelli	**	**
	Frustulia rhomboides		**
	Gomaphoneis herculeans	**	
	Gyrosigma balticum	***	***
	Guinardia delicatula	***	
	Hemidicus cuneiformis	***	***
	Leptoclindricus danicus		***
	Licmophora ehrenbergii	**	**
	Melosira granulate	***	
	Melosira spaerica		***
	Navicula digitoradiata		**
	Navicula petersenii	***	***
	Nitzschia closterium	**	**
	Nitzschia sigma	***	***
	Nitzschia ralida	***	
	Opephora martyi	**	
	Pleurosigma capense	**	**
	Pleurosigma directum	***	***
	Pseudo-nitzschia australis	**	
	Pseudo-nitzschia delicatissima		***
	Rhizosolenia cylindrus		***
	Rhizosolenia hebetata	**	**
	Rhizosolenia imbricata	***	
	Schroederlla delicatula		***
	Skeletonema costatum	**	
	Stauroneis par vulavar prominula		***

Cont...

	Steriatella unipunctata	**	**
	Surirella nobilis	**	
	Thalassionema nitzchioides	***	
	Thalassiosira decipiens	**	**
	Thalassiosira eccentrica	***	
Dinophyta		10, 170	58, 950
	Alexandrum catenella		***
	Ceratium dens	**	**
	Ceratium lineatum	***	***
	Dinophysis acuminata	**	**
	Dinophysis fortii	***	***
	Dinophysis rotundata	***	***
	Gonyaulax spinifera	**	**
	Preperidinium meunieri	**	**
	Prorocentrales rostratum		***
	Prorocentrum micans	***	***
	Protoperidinium conicoides	***	
	Protoperidiniumexc entricum	***	
	Protoperidinium obtusum	**	**
	Protoperidinium subinerme	***	
	Scrippsiella trochoidea		**
	Spatulodinium cf pseudonocti	**	**
Chlorophyta	*Ankistrodesmus fractus*	24, 210	43, 020
	Chlorella ellipsoidea	***	***
	Chlorocloster pyreniger		***
	Chlorococcum infusionum	***	***
	Closterium kuetzingii	**	
	Closteriopsis longissima		***
	Cosmarium panamense	**	**
	Docidiumund ulatum	***	***
	Eutreptiella gymnastica	**	
	Hyalotheca dissiliens	***	***
	Palmellopsis gelatinosa		***
	Planktosphaeria gelatinosa	**	
	Polytoma obtusum	**	
	Microspora floccosa	**	**
	Schroederia setigera		***
	Selenastrum gracile		***
	Stylosphaeridium stipitatum		**
	Ulothrix cylindricum	**	**
		***	
Cyanobacteria	*Aphanizomenon flos-aquae*	9, 540	10, 170
	Ceolosphaerium kuetzingianum	***	***
	Chamaesiphon incrustans		**
	Dactylococcopsis acicularis	**	
	Dictyocha octonaria		***
	Glaucocystis duplex	**	**
	Gloeocapsa punctata		**
	Microcystis aeruginosa	**	
	Microcystis flos-aquae	**	**
	Nostochopsis lobatus		**
	Oscillatoria rubescens		**
	Oscillatoria splendida		**
	Rivularia species		**
	Symploca muscorum	**	
			**
Rhodophyta	*Kylinella latvica*	0	450
			**
Grand Total (ind/L)		77, 670	178, 290

NB: *** (Abundant), ** (Present)

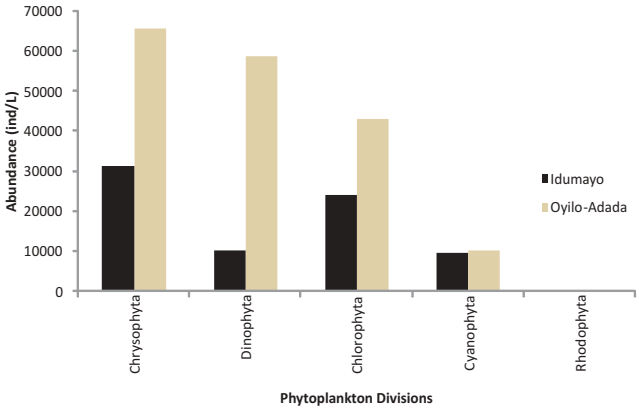

Fig. 2. Phytoplankton abundance by sites

Table 3. Abundance and Diversity of Phytoplankton of the study sites

Phytoplankton divisions/Abundance	Idumayo	Oyilo-Adada
Chrysophyta	31, 320[a]	65, 700[b]
Shannon – Weiner index, (H')	7.54[w]	6.82[w]
Dinophyta	10, 170[c]	58, 950[d]
Shannon – Weiner index, (H')	5.89[x]	5.72[x]
Chlorophyta	24, 210[e]	43, 020[f]
Shannon – Weiner index, (H')	0.09[y]	0.00[y]
Cyanophyta	9, 540[g]	10, 170[g]
Shannon – Weiner index, (H')	0.05[z]	0.08[z]
Rhodophyta	0[e]	450[e]
Shannon-Weiner index, (H')	0.00	0.00

consequence phytoplankton community. Chrysophyta was the most abundant phytoplankton division identified in the two rivers while Cyanobacteria and Rhodophyta were the least. High abundance and diversity of Chrysophyta recorded could be due to their ability to utilize available nitrate

and other nutrient such as silicate more than other phytoplankton divisions as suggested by Schelske and Stoermer (1972).This conformed to the report of Okogwu and Ugwumba (2013) that recorded Chrysophtyta as the most abundant group in Cross River. Ekwu and Sikoki, (2006) also recorded Chrysophyta as the most abundant group in Cross River estuary. The low abundance and diversity of Cyanobacteria tend to support earlier suggestions that the rivers are low in nutrient and thus, relatively unpolluted.

In conclusion, the environmental variables and phytoplankton of the two rivers were comparatively similar although higher abundance was recorded in Oyilo-Adada River. High abundance and diversity of phytoplankton in the two rivers suggested the health status of the ecosystem although the presence of cyanobacteria indicated periodic intrusion of nutrients from riparian farmlands. However, there is need to regulate human activities at/around the rivers to maintain its water quality for sustainable use.

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Application of Artificial Neural Network For Modeling Rice Pest and Natural Enemy for Nadia District of West Bengal

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Abstract: Time series prediction of pest and natural enemies is most important for the crop management and minimizing the pesticide use and the Artificial neural network (ANN) model is most powerful Artificial intelligence (AI) machine learning models have the capacity to generalize more with less error and it is also important to investigate the convergence of the Back propagation (BP). In the present study separate and efficient neural network model was developed for Gall Midge, Brown Plant Hopper and Damsel fly and the model performance criteria such as RMSE, RMAE, CC, MEF, AIC and BIC was calculated for each stage and compared. Performance of the network at training, validation and testing stage checked using different number of epochs with minimum learning rate (0.01). Selection of best architecture was made based on Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC), that network with less AIC and BIC value were selected and which is free from over fitting. Therefore ANN methodology could be used to predict the incidence of pests and damsel fly (Natural enemy) for better management practice well in advance and to avoid the environmental pollution due to more use of chemical pesticides.

***Key Words*:** Artificial neural network, Akaike information criterion, Bayesian information criterion, Back propagation, Performance indicators

Rice has long been the staple food for more than 65% of the population in our country, India. It is the largest consumed calorie source among the food grains catering to the needs of about 70 percent of the world population and about 90% of Asian population. India is the second largest producer of rice in the world next to China with a share of more than 20 percent of the total rice production in the world. The all India area, production, and yield of rice in the year 2008-09 were 45.54 million hectares, 99.18 million tonnes and 2178 kg ha^{-1}, respectively. Among the districts in West Bengal during 2007-08, Burdwan turns out to be the district with the highest production of rice (1858.6 thousand tonnes) followed by West Midnapore and Birbhum, Bankura and Murshidabad. However, in terms of area under rice cultivation, West Midnapore stands highest, followed by Burdwan, Bankura Murshidabad and Birbhum. However, the highest productivity of rice can be traced to the district of Jalpaiguri, followed by Bankura and Birbhum. Nadia district produces 683 thousand tonnes of rice from 240.7 thousand hectare area with productivity of 2030 kg ha^{-1}. (Anon., 2010).

Severity of rice pests is influenced by crop growth, prevailing weather and time. For the efficient management of crop pest, study of impact of climate change and time on rice crop-pest interactions requires carefully collected data on long term basis. A study carried out by Rockfeller foundation in 1991, Herdt reveals that seven out of 20 major challenges in rice production are insect pest and diseases. Among the biotic stresses insect pests cause about 10- 15 per cent yield losses. The average yield losses in rice have been estimated to vary between 21-51 per cent. Yellow stem borer, brown plant hopper (BPH) and gall midge were the key pests in rice causing 25-30, 10-70 and 15-60% yield losses, respectively. At national level, stem borers accounted for 30 per cent of the losses while plant hoppers 20 per cent, gall midge 15 per cent, and leaf folder 10 per cent and other pests 25 per cent (Herdt *et al.,* 1991). Unless weather parameters, the incidence of pests in rice varies with respect to time. Therefore time series prediction of pests in rice gained more importance in the present context. Many statistical techniques are available in the literature to apply for time series prediction like,

Regression technique, Box-Jenkins Autoregressive Integrated Moving Average (ARIMA) ,Autoregressive Conditional Heteroscedasticity (ARCH), Generalized Autoregressive Conditional Heteroscedasticity (GARCH), Fuzzy regression and Artificial Neural Networks (ANN). ANN is an information processing paradigm that is inspired by the way biological nervous systems, such as the brain process information. Now a day's ANN gained more importance in the field of prediction. Some of the works on neural network was reviewed, the understanding of *Helicoverpa armigera* pest population dynamics related to chickpea crop using neural networks was studied and results showed that neural network method successfully predicts the pest attack incidences for one week (Gupta *et al.,* 2003) in advance. ANN technique was applied for forewarning crop age at first appearance of powdery mildew of mustard for using data for four years on disease severity with different dates of sowing.

The model was validated from the 5th year's data. The technique worked very well for forewarning by Agrawal *et al. (2004)*.

Further research advancement led to development of weather-based location-specific forewarning models based on multiple or stepwise regression, Discriminant function analysis, ANN for diseases and insect-pests and these have been validated with success, even with issue of agro-advisories for public use. Arun and Baskaran (2013) used ANN sigmoid activation function to predict annual rice production in Tamil Nadu which has provided 100 per cent accurate prediction. As forecasting is performed via prediction of future behaviour (unseen part) from examples of past behaviour, it is an ideal application area for ANNs, at least in principle.

By considering the advantage of ANN technique and importance of pest and natural enemy, prediction for pest of rice and damsel fly were studied and time of planting also play a very important role in escaping the pest incidence in rice and there by farmers can minimise the pesticide use for controlling the environmental pollution.

MATERIAL AND METHODS

Time series data regarding gall midge, damsel fly and Brown Plant Hopper collected from e-pest surveillance in Bidhan Chandra Krishi Vishwavidyalaya for Nadia district of West Bengal during 2013 kharif season. Nadia is a prominent district in West Bengal and covers an area of 3,927 sq km. which is located between 22 degree 53" and 24 degree 11" north latitude and 88 degree 09" and 88 degree 48" east longitude. The district is in the shape of linear and is 46 feet above mean sea level (MSL).

Artificial neural network approach: ANNs are parallel computing systems made up of a large number of simple, highly interconnected processing elements called nodes or neurons that process information by their dynamic-state response to the external signals and can handle imprecise information. Important features of ANN are a set of processing units; an activation state for each unit equivalent to its output; connections between the units, generally defined by a weight w_{jk} that determines the effect that unit j has on unit k, a propagation rule that determines the effective input of the unit; an activation function, a scalar-to-scalar function that transforms inputs to a unit; an external input (bias, offset), similar to a parameter estimate for each unit; and a method for information gathering, the so-called learning rule.

Number of training algorithms such as Back Propagation Network (BPN), Cascade Correlation Network (CNN), Conjugate Gradient Network (CGN), Genetic Network (GN), etc is commonly used in ANN. The objective in training algorithm of ANN is to reduce the global error between the predicted and targeted outputs. From the recent studies on ANN, it may be observed that the number of researchers have applied different networks.

A processing unit can be simply expressed as follows:

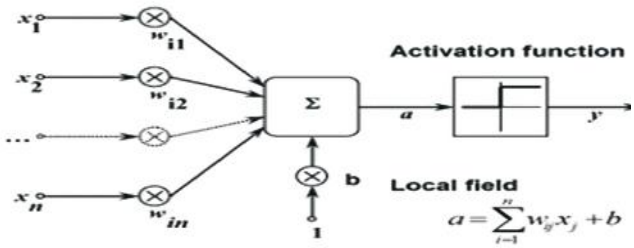

Fig. 1. Neural network

where x_1, … x_n are inputs; w_{i1}, … w_{in} are weights; and y_j is the output.

There are three types of unit (neuron): input units receive data from outside the network; output units send data out of the network; and hidden units, whose input and output remain within the network, perform internal computations to provide the nonlinearity that makes ANN powerful. Each unit can have one or more inputs but only one output. An input to a unit is either the data from outside the network, or the output of another unit, or its own output. Hidden and output units combine all values feeding into the unit using a combination function such as a linear combination function, which is then transformed by an activation function such as a sigmoid function. Weighted sum of input variables is then transformed by each hidden node using the activation function *f* which is usually a non-linear sigmoid function. In a similar manner, the output node also receives the weighted sum of the output of all the hidden nodes and produces an output by transforming the weighted sum using its activation function *g*. In time series analysis, *f* is often chosen as the Logistic Sigmoid function and *g*, as an Identity function. The Logistic function is expressed as:

$$f(y) \quad \frac{1}{1 \quad e^{\,y}}$$

Output is compared with the target value to compute the value of the error function. A variety of optimization techniques exist that can tune the weights in order to find the minimum of the error function. More on the fundamentals of ANN and computational implementations can be found in Bishop and Hertz *et al*.(1995). Of the many variations of ANN, in this study a fully connected feed-forward network, also known as a multilayered perceptron, has been used, and for simplicity a three-layer network structure (input-hidden- output layer) has been considered. As previously published weather-based models for anthracnose

(Chakraborty and Billard,1995) are based on multiple linear regression analysis, and many plant pathologists have used this approach to develop disease forecasting.

Main components of information processing in the Neural Networks are: Inputs, Weights, Summation Function (weighted average of all input data going into a processing element (PE), Transformation function and Outputs (Fig. 1). Gradient descent is the most popular algorithm and used for the training of BPN (Kaltech, 2008). Each input unit of the training data set is passed through the network from the input layer to output layer. The network output is compared with the desired target output and output error (E) is computed using Eqn. (1). This error is propagated backward through the network to each neuron, and the connection weights are adjusted based on Eqn. (2).

$$E \quad \frac{1}{2} \sum_{i\ 1}^{N} (Q_i \quad Q_i^*)^2 \qquad \text{..... Eqn. (1)}$$

$$W_{ij}(N) \qquad \frac{E}{W_{ij}} \qquad W_{ij}(N \quad 1) \qquad \text{..... Eqn. (2)}$$

In BPN, momentum factor (á) is used to speed up training in very flat regions of the error surface to prevent oscillations in the weights and learning rate (=0.01) is used to increase the chance of avoiding the training process being trapped in local minima instead of global minima.

Model selection criteria: Neutral networks and other AI machine learning models are prone to "over fitting" (Steve Lawrence *et al.,* 1997). When the numbers of parameters are increase, significant over fitting can be observed and resulted in poor generalization. The over fitting is a common problem in multilayer perceptron (MLP) and there several theories developed to determine the optimum neural network architecture and which maximizes the generalization. Chen and Adams expressed that the performance of ANN could be analysed using model performance indicators such as model efficiency, correlation coefficient, root mean square error and root mean absolute error are expressed by:

$$\text{Model Efficiency}(MEF) \quad 1 \quad \frac{\sum_{i\ 1}^{N} (Q_i \quad Q_i^*)^2}{\sum_{i\ 1}^{N} (Q_i \quad \bar{Q})^2}$$

$$\text{Correlation Coefficient}(CC) \quad \frac{\sum_{i\ 1}^{N} (Q_i \quad \bar{Q})(Q_i^* \quad \bar{Q^*})}{\sqrt{\sum_{i\ 1}^{N} (Q_i \quad \bar{Q})^2 \sum_{i\ 1}^{N} (Q_i^* \quad \bar{Q^*})^2}}$$

$$\text{Root Mean Square Error}(RMSE) \quad (1/n) \sum_{i\ 1}^{N} (Q_i \quad Q_i^*)^2 \quad ^{0.5}$$

$$\text{Root Mean Absolute Error}(RMAE) \quad (1/n) \sum_{i\ 1}^{N} |Q_i \quad Q_i^*| \quad ^{0.5}$$

Where, Q_i-Observed, Q_i*-Predicted.

In this study, the akaike information (Akaike, 1973) and Bayesian information criterion were also used to compare the model for Gall midge, BPH and Damsel fly prediction. AIC is widely used in statistical inference, the generalized final prediction error (GPE) as proposed by Moody (1992) which is a measure of the expressive power of a network. The BIC to compare models (Schwarz, 1978), it is used for large sample theory and they do not depend on priori distribution. Lower the values of AIC and BIC better will be the model. AIC and BIC can be expressed as:

$$AIC \quad n * \ln(\frac{RSS}{n}) \quad 2 * k$$

$$BIC \quad n * \ln(\frac{RSS}{n}) \quad k \ln(n)$$

Where, n-Number of data points, RSS-Residual Sum of square, k-Number of free parameters.

RESULTS AND DISCUSSION

The percent samples used in different stages of neural network model for Gall Midge (GM), Brown Plant Hopper (BPH) and Damsel Fly (DF) were presented in the table 1. For gall midge, 70% of samples used for training, 15% for validation and 15% for testing. In case of brown plant hopper, 54% of samples for training, 23% for validation and 23% samples used for testing and for damsel fly during training 46% of samples and 23% samples were used for both validation and testing. Three lags were used as an input for the gall midge and brown plant hopper architecture and 4 lags were used as an input in case of damsel fly.

Table 1. Sample used for training, validation and testing for different artificial neural network architectures of different rice pests and natural enemies

Insect	Training	Validation	Testing	lag
Gall Midge (*Orseolia oryzae*)	70	15	15	3
Brown plant hopper (*Nilaparvata lugens*)	54	23	23	3
Damsel fly (*Agriocnemis pygmaea*)	46	23	23	4

For gall midge different neural network models were tried at different epochs to achieve minimum training, validation and testing error. The 3-2-1architecture, which used 2000 epochs with logistic function (as an activation function) showed better validation performance at 1812 epoch which produced 0.064, 0.011 and 0.010 of training , validation and testing error respectively. The architecture 3-3-1 with 5000 epoch produced less training error (0.092), validation error (0.008) and testing error (0.008) at 67 epochs and the architecture 3-4-1 produced less training error (0.058), which was better as compared to 3-2-1 and 3-3-1 architectures with 2000 and 5000 epochs, respectively but

validation error and testing error, which was high as compared to rest two architectures (Table 2).

Table 2. Artificial neural network architectures for pest and natural enemy of rice with number of epochs used, training, validation and testing error

Model	Epoch	Training error	Validation error	Testing error
Gall midge (*Orseolia oryzae*)				
3-2-1	2000	0.06	0.01	0.01
3-3-1	5000	0.09	0.01	0.01
3-4-1	6000	0.06	0.09	0.06
Brown plant hopper (*Nilaparvata lugens*)				
3-5-1	2500	0.06	0.06	0.1
3-6-1	6000	0.04	0.14	0.08
3-7-1	8000	0.19	0.05	0.11
Damsel fly (*Agriocnemis pygmaea*)				
4-8-1	3000	0.04	0.04	0.08
4-9-1	4000	0.05	0.06	0.03
4-10-1	5000	0.01	0.04	0.08

The architecture 3-2-1 during training showed less Root Mean Square Error and Root Mean Absolute Error than the 3-3-1 but RMSE and RMAE was found not better than the 3-4-1, Multiple Correlation coefficient (CC) in 3-2-1 was same as that of 3-3-1 but found better than 3-4-1. Model efficiency of the architecture 3-2-1 was high compared to 3-3-1 and 3-4-1in all the three stages (training, validation and testing). During validation and testing, the architecture 3-2-1 and 3-3-1 were performed equally well than 3-4-1 based on the performance indicators (Table 3). Overall performance of the model 3-2-1 was better as compared to 3-3-1 and 3-4-1 produced less error (RMSE, RMAE), high correlation (CC) and model efficiency and it is concluded that the architecture 3-2-1 was better as compared to rest two architectures in predicting the gall midge incidence in rice for Nadia district of West Bengal (Table 4).

Neural network architectures for brown plant hopper, 3-5-1, 3-6-1 and 3-7-1 were trained using 2500, 6000 and 8000 epochs, respectively and the neural architecture 3-6-1 produced less training and testing error as compared to 3-5-1 and 3-7-1 architecture. The architecture 3-7-1 produced less validation error compared to 3-5-1 and 3-6-1 (Table 2). Performance indicators showed that, the architecture 3-6-1was better as compared to 3-5-1 and 3-7-1 during training and testing stage but in validation stage the model 3-6-1 performed inferior than rest two neural network architectures (Table 3). Overall performance of the neural network architectures for brown plant hopper revealed that, the architecture 3-6-1was found better as compared to rest of the architectures based on the performance indicators (Table 4).

The architectures for DF (Table 2), 4-10-1 with 5000

Table 3. Performance indicators for different artificial neural network architectures for gall midge (*Orseolia oryzae*), brown plant hopper (*Nilaparvata lugens*) and damsel fly (*Agriocnemis pygmaea*) of rice during training, validation and testing

Model	Performance indicators	Gall midge (*Orseolia oryzae*) Training	Validation	Testing	Model	Brown plant hopper (*Nilaparvata lugens*) Training	Validation	Testing	Model	Damsel fly (*Agriocnemis pygmaea*) Training	Validation	Testing
3-2-1	RMSE	0.15	0.03	0.02	3-5-1	0.09	0.06	0.1	4-8-1	1.32	1.44	2.75
	RMAE	0.37	0.16	0.14		0.3	0.2	0.24		1.06	0.95	1.34
	CC	0.98	0.99	0.99		0.96	0.95	0.86		0.99	0.83	0.99
	MEF	0.96	0.99	0.99		0.98	0.98	0.99		0.99	0.99	0.99
3-3-1	RMSE	0.21	0.02	0.02	3-6-1	0.06	0.11	0.07	4-9-1	1.58	1.99	1.19
	RMAE	0.42	0.13	0.14		0.22	0.25	0.21		1.2	1.34	0.96
	CC	0.99	0.99	0.99		0.98	0.92	0.93		0.98	0.95	0.99
	MEF	0.94	0.99	0.99		0.99	0.98	0.99		0.99	0.98	0.99
3-4-1	RMSE	0.12	0.19	0.13	3-7-1	0.06	0.09	0.1	4-10-1	0.52	1.35	2.61
	RMAE	0.33	0.4	0.36		0.23	0.22	0.24		0.72	1.13	1.49
	CC	0.98	0.98	0.99		0.98	0.95	0.86		0.99	0.96	0.99
	MEF	0.96	0.94	0.97		0.99	0.99	0.98		0.99	0.99	0.99

Where, RMSE-Root Mean Square Error, RMAE-Root Mean Absolute Error, MEF-Model Efficiency, and CC-Multiple Correlation Coefficient

Table 4. Overall performance of different artificial neural network architectures for gall midge (*Orseolia oryzae*), brown plant hopper (*Nilaparvata lugens*) and damsel fly (*Agriocnemis pygmaea*)

Model	RMSE	RMAE	CC	MEF
Gall midge (*Orseolia oryzae*)				
3-2-1	0.12	0.31	0.98	0.97
3-3-1	0.17	0.35	0.98	0.94
3-4-1	0.14	0.35	0.98	0.96
Brown plant hopper (*Nilaparvata lugens*)				
3-5-1	0.11	0.31	0.94	0.97
3-6-1	0.1	0.28	0.95	0.98
3-7-1	0.11	0.29	0.94	0.98
Damsel fly (*Agriocnemis pygmaea*)				
4-8-1	1.81	1.11	0.97	0.99
4-9-1	1.61	1.18	0.98	0.99
4-10-1	1.52	1.06	0.98	0.99

Where, RMSE-Root Mean Square Error, RMAE-Root Mean Absolute Error, MEF-Model Efficiency, and CC-Multiple Correlation Coefficient

epochs produced less training error (0.018) than 4-8-1(0.041) and 4-9-1 (0.051), validation error (0.044) was found less in the architecture 4-8-1 than the validation produced by 4-9-1 and 4-10-1. In testing, 4-9-1 (0.039) produced less error as compared to 4-8-1(0.084) and 4-10-1(0.089). Performance of the architecture 4-10-1 was less during training and validation stage based on RMSE (0.524), RMAE (0.716), CC (0.99) and MEF (0.998). In testing stage model 4-9-1 found better RMSE (1.193), RMAE (0.961) and CC and MEF found better in all the 3 ANN architecture (Table 3) and after comparing the model based on overall performance of the performance indicators *viz.,* RMSE, RMAE, CC and MEF, it is evident that, architecture 4-10-1 found better as compared to 4-8-1 and 4-9-1 based on the RMSE (1.5157), RMAE (1.0641), CC (0.9938) and MEF (0.9822) (Table 4).

AIC and BIC value for 3-2-1 architecture was less as compared to 3-3-1 and 3-4-1. The architecture 3-2-1 considered as best architecture as compared to 3-3-1 and 3-4-1, even all the performance indicators (Table 3) showed better and there was no significant over fitting observed from the model 3-2-1 and also the number of free parameters was less as compared to 3-3-1 and 3-4-1. Therefore neural network 3-2-1 is the optimum architecture for the gall midge prediction. Neural network architecture 3-5-1 for brown plant hopper prediction and 4-8-1 for damsel fly found low AIC and BIC value as compared to 3-6-1 and 3-7-1 architecture for brown plant hopper and the architecture 4-8-1than 4-9-1 and 4-10-1 for damsel fly. Architecture 3-5-1 in case of brown plant hopper and 4-8-1 considered as optimum architecture for the prediction of BPH and damsel fly prediction respectively (Table 5).

Neural network architecture in case of brown plant hopper and damsel fly prediction *viz.,* 3-5-1 and 4-8-1 were found better in terms of selection criteria and had less parameter as compared to rest two architectures. From this study it is clear that, when the number of parameters goes on increasing, the generalization capacity of the neural network diminishes due to over fitting (Steve Lawrence *et al*., 1997). Therefore the architectures 3-2-1 for gall midge, 3-5-1 for brown plant hopper and 4-8-1 for damsel fly found optimum for the future prediction of the pest and natural enemies in rice crop. Even though other models performed better in terms of RMSE, RMAE, CC and MEF but due to high AIC and BIC value those architectures were significantly suffered from over fitting and cannot considered as a better architectures for the prediction purpose.

MLP trained with BP are biased towards smoother solutions and problem of over fitting is most common. Therefore in the present study the architectures for gall midge, brown plant hopper and damsel fly were tried with MLP and architecture found over fitted due to high AIC and BIC values even though the models were better based on the performance indicators, but failed in the approximation. Therefore the ANN architectures with less AIC and BIC were selected for the prediction purpose.

Many of the researchers (Vivekanandan, 2011; Chen and Adams, 2006; Patrick Carriere *et al*., 1996) selected the neural network architecture based only on the

Table 5. Akaike information criterion and Bayesian information criterion for gall midge (*Orseolia oryzae*), brown plant hopper (*Nilaparvata lugens*) and damsel fly (*Agriocnemis pygmaea*) for best architecture selection

Insect	Model	k	RSS	AIC	BIC
Gall midge (*Orseolia oryzae*)	3-2-1	8	0.20	-54.23	-48.05
	3-3-1	12	0.41	-34.68	-25.41
	3-4-1	16	0.27	-33.53	-21.16
Brown plant hopper (*Nilaparvata lugens*)	3-5-1	20	0.162	-33.532	-18.08
	3-6-1	24	0.137	-28.215	-9.673
	3-7-1	28	0.161	-17.606	4.027
Damsel fly (*Agriocnemis pygmaea*)	4-8-1	40	39.28	94.37	125.27
	4-9-1	45	31.09	100.63	135.40
	4-10-1	50	27.57	108.71	147.34

Where, k-Number of free parameters, RSS- Residual Sum of Square, AIC-Akaike Information Criterion, BIC-Bayesian Information Criterion

RMSE, RMAE, CC and MEF but only these are not sufficient for selecting the best architecture and sometimes architecture may fail due to significant over fitting. Therefore, the most important model criteria's are AIC and BIC (for large samples) should be used as a solution for over fitting and to select the most efficient neural network architecture (Gaurang Panchal *et al.,* 2010). It is concluded that, the architectures with less free parameters have more generalization capacity and free from over fitting. The performance indicators (RMSE, RMAE, CC and MEF) along with AIC and BIC could be used to find a most efficient Artificial Neural Network architecture. The MLP trained with back propagation is very important and powerful methodology and it could be used to predict the pest incidence and population dynamics of natural enemies for the Nadia district of West Bengal.

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Efficacy of Some Plant Powders against *Lasioderma serricorne* Fab. in Fennel

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***Abstract*:** Six plant products *viz.*, neem kernel, karanj kernel, neem leaf, eucalyptus leaf, datura leaf and mint leaf (@ 1.0, 3.0 and 5.0 g/100g) were evaluated against *Lasioderma serricorne* infesting stored fennel under laboratory conditions. Significant differences were observed in developmental period, adult emergence, longevity of adults, grain damage and weight loss between treated and control sample. Neem kernel powder was found to be most effective in increasing the developmental period (71.04 days) and reducing adult emergence (20.35 per cent), longevity of adult (male: 10.17 days and female: 13.10 days), seed damage (9.95 per cent), weight loss (2.72 per cent) followed by karanj kernel, datura leaf, neem leaf, mint leaf and eucalyptus leaf powder at 5.0 g/100g seed.

Key Words: Cigarette beetle, Eucalyptus, Karanj kernal, *Lasioderma serricorne,* Neem kernal

The cigarette beetle, *Lasioderma serricorne*. (Coleoptera: Anobiidae) is the serious pest of several stored commodities. Beside its main host tobacco and cigarettes, it has also been recorded on turmeric, ginger, castor beans, wheat, coconut meal, pepper, cardamom, mustard, chilli, fennel, cumin and opium leaves (Dimetry *et al*., 2004; Mahroof and Phillips, 2008; and Sharma, 2007). Different plants were known to possess some insecticidal properties and as such they have been used in protecting the grains against the damage of number of stored grain pests in different parts of the country according to local availability of such materials. The growing awareness of environmental hazards due to synthetic insecticides has attracted attention towards pesticides of plant origin. In recent years, several plants products (leaf, kernel powder, seed extracts and seed oils) have been identified which can be used as safe and renewable sources of insecticides (Meena and Bhargava, 2005). Therefore, there is a need to develop safe alternatives to conventional insecticides and fumigants to protect stored grains and seeds from insect pest infestation.

MATERIAL AND METHODS

The fennel seeds were sterilized at 60$\pm$ 5^{0}C for 8 hours in order to eliminate both apparent and hidden infestation of insects and mites, if any. These grains were conditioned at least for a week in an environmental chamber maintained at 30$\pm$ 2^{0}C and 75 per cent relative humidity to raise their moisture content. Six plant products powder *viz.* Neem kernal powder (*Azadirachta indica* A. Juss), Karanj kernel powder (*Pongamia glabra* Vent.), Neem leaf powder (*Azadirachta indica* A. Juss), Eucalyptus leaf powder (*Eucalyptus hybrida* L. Herit), Datura leaf powder (*Datura alba* Nees) and Podina leaf powder (*Mentha arvensis* L.) were used for this study. The fine powders of different plant products were prepared by drying them in shade and then grinding in electric grinder. The powders were sieved through 60 mesh sieve and mixed with seeds @ 1.0, 3 and 5.0 g/100 g seeds. A control (untreated) was also kept simultaneously. Treatments were laid out in a completely randomised design with three replicates. Ten pairs of newly emerged adults were released in jar containing treated seeds with different plant powders for taking the observations on developmental period, adult emergence, adult longevity, seed damage and weighted loss. Development period was work out by recording the dates of egg lying and dates of adult emergence on treated food with different doses of test oils. The per cent adult emergence was worked out on the basis of number of eggs laid and number of adults emerged. The longevity of adults was determined by recording the dates of their emergence and the dates of their natural death. The per cent seed damage and weight loss was calculated as per the procedure given by Adams and Schulten (1978) and Haris and Lindblad (1981). Seed damage was calculated by counting the damaged and undamaged seeds. The loss in weight was worked out by subtracting the final weight from the initial weight and converted into % weight loss.

RESULTS AND DISCUSSION

In the present studies, all the doses of different plant powders were significantly superior in increasing the total

developmental period over control (Table 1). The developmental period in all the treatments increased with the increase in dose level. The mean developmental period varied from 46.56 to 69.17 days in different treatments. The neem kernel powder treatment showed superiority over all other treatments to enhance the developmental period of the pest (69.17 days) followed by karanj kernel powder (68.89 days). Datura leaf powder to be next effective treatment followed by neem leaf, mint leaf and eucalyptus leaf powders. No work on the effect of plant powders on the developmental period of *L. serricorne* is available, however, same type of work on other insect have been discussed. Shukla and Toke (2013) studied that plant extracts showed deleterious effects on the growth and development of stored grain insect. The increase in the developmental period is certainly due to antifeedant and repellent effect of plant products (Chebet *et al.*, 2013).

The per cent adult emergence decreased with the increase in dose level of the test compounds (Table 2). The minimum percentage of adult emergence was recorded from fennel seeds admixed with neem kernel powder followed by karanj kernel, datura leaf, neem leaf, mint leaf and eucalyptus leaf powders. These findings are slightly supported with results of Maity (2004) who reported significant reduction in adult emergence in spices admixed with neem leaf powder. Regarding the longevity of male and female beetles, it was gradually decreased with the increase in dose level of each treatment (Tables 3 and 4). While assessing the results of different plant powders, it was found that the neem kernel powder was the most effective in reducing the longevity of both sexes. Not much work is available on the effect of plant powders on the longevity of adults, however, Jain and Kumar (2001) found significant effect of neem kernel and leaf powders on the longevity of adults of *Corcyra cephalonica*. Shukla and Toke (2013) reported that plant extract reduce the larval and pupal period of the stored grain insect.

While comparing the data on the effectiveness of various plant powders against *L. serricorne,* it was observed that neem kernel, karanj kernel and datura leaf powders exhibited effective control of this pest thereby reducing the grain damage and weight loss appreciably (Tables 5). Powders of neem leaf and mint leaf were moderately effective but eucalyptus leaf powder was less effective in reducing the grain damage and weight loss. Not much work is available so it was correlated with the other pests. Chebet *et al.* (2013) reported that crude powder of Azadirachta indica cause 46.2-52.2 per cent reduction in grain damage by *Prostephanus truncates*. Chander (2003) found significant reduction in grain damage and weight loss by *R. dominica* with karanj kernel, dharak leaf, and datura leaf powder treatments, support the present findings.

Table 1. Effect of plant powders on total developmental period of *L. serricorne*

Dose (part per 100 parts of seeds w/w)	Neem kernel powder	Karanj kernel powder	Neem leaf powder	Eucalyptus leaf powder	Datura leaf powder	Mint leaf powder	Mean
1.0	67.32	67.98	57.13	44.25	63.33	47.15	58.03
3.0	69.15	68.12	60.87	46.74	64.90	59.50	59.88
5.0	71.04	70.57	62.42	48.69	66.44	51.34	61.75
Mean	69.17	68.89	60.14	46.56	64.89	49.33	
Control	43.49						
CD (p=0.05) Treatment-0.56; Dose-0.39; Treatment x Dose-0.95							

Table 2. Effect of plant powders on adult emergence of *L. serricorne*

Dose (part per 100 parts of seeds w/w)	Neem kernel powder	Karanj kernel powder	Neem leaf powder	Eucalyptus leaf powder	Datura leaf powder	Mint leaf powder	Mean
1.0	33.23(35.20)	36.73(37.30)	44.09(41.55)	59.76(50.63)	41.13(39.89)	51.79(46.03)	44.44(41.77)*
3.0	26.67(31.09)	28.29(32.13)	40.21(39.35)	53.21(46.84)	36.25(37.02)	49.37(44.64)	39.0(38.51)
5.0	20.35(26.81)	25.37(30.24)	35.34(36.47)	45.70(42.53)	31.67(34.25)	45.81(42.60)	34.04(35.48)
Mean	26.75(31.04)	30.13(33.23)	39.85(39.13)	52.89(46.67)	36.35(37.05)	48.99(44.42)	
Control	71.08(57.90)						
CD (p=0.05) Treatment-0.37; Dose-0.26; Treatment x Dose-0.65							

* Percentages transformed to angles; outside values are its back transformation to percentages

Table 3. Effect of plant powders on longevity of male and female adult of *L. serricorne*

Doses (part per 100 parts of seed w/w)	Neem kernel powder		Karanj kernel powder		Neem leaf powder		Eucalyptus leaf powder		Datura leaf powder		Mint leaf powder		Mean	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
1.0	15.30	16.00	19.95	20.23	23.87	24.27	29.23	29.01	20.0	22.00	27.23	26.97	22.93	23.08
3.0	13.77	14.13	17.01	17.33	21.98	22.32	27.03	26.63	19.16	19.66	25.25	25.03	20.70	20.85
5.0	10.17	13.10	14.25	15.00	20.33	21.30	26.00	25.99	17.25	17.23	23.00	23.24	18.50	19.31
Mean	13.08	14.41	17.07	17.52	22.06	22.63	27.42	27.21	19.47	19.63	25.16	25.08		
Control	38.00	38.94												

CD (p=0.05)	Male	Female
Treatment	1.35	1.49
Dose	0.95	1.06
Treatment x dose	2.34	2.59

Table 4. Effect of plant powders on grain damage by *L. serricorne*

Dose (part per 100 parts of seeds w/w)	Neem kernel powder	Karanj kernel powder	Neem leaf powder	Eucalyptus leaf powder	Datura leaf powder	Mint leaf powder	Mean
1.0	17.12(24.44)	20.85(27.15)	25.39(30.25)	29.12(32.65)	23.52(28.10)	28.00(31.94)	24.00(29.24)*
3.0	15.12(22.88)	18.25(25.29)	23.87(29.23)	25.00(29.99)	18.52(25.76)	23.16(28.76)	20.72(26.98)
5.0	9.95(18.42)	11.27(19.60)	21.57(27.66)	21.33(27.50)	14.23(22.14)	20.03(26.58)	16.38(22.93)
Mean	14.06(20.48)	16.79(24.02)	23.61(29.05)	25.15(30.05)	18.89(25.63)	23.73(29.09)	
Control	41.05(39.84)						
CD (p=0.05) Treatment-1.04; Dose-0.73; Treatment x Dose-1.79							

*Percentages transformed to angles; outside values are its back transformation to percentages

Table 5. Effect of plant powders on weight loss by *L. serricorne*

Dose (part per 100 parts of seeds w/w)	Neem kernel powder	Karanj kernel powder	Neem leaf powder	Eucalyptus leaf powder	Datura leaf powder	Mint leaf powder	Mean
1.0	5.73(13.74)	6.20(14.32)	11.03(19.39)	13.20(21.27)	8.11(16.54)	11.35(19.68)	9.27(17.49)*
3.0	3.88(11.23)	4.48(12.18)	5.57(15.93)	9.45(17.89)	8.05(16.44)	8.33(16.74)	6.96(15.07)
5.0	2.72(9.43)	3.33(10.36)	4.77(12.54)	7.44(15.79)	5.17(13.10)	5.19(13.11)	4.77(12.39)
Mean	4.11(11.47)	4.67(12.29)	7.79(15.95)	10.03(18.31)	7.11(15.36)	8.29(16.51)	
Control	16.69(24.12)						
CD (p=0.05) Treatment-1.50; Dose-1.06; Treatment x Dose-2.60							

*Percentages transformed to angles; outside values are its back transformation to percentages

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Determinants of Household Probability to Take Up Non-Farm Activity-An Application of Logit Analysis

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***Abstract*:** Non-farm activities play an important role in rural economy in a country like India. In order to examine the factors influencing to take up non-farm activity, the present study utilized the data collected in the irrigated command area of Mandya district. The data collected on 900 households, selected using two stage sampling is used in the study. Logit model is used to identify the determinants of household probability to take up non-farm activity. The entire command area one-third of households have probabilities of more than 0.5 to take up non-farm activity. The variables education, age, number of working adults and annual farm income, land holding were significant in the model in classification of households into households with and without non-farm activity. The households which had younger members, and who have more years of schooling and three or four working adults and larger land holding have a greater chance of taking up non-farm activity. In areas with less irrigation, farm households take up non-farm activity as an alternate source of income.

Key Words: Binary Logit Model, Non-Farm Activity, Odds ratio, Probability

The rural economy of India is predominantly based on agriculture and other allied activities related to agriculture sector. Rural development includes progress both in farm and non-farm activities. Non-farm activities provide not only alternative sources of income and employment for the rural poor but also stimulate agricultural production. Rural population mainly depends on agriculture sector both for employment and livelihood. The agriculture sector is unable to create additional gainful employment to absorb growing rural population. The population pressure in rural areas has resulted in fragmentation of land holdings making them uneconomical. The employment in agriculture is seasonal. Considering the increased pressure on land, there exists a limited scope for increasing employment in agriculture. Hence, the employment in the non-farm sector becomes an important option for studies. The share of non-farm income and employment in the total income and employment among the rural household plays an important role in the rural economy of India. There are also evidences to show that productivity and profitability in the non-farm sector is generally higher than in the non-farm sector (Fisher *et al*., 1998).

The rural non-farm sector comprises of all the non-farm activities other than crop and animal husbandry taken up by the farm households which are carried out in the rural areas. They are: manufacturing and processing, repair, construction, trade and commerce, transport and other supporting services in villages and rural towns undertaken by the farm house holds.Thus, this study helps in identifying the determinants and impacts of non-farm activities, also provide necessary analytical insights and also provide clues about the character of socio-economic changes which might be induced by the adoption of employment-oriented strategy to promote the rural non-farm economy. In order to examine the role of non-farm activities in augmenting income of rural household and providing employment opportunities in the irrigated Command area, the present study was undertaken in the Cauvery Command area of Mandya district, with the objective of estimating household probability to take up non-farm activity.

MATERIAL AND METHODS

The data collected in the project “Role and contribution of irrigation to rural non-farm activity-A case of Cauvery Command” funded by MOSPI, Government of India, was used for the investigation (Gopinath Rao and Chandrashekar, 2012).The details regarding age of the farmer, education level, family composition, land holding pattern, crops grown, livestock maintained, non-farm activities: nature, investment made, seasonality of produce, type of raw material, number of persons engaged and income generated of sample households from the three reaches of

each 300 households, total of 900 families were collected.

Logit model: Assuming a normally distributed error term (v_i), the parameters of logit model are estimated using a maximum likelihood estimation procedure and this was done through a software GRETL. Logit model is estimated for the entire command area and also estimated for all the three reaches by using the above six explanatory variables. A binary logit model is useful for the kind of a situation where the prediction of the outcome is binary (Yes/No) based on values of a set of predictor (explanatory) variables is needed. Hence, in the present study a binary logit regression model was used to determine the probability of a household to take up non-farm activity.

In this analysis, dependent variable (Y_i) is the household taking or not taking the non-farm activity. The major interest is the probability of household taking up non-farm activity. Since Y_i is a random variable (dichotomous), it can take the values 0 or 1, where 1 denotes the household taking non-farm activity and 0 denotes the household not taking up non-farm activity.

$$y_i \quad \begin{matrix} 0, & 1 \quad p_i \\ 1, & p_i \end{matrix}$$

If X_1,....., X_n are explanatory variables, then the logistic model specifies that the conditional probability of event (i.e., that Y = 1) given the values of X_1.....,X_n is as follows

$$p(y_i) \quad \frac{1}{1 \quad e^{\hat{a}_0 \quad \hat{a}_i X_i \quad v_i}}$$

Where, v_i is an error term

For ease of interpretation of the coefficients, a logistic model could be written in terms of the odds and log of odd. The odds ratio is the ratio of the probability that a household having non-farm activity (p_i) to the probability of a household not taking non-farm activity (1- p_i). That is:

$$\frac{p_i}{1 \quad p_i} \quad e^{\hat{a}_0 \quad \hat{a}_i x_i \quad v_i}$$

In order to linearize the right hand side, we take logarithm on both sides

$$\ln \quad \frac{p_i}{1 \quad p_i} \quad \hat{a}_0 \quad \hat{a}_i x_i \quad v_i$$

Six important explanatory variables have been selected from the data for the logit model analysis, they are defined as follows

X_1 = Age of family head (years); X_2 = Education (Number of years of schooling); X_3 = Number of Working Adults in the family (NWA); X_4 = Land holding (hectare) (LH); X_5 = Annual farm income (Agriculture + Animal husbandry) Income (Rs) (AFI); X_6 = Other income (Dummy variable, if Yes=1 and No=0)

Multi-collinearity test: Multi-collinearity is near linear independence among the explanatory variables. The presence near linear dependence can dramatically impact the ability to estimate the Logit regression coefficients. Variance inflation factor (VIF) is a very useful technique in detecting multicollinearity among the explanatory variables and values of more than 10 indicate a high degree of collinearity among the independent variables. VIF was estimated using the formula stated below

$$VIF_j = \frac{1}{1 - R_j^2} \quad j = 1, 2 \ldots p$$

where, R^2_j is coefficient of determination obtained when X_j variable is regressed on the remaining (p-1) regressors.

RESULTS AND DISCUSSION

The results of the logit model for the entire command area reveals that the variables education of the family head and the number of working adults in the family are significantly contributing to the model in all the reaches (Table 1). The variable age of the family head and land holding of the household are significant in upper and in the entire reach but, the variable annual farm income is significant for the entire reach. The variables such as education, number of working adults, land holding and Other income have positive coefficient (i.e., odds ratio will be greater than 1) indicates the increase of probability in taking up non-farm activity whereas the variable age of family head has negative coefficient (i.e., odds ratio will be less than 1) showing the decrease of probability in taking up non-farm activity. The coefficient of the variable annual farm income is close to zero (i.e., odds ratio is nearly equal to one) indicating that no change in the odds, but negative sign of the coefficient indicates that chance of taking up non-farm activity decreases with increase in annual farm income**.** The distribution of households with regard to probabilities to take up non-farm activity based on the estimated coefficients of entire command area is positively skewed (Table 2). Out of 900 sample households, 35.9 per cent of households have probability of more than 0.5 to take up non-farm activity, and remaining 64.1 per cent of households have probability less than 0.5 to take up non-farm activity. The maximum number of households of about 77.3 per cent falls under the probabilities in the range 0.3 to 0.6 to take up non-farm activity. 7.2 per cent and 15.2 per cent of households have probability less than 0.3 and more than 0.6 respectively to take up non-farm activity.

The probability for an annual farm income of Rs.

Table 1. Logit estimates of three reaches and entire command area

Variables	Upper reach		Middle reach		Lower reach		Entire area	
	b_i's	Odds ratio	b_i's	Odds ratio	b_i's	Odds ratio	b_i's	Odds ratio
Constant/ intercept	- 0.6510	0.5215	- 1.9092**	0.1482	- 1.6956**	0.1902	- 1.2808**	0.2778
X_1	- 0.0274*	0.9729	0.0052	1.0052	0.0053	1.0053	- 0.0077	0.9924
X_2	0.0931*	1.0975	0.0533*	1.0548	0.0959*	1.1006	0.0691**	1.0716
X_3	0.2928*	1.3402	0.3604**	1.4340	0.2315*	1.2604	0.3073**	1.3597
X_4	0.2528*	1.2876	0.0875	1.0914	0.0477	1.0489	0.0946*	1.0992
X_5	- 1.06E-05*	0.9999	- 4.03E-06	0.9999	- 4.34E-06	0.9999	- 4.96E-06*	0.9999
X_6	0.0671	1.0694	- 0.1464	0.8639	0.2651	1.3036	0.0732	1.0760

*significant at 5 per cent level of significance; **significant at 1 per cent level of significance

Table 2. Frequency distribution of households with respect to their probabilities of taking up non-farm activity for the entire area

Probability	Number of households	Percent
0.2-0.3	65	7.22
0.3-0.4	220	24.44
0.4-0.5	292	32.44
0.5-0.6	184	20.44
0.6-0.7	79	8.78
0.7-0.8	39	4.33
0.8-0.9	14	1.56
0.9-1.0	7	0.78
Total	900	100.00

Table 3. VIF values for all the variables used in the logit models

Variable	Variance inflation factor (VIF)			
	Upper	Middle	Lower	Overall
Age of family head (Years)	1.113	1.164	1.174	1.116
Education (Number of school years)	1.386	1.335	1.138	1.237
Number of working adults	1.763	1.471	1.243	1.445
Land holding (hectares)	2.384	4.961	1.271	1.241
Annual farm income (Rs)	2.493	4.436	1.410	2.377
Other income	1.222	1.018	1.040	1.044

100,000 and for age group of 25 with specific levels of other variables by using the above estimated coefficients of entire command area as estimated and shown in the figure 1. It is observed that the households of age group 25 the probability to take up non-farm activity is highest (0.6407) for the household with 4 hectares of land, 4 working adults in the family, 10 years of schooling and no other source of income. Similarly the probability to take up non-farm activity is lowest (0.2514) for the household with no education, two hectares of land, and two working adults in the family and no other source of income. The households of age group 50 the probability to take up non-farm activity is highest (0.6407) for the household with 4 hectares of land, 4 working adults in the family, 10 years of schooling and no other source of income (Fig. 2). Similarly the probability to take up non-farm activity is lowest (0.2514) for the household with no education, two hectares of land, and two working adults in the family and no other source of income. These studies indicate how the variables are influencing to take up non-farm activity. The probabilities are increasing from top to bottom because the variables as education, number of working adults, land holding and other income have positive coefficient showing the increase of probability in taking up non-farm activity. The probabilities in fig. 2 is less than the probabilities in fig. 1 for the same values of variables except

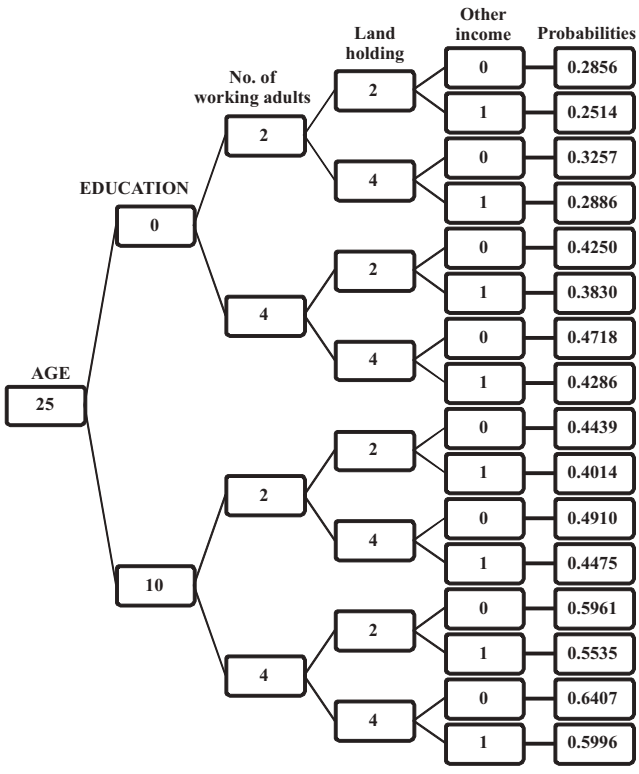

Fig. 1. Flow chart showing probabilities of taking non-farm activity for the age group of 25

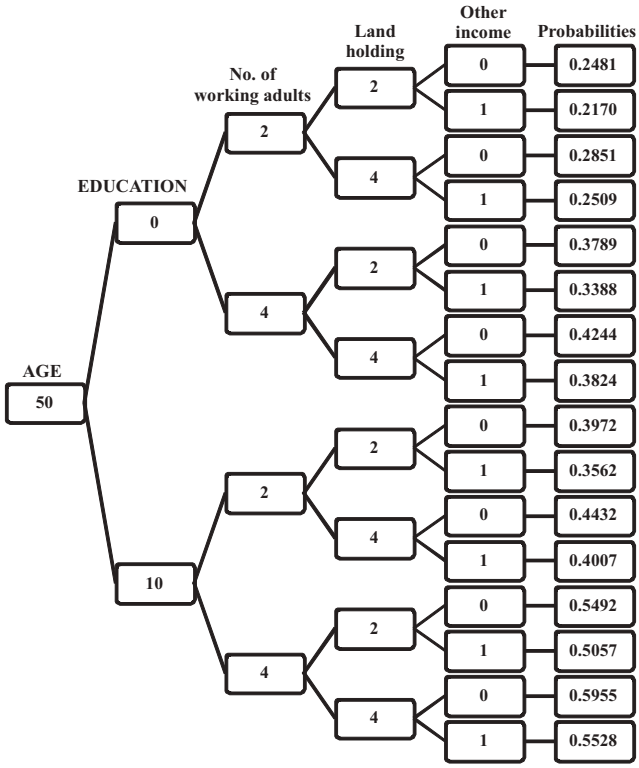

Fig. 2. Flow chart showing probabilities of taking Non-farm activity for the age group of 50

age which indicates that the variable age of family head has negative coefficient showing the decrease of probability in taking up non-farm activity.

Multi-collinearity test among independent variables used in the model: Variance inflation factor values of more than 10 indicate a high degree of collinearity among the independent variables. Table 3 shows that the variables which are included in the above models have VIF less than 10. Hence, it can be safely concluded that the variables selected for study have no problem of multi-collinearity.

All the above models are significant with respect to log likelihood chi-square and two third of households are correctly classified with the help of logit model (Table 4).

Table 4. Performance of Logit model in different reaches

Parameters	Upper	Middle	Lower	Entire
Per cent of households correctly predicted	68.0	62.0	60.3	67
Chi-square	32.7*	32.8*	13.6*	22.5*

*significant at 1 per cent level of significance

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Community Participations in Disaster Management: A Case Study of Bangladesh

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Abstract: Peoples of the Bangladesh witness natural and other disasters every year that causing serious natural, environmental, ecological, agricultural and human disruptions. The study was conducted with 245 participants in the upazila (sub-division) of Morelganj and Sharankhola in the district of Bagherhat, Bangladesh. The young (60%) and higher educated people (41.62%) were more interest and concern in disaster management and the coastal people (46.53%) was severe affected by flood, cyclone and storm that makes them more vulnerable in the society and most of the people (58.37%) do not get warning information of disasters due to lack of modern weather forecasting technology. Moreover, people of coastal areas use their indigenous knowledge to mitigate the risk of natural disaster and there was no opportunity for general people (88.92%) to participate with government policy in disaster management. The government and NGOs should planned to further consolidate the empowerment process by realizing community capacity-building through awareness building, training and skill development of the local people and expanding disaster management studies in the education system for effective disaster management in Bangladesh.

Key Words: Bangladesh, Natural disaster, Community participation, Disaster management

Bangladesh is fifth in the list of 173 countries that are most prone to natural disasters. There are about 150 million people in the country and stands out in a poverty league with more than half of its population estimated (50%) to live below the poverty line and more than one-third living in extreme poverty (World Bank, 2014). The frequency of natural disasters within the boundaries of Bangladesh has increased during recent years and its geographical disaster vulnerability is due to its exceedingly flat, low-lying, alluvial plain covered by over 230 rivers. Peoples of this poor country witness natural and other disasters every year, causing serious natural, environmental, ecological, agricultural and human disruptions (Islam and Hasan, 2015). The areas of riverside, commonly known as coastal areas in the district of Bagherhat is subject to frequent environmental hazards like floods, cyclone and storm surges, tornadoes, drought and riverbank erosion. In 2007, a total of 30 districts including Bagherhat District were affected by the cyclone *SIDR* (very severe cyclonic storm). Out of them, 12 were affected seriously and the rest partially. About 10 million people affected, as more than 5,000 people faced death in the cyclone *SIDR* (Hossain, 2009). High tides and occasional cyclone storm surges from the Bay of Bengal also cause floods in the coastal areas. Cyclone and the associated storm surges, take a massive toll of lives and properties, rainfall and river floods are annual phenomena causing unfold miseries to the peoples and damages to crops, properties and infrastructures in Bagherhat District (Islam and Hasan, 2015).Despite its renowned experience and on-going progress for coping with disaster, Bangladesh still experiences a dearth of optimal coordination among physical, societal and technological systems in its most hazardous zones (Alam and Collins, 2010).

Community participation, generally, refers to the involvement of people in any project to solve their own problems or to develop their socio-economic conditions. They participate in setting goals and preparing, implementing and evaluating plans and programs (Hossain, 2013). A study by Zamir (2006) suggests that disaster management within Bangladesh requires a community-based approach. This is particularly true with regard to containing the pernicious effects of regular flooding in communities residing near wetlands and riverbanks. This format is using in Switzerland, Germany, China, Korea and Japan to respond during times of natural disasters (Fawcett, 2012). Hence, disaster event should be faced with proper plan and programs through which active participation of affected people has to be ensured in an attempt to reduce the damages of property and to shorten the pains and sufferings of people as well as enhance the sustainable development process (Hossain, 2013). The active participation of the local communities will be more effective in enhancing local capacity building to recover the disaster affected coastal people in Bangladesh (Islam and Hasan, 2015). Hence, the present study intends to explore the community participation in disaster management programs and policies and coping strategy in pre-disaster, during disaster and post-disaster in coastal Bangladesh.

MATERIAL AND METHODS

The study was conducted on 2013 (January to July) in four villages (Baraikhali, Jeodhara, Dhansagar and Khontakata) at the Upazila (sub-division) of Morelganj and Sharonkhola in the district of Bagherhat, Bangladesh which are of the most disaster prone areas in the country. The study employed a survey and face to face interview used a semi-structured interview schedule. The purposive samples were carried out with 245 participants who included local peoples, government and Non-Government Organizations (NGOs) officials at the Upazila of Morelganj and Sharonkhola. Data were analyzed by descriptive statistics and findings were presented by tables, figures and graphs (Fig. 1).

RESULTS AND DISCUSSION

A survey and face-to-face interview was conducted with 245 local people to find out the participation mechanism of people in disaster management process. Among the participants, 64.89 percent of male and 35.11 percent of female were in the field and most important things was near 60 percent of young people (21 to 40 years age group) were showing more interest and concern on disaster management (Table 1). Increasing age gradually erodes the physical capabilities of the people and puts them in disadvantaged situation than the younger cohort (Hutton and Haque, 2004). However, experience may help them in coping strategy during disaster. Special attention should be given to ensuring that all groups are able to participate, including those with specific needs and/or those who are marginalized and lacking a voice in decision-making (Islam *et al.,* 2013).

A similar finding on marital status was that 69.79 percent were married. It was proved that the rate of divorce was very low in the study areas. It appeared that 41.62 percent respondents were complicated tertiary level

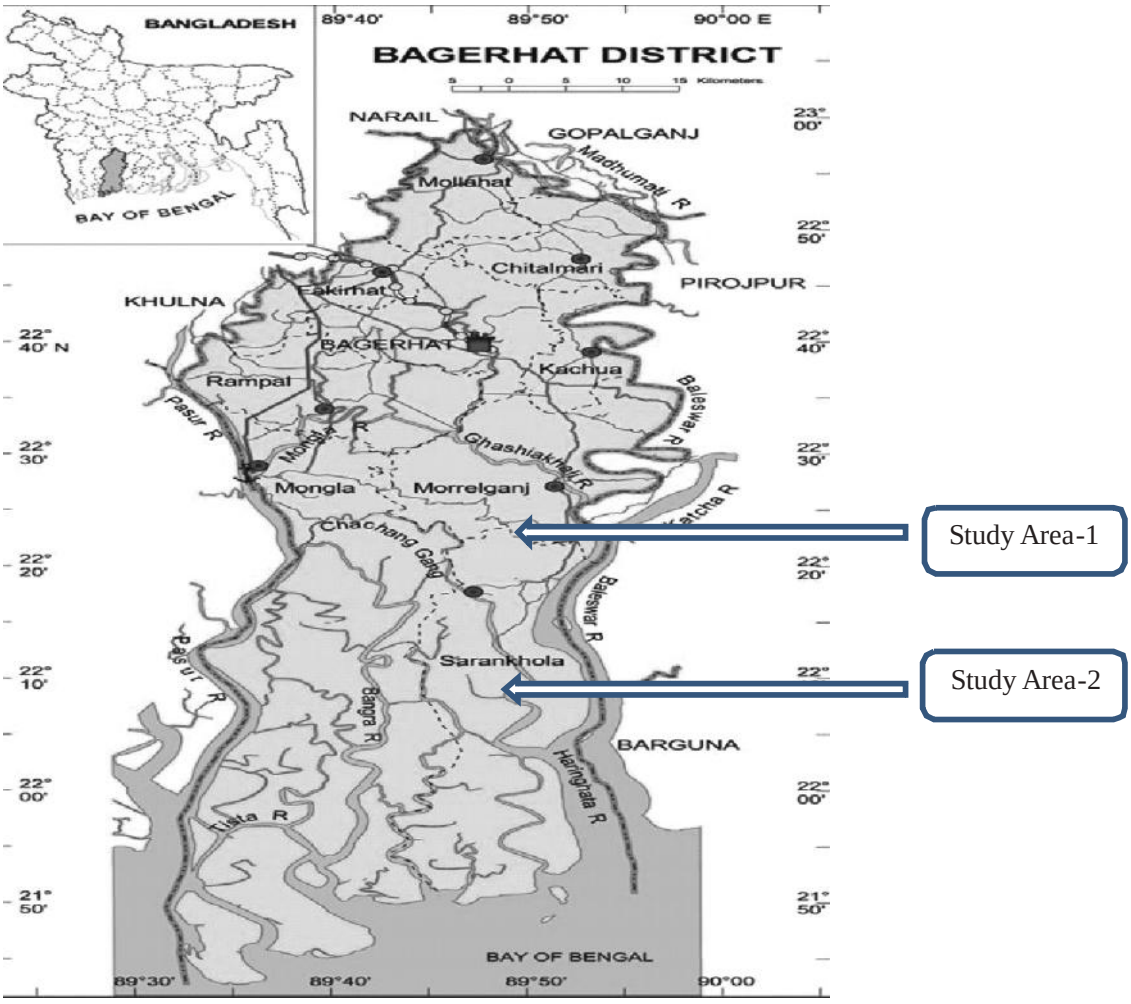

Fig. 1. Map of the district of Bagerhat in Bangladesh

Table 1. General information of the respondents

General information	Number of respondents (per cent)
Gender of the respondents	
Male	159 (64.89)
Female	86 (35.11)
Age of the respondents years	
0-20	13 (5.30)
21-30	68 (27.75)
31-40	79 (32.24)
41-50	43 (17.55)
51-60	27 (11.02)
61+	15 (6.12)
Marital status of the respondents	
Married	171 (69.79)
Unmarried	61 (24.89)
Divorced	07 (2.85)
Widow	06 (2.44)
Education qualification	
Primary	57 (23.26)
Secondary	39 (15.92)
Higher secondary	47 (19.18)
Graduate	61 (24.89)
Post graduate	41 (16.73)
Category of the respondents	
Community peoples	205 (83.67)
Union Council (UC) officials	28 (11.42)
NGO officials	08 (3.26)
Govt. officials	04 (1.63)
Profession of the respondents	
Student	27 (11.02)
Agriculture	49 (20)
Government job	47 (19.18)
NGO job	15 (6.12)
Fisherman	39 (15.91)
Business	23 (9.38)
Housewife	45 (18.36)

education and it could be highlighted that higher educated person was more concern about natural disaster, environment pollution and effective disaster management. Education is considered as one of the crucial determinants of coping and adaptation for both supporting survival and enhancing quality of life (Paul and Routray, 2011).The study was selected communities people (83.67%) as they are always suffered by natural disaster and involved in disaster management and their opinion is more valuable to make proper policy for disaster management in Bangladesh. Community participation initiatives are likely to be most effective when viewed as key elements in much wider processes of disaster prevention, sustainable development planning and institution-building, rather than as stand-alone local projects concentrating on short-term disaster preparedness goals (Allen, 2006). The majority (35.91%) respondents were farmer and fisherman who relied on their livelihood on agricultural activities and fishing (Table 1). The economy of Bangladesh is based on agriculture with two thirds of the population engaged (directly or indirectly) on agricultural activities (Hossain and Rao, 2014; Hossain *et al*., 2016). Hence, the overall impact of disaster change on agricultural production in Bangladesh would be wide spread and devastating for the country's economy. Beside this, other impacts of climate change such as - extreme temperature, drought and salinity intrusion are also responsible for the declining crop yields in Bangladesh.

The study shown that 46.53 per cent respondents mentioned they were severe affected by flood, cyclone and storm in each year. Almost one fourth of the total population of the country live in the coastal areas of Bangladesh, where majority of the population are affected by coastal floods/tidal surges, river-bank erosion and salinity. Tropical cyclones and storm are particularly severe in the Bay of Bengal, Bangladesh (Haque *et al*., 2012). During disaster period, 72.64 per cent established that they loss of crops-livestock, trees, houses and that makes them more vulnerable in the society (Fig 2). The death in livestock was 44,602 cattle (37391 cow and 7211 buffalo), 63,321 sheep and goat and 25,73,019 chicken and duck in 2007. The huge death of livestock is indicating the remarkable weakness or negligence of the preparedness of cyclone *SIDR* for saving the life of animals and birds (DLS, 2013). There is evidence that more women die in cyclone and flash-flood events than men (Alam and Collins, 2010).

The loss of human life has been drastically reduced due to pre and posts disaster management activities.

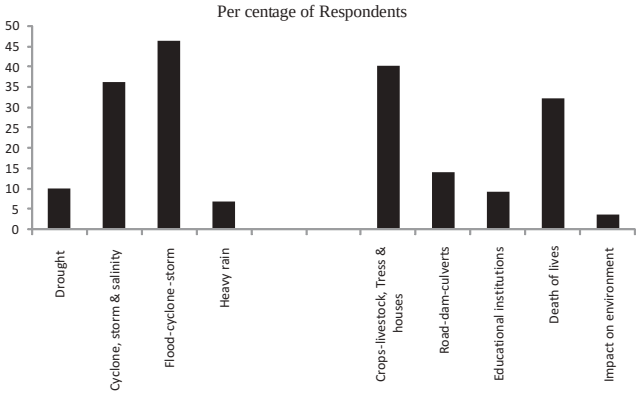

Fig. 2. Types of natural disaster and damages of during disaster in the Upazila of Morelganj and Sharankhola

However, the death/loss of livestock remains in a dangerous level although the livelihood of poor, vulnerable and marginal farmers is highly depending on the livestock. The loss of infrastructures like houses, institutions, cultivable lands and crops and livelihoods were simply destroyed in the affected areas (Islam and Hasan, 2015; Mallick and Vogt, 2014). The disaster leads risk loss of life, death of family members, disability and other health impacts, dislocation, poverty, homelessness and psychological post-traumatic stress reactions such as anxiety, numbing and flashbacks (Haque *et al*., 2012; Norris, 2005). In the days ahead it is envisaged that the frequency and severity of floods, tidal surge, cyclone, storm surges, earth quake will increase the loss of livestock and poultry unless entire existing disaster management system is well structured.

In the present study, 48.15 per cent of the respondents were mentioned that disaster warning information should be a solution in various aspects like earlier prevention, rescued operation rapidly (Table 3). Apart from early warning systems, cyclone shelters and coastal embankments have contributed to reducing death rates in Bangladesh (Haque *et al*., 2012). Poor maintenance of some of the existing infrastructure and a lack of inadequate shelters and infrastructure to protect at risk during cyclones. People living in disaster-prone coastal districts are worried that if cyclones or other large storm surges hit, they could carry huge costs in terms of lives and livelihoods. The disaster management program in Bangladesh should be combination of both the development of physical infrastructure and non-structural practices. Development of physical infrastructure should covers construction of cyclone and flood shelters for emergency resort and erection of flood protection embankments, drainage channel, sluice gates and regulators as safety measures against inundation by tidal waves, storm-surges, flooding and establishment of emergency operation center that will protect against both flash floods and storm surges during a cyclone and will also help protect cropland, fisheries and livestock (Haque *et al*., 2012; Hossain, 2013).

During disaster period and after, the coordination and integrated efforts are very much essential among NGOs, government organizations and local community. Without this, it would be impossible for proper disaster management. Due to lack of participation of such organizations and groups, it is almost impossible for the government alone to manage the disaster management effectively. Alongside the government and different government agencies, it is also vital to engage the local people and local communities in disaster management (Islam *et al.*, 2013; Zamir, 2006). Additionally, government should provide financial support to vulnerable communities to help them adapt to and to mitigate disaster related risks in coastal areas in Bangladesh (Haque *et al*., 2012).

The 37.55 per cent of the respondents was taken preparation to move another place, preserve additional dry foods and sold out of livestock/kept to another place to cope from natural disaster (Table 2). Some coastal people send their valuable materials to their relatives in safer areas. They also try to send domestic animals to highland areas and some habitants of the near coastal area also sought shelter in their relative's homes located in the inner areas (Alam and Collins, 2010). Moreover, a large number (14.28%) were not

Table 2. Way of damages reduced and coping strategy

Damages and coping strategy	Number of respondents (per cent)
Damages of disaster can be reduced through	
Disaster warning information should be disseminate earlier	35 (14.28)
Rescued operation should be done rapidly	25 (10.20)
Should be build enough cyclone shelter centreand constructed strong dam	18 (7.34)
Provide sufficient medicine and health care facilities	23 (9.38)
To provide sufficient relief- food, cloth, pure drinking water	56 (22.85)
Adequate financial assistance during and after disaster for rehabilitation	27 (11.02)
To create awareness and training for disaster management	61 (24.89)
Coping strategy taken by respondents	
Not taken any preparation	35 (14.28)
Preparation to move another place	40 (16.32)
Preserving foods for disaster	46 (18.77)
Preparation to move another place, preserving dry foods and sold out of livestock/kept to another place	92 (37.55)
Preparation to move another place and preserving additional dry foods	32 (13.06)

taken any preparation due to illiteracy, lack of awareness, communication problems and some people do not understand or follow the warnings. Instead of moving to cyclone shelters, people in coastal areas often still believe in a wait and see approach. The reasons are thought to be disbelief of warnings among coastal dwellers, the utilization of incorrect methods in the warning system, the distance of cyclone shelters from settlements, mismanagement of weather forecasts and a lack of proper management of the cyclone shelters (Alam and Collins, 2010; Haque *et al*., 2012; Islam, 2012).

Under the community empowerment, the government, NGOs should planned to further consolidate the empowerment process by expanding the program and by realizing community capacity-building through awareness and skill development and by expanding disaster management studies within the school system and staff training (Haque and Uddin, 2013).The number of undergraduate and post graduate level courses on disaster risk reduction (DRR) is still very limited in Bangladesh. There is still a gap in the transfer of knowledge from school to universities to the disaster manage mention the local community level. In school and colleges the students must be taught the need and procedure of disaster management. Hence, that any disaster the affects people may be given immediate attention and property is recovered and saved at the earliest (Zimmermann *et al*., 2010).

In perception on receiving warning information, 60.40 per cent respondents were received information before disaster, 69.38 per cent were taken preparation to avoid the risk of disaster and 48.17 per cent mentioned that there was not sufficient cyclone center, so people can take shelter during disaster (Table 3). Thousands of people evacuated from their houses to the evacuation sites. However, a significant shortage of public shelters have left many having to manage small makeshift shelters on roads and have been living there in a state of extreme vulnerability (Haque *et al*., 2012). The 89.80 per cent of the respondents said no body was consult with them before adopting disaster management program and 88.92 per cent was highlighted that there were no opportunity for general people to participate with government policy in disaster management. Community participants are important from a resilience perspective, as it allows individuals to draw on community resources and increase the likelihood that communities can effectively address their collective concerns (Green and Haines, 2011). The local people or community representatives knows very well their needs as a result of disasteras well as know how to manage the disaster instantly (Islam *et al.*, 2013; Zamir, 2006). Considering such background, different agencies will

Table 3. Perception of the respondents on disaster management

Respondents perception	Number of respondents (per cent)
Disaster information is known before disaster	
Yes	148 (60.40)
No	97 (39.60)
Preparations were taken to avoid risk of disaster	
Yes	170 (69.38)
No	75 (30.62)
Is any cyclone shelter centre in this region?	
Yes	53 (21.63)
No	74 (30.20)
Not enough	118 (48.17)
Make consults with local people before adopting disaster management program?	
Yes	25 (10.20)
No	220 (89.80)
Is there any opportunity for general people to participate with any Government policy in disaster	
Yes	27 (11.02)
No	218 (88.92)
Have you taken participation to any disaster management related meeting/rallies or training?	
Yes	31 (12.65)
No	214 (87.35)

be able to establish a more integrated disaster management with institutional and development programs and activities to reduce the impact of disasters and disaster vulnerability of peoples in Bangladesh (MoFDM, 2013).

The entrenched hierarchical administrative set-up is not eager to accept the opinion of illiterate but wise and experienced local people in policy cycle. The reluctance of most of the officials of local level administration to take into consideration of people's perception about disaster, leave little scope for inputs to decision-making for participatory approach to disaster management (Hossain, 2013). Various promising disaster reduction approaches tested by local organizations and communities have not been merged into a common national approach. The limited access of vulnerable people to information about policies is also a factor that hinders the implementation of the plan at the national level in Bangladesh (Zimmermann *et al.*, 2010). As disasters cannot be avoided so adoption of proper projects and programs can minimize the destruction and sufferings of disasters. The agencies concerned should consult with the local peoples. This will make people to aware about the adverse effect of climate change as well as prepare them to resiliently face the natural calamities before, during and after their occurrence (Zaman, 2012).

In this study, the crucial fact was that 87.35 per cent not participate any disaster management related meeting/rallies or training that would help them to empower in disaster management (Table 4). Government, local bodies, NGOs, members of the society and international community needs to have their professionally skilled human resource to combat any disaster to reduce loss of lives and property. The capacity to cope requires continuing awareness, resources and good management, both in normal times as well as during crises or adverse conditions. Coping capacities contribute to the reduction of disaster risks (Zimmermann *et al.*, 2010). **T**he local peoples' participation on policy making and disaster management which emphasize local leadership who will provide many opportunities to formulate an effective community led recovery policy. It is proved that the local institutions are more likely to promote and sustain hazard mitigation (Islam *et al.,* 2013; Islam and Hasan, 2015). Along with the climate change impacts, ineffectiveness of relief and

Table 4. Types of assistance and rehabilitation activities

Respondents perception of assistance and rehabilitation	Number of respondents (per cent)
Assistance received from	
Relatives and neighbours	127 (51.83)
Government	23 (9.38)
NGOs	16 (6.53)
Relatives and NGOs	43 (17.55)
Relatives andgovernment	13 (5.30)
Relatives, government and NGOs	23 (9.48)
Post-disaster rehabilitation activities were done by	
Own efforts	111 (45.30)
Helped by relatives	45 (18.36)
Helped by UC- disaster management committee (DMC)	11 (4.48)
Helped by other voluntary organization	09 (3.67)
Own efforts and relatives	22 (8.97)
Own efforts and voluntary groups/clubs	31 (12.65)
Own efforts, relatives and voluntary groups/clubs	16 (6.53)
Type of assistance were provided for rehabilitation after disaster	
Cash	31 (12.65)
Food-cloth	25 (10.20)
Agricultural inputs	18 (7.34)
House repairing materials-tin	11 (4.48)
Cash, agricultural-inputs and house repairing materials	99 (40.40)
Cash and food-cloth	19 (7.75)
Not received any assistance	42 (17.55)

rehabilitation activates, corruption and low participation of local people in the planning and implementation process, governance failure have been identified as the major challenges in saving poor people's interest in disaster management program in Bangladesh (Bijoy and Chakraborty, 2013).

Financial or other relief assistance from government or NGOs could play an important role to recovery from damages of disaster in Bangladesh. However, 51.83 per cent was received assistance from their relatives and neighbors not from government agency or NGOs to recovery of damages from disaster (Table 4). Though the people of the coastal areas are not getting proper support from the government and NGOs, they relied on relatives and neighbors. The post-disaster initiative such as the relief distribution alone is not enough to enable people to cope with disaster situations resiliently and to fully recover (Mallick *et al*., 2005). The efforts of the government were ineffective because of irregularities and widespread corruption by government authorities involved in implementing relief and rehabilitation programs (Begum, 2014). These findings are also consistent with earlier studies that reflect competing interests, scarce resources, conflicting views and nepotism in relief distribution (Marsden, 2005; Nakagawa and Shaw, 2004; Saha, 2015). The incidence of injustice after natural disaster was practiced by a particular group of people involved in rehabilitation programs, capacity building activities, credit programs, allocation of medical facilities, disaster management trainings, disaster reliefs and resources works financial assistances that makes victims more vulnerable (Saha, 2015).

Eventually, majority (57.95%) of the respondents were done of post-disaster rehabilitation activities by their own efforts, relatives and voluntary groups. The family members, relatives, neighborhoods and friends are essential elements to play a significant role in a household responds to natural disasters in Bangladesh (Islam and Walkerden, 2014). Community people were involved in the evacuations and relief efforts, both helping family members and also surrounding neighbors and friends. During the recovery, community members focused more on the needs of their particular household repairing their own shelters, and re-establishing their livelihoods (Islam and Walkerden, 2014). A community led post-disaster recovery policy is mostly important for the disaster affected people in Bangladesh, where a large number of the marginalized and poor people live (Islam and Hasan, 2015; Zaman, 2012).

The disaster recovery literature suggests homogenous communities have an advantage over less-connected communities in promoting community redevelopment (Chamlee-Wright and Storr, 2011). In disaster periods, the first responders are the local community because disaster response organizations often need a minimum 48-72 hours to reach the affected areas-sometimes longer due to communication and access difficulties. It is claimed that assistance in recovery is largely provided by family members and neighbors (Chamlee-Wright and Storr, 2011). Although a large number (40.40%) of respondents were received assistance but also it was not sufficient to recovery of disaster damages in the Upazila of Morelganj and Sharankhola (Table 4). Apart from distribution issues, another challenge is that relief goods are not sufficient in quantity (Begum, 2014).

Governmental responses to face natural disaster have been soundly criticized as slow, unresponsive or insufficient. Top-down intervention alone in disaster management was insufficient because such intervention often paid little attention to addressing community dynamics, perceptions and needs, ignored the potential of local resources and capacities that in some cases increased people's vulnerability (Murshed, 2007). The national and local voluntary agencies have lack of adequate financial resources to operate community-based program for disaster management. Due to scarcity of resources the people could not repair their houses, disaster shelter, road or culverts by themselves and a large number of people were displaced from their homes (Begum, 2014; Hossain, 2013). Moreover, the government could not repair the damaged embankments even after several years (Begum, 2014).

The purpose of a disaster warning service is to detect and forecast threatening disaster events so that the public can be alerted in advance and can undertake appropriate responses to minimize the impact of the event. This is a particularly important technology in developing countries, where disaster results in massive loss of life and property. Disaster warnings are a highly important adaptive measure where protection through large scale, hard defenses, is not desirable or possible (Linham and Nicholls, 2010). However, majority of the (58.37%) respondents were not received warning by modernizing early warning systems (Fig 3). It means that most of the people do not get warning information of disasters due to lack of modern weather forecasting technology likely Radio and Television. People of coastal areas use their indigenous knowledge, methods and strategy to cope with disaster for long days. Most of the inhabitants of coastal areas depend on the indigenous technology for getting the signal of disaster (Islam, 2012).

The coastal people excluded from modern information system and apply indigenous techniques to minimize disaster, keep their eyes active on monsoon winds

and change of seasons for forecasting disasters. Uncertainty in predicting cyclone landfall and inaccurate early warning demonstrate the institutional weakness of cyclone preparedness programs (CPP), which would increase incredibility and confusion of the communities to upcoming hazards and would also profoundly influence the future evacuation process and expose countless residents to adverse effects of catastrophic disasters (Saha, 2015).An early warning system should be coupled with emergency planning measures, such as the provision of evacuation routes and flood shelters and should also contain an awareness raising element (Linham and Nicholls, 2010).

People also could announce the warning of cyclone or tidal bore through loud speaker of religious institutions (mosque, temple and pagoda) or by beating drums so that people could take preparation to combat disaster (Hossain, 2013). A considerable number of booklets, brochures, videos and other awareness material should be produced in local languages for this purpose, and distributed among local communities to help them cope with future disasters (United Nation, 2006).Currently, the country has developed a number of modern technologies in disaster management and recovery system which will be helpful for the coastal areas to minimized disaster (Islam and Hasan, 2015). It is noticeable that 40.40per cent of the respondents were not known who was running the disaster warning campaign in these coastal areas (Fig. 3). There is no broad-based ownership of the DRR action plans, resulting in different stakeholders implementing them in so many different ways in Bangladesh (Zimmermann *et al.*, 2010). An effective disaster warning service requires cooperation between different agencies, such as the government, relief agencies and local communities. As such, this approach not only provides technical challenges but also, organizational ones. Lack of awareness among peoples is another cause for not knowing regarding disaster warning camping.

Policy recommendations

Disasters cannot be avoided but effects can minimize the destruction using proper and sustainable

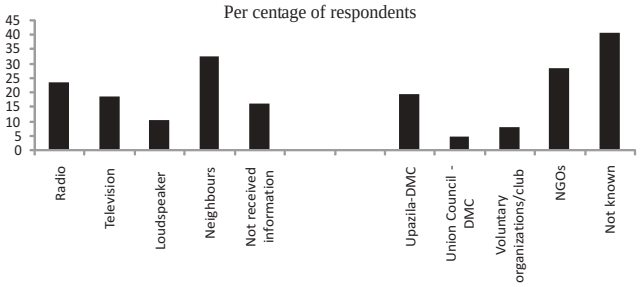

Fig. 3. Medium of receiving information and disaster warning campaigns

projects and programs that should be managed properly and transparently. More important, these should be undertaken with the consultation of local community peoples for disaster management and rehabilitation. Planners, policymakers and development practitioners should endeavor to incorporate local knowledge into environmental and adaptation strategies.

Since community members are the direct and most seriously affected victims, effective and sustainable partnership requires a change from a partnership approach based on equality to a focus on the community (Bhatt and Reynolds, 2012).To increase people's awareness of the severity of cyclone hazards, the government and NGOs should further strengthen the existing awareness programme and initiate educational campaigns in coastal districts to ensure prompt use of public shelters during cyclones, early evacuation and recovery. The knowledge of affected communities might be increased through trainings, preparedness programs, disaster risk reduction and climate adaptation efforts adopted by state and non-state actors regarding on what kinds of elements are exposed to risk and what kinds of strategies might be taken to save community resources from potential threats (Saha, 2015). Communities may not be scientific in comprehension but the richness of experience and indigenous knowledge is a resource to be recognized. If their resources are developed with proper training and information, the communities would be able to safeguard and minimize disaster risks. Bangladesh should develop policy, legislative and institutional frameworks for disaster risk reduction and that are able to develop and track progress through specific and measurable indicators have greater capacity to manage risks and to achieve widespread consensus for, engagement in and compliance with disaster risk reduction measures across all sectors of society.

CONCLUSION

It can be concluded from this study findings that the majority of the population of the coastal areas were affected by natural disaster that makes them vulnerable in the society. Bangladesh is highly vulnerable to natural hazards and it also has a long history of coping and managing major disaster by local community. A multi-hazard approach for all aspects of disaster management policy and practice must be instituted. The participation of local community on disaster management will improve their ability to work with other actors to build resilience, increase accountability and transparency and improve response, this includes, communities, the private sector, academia and regional and international actors. Further, the disaster management program should be in collaboration with the government for

undertaking joint initiatives, capacity development at family, union and Upazila levels in management and preparedness for disasters in coastal areas in Bangladesh.

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Qualitative and Quantitative Analysis of Planktonic Fauna of Puzhal Lake, Chennai - A Pre and Post Flood Analysis

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***Abstract*:** Puzhal Lake is one of the rain-fed reservoirs and a drinking water source for the Chennai city. The planktonic populations were assessed by qualitative and quantitative analysis before and after the historic heavy rainfall that led to a heavy deluge in this area. Rotifers, cladocerans, ostracods and copepods constitute the foremost groups of zooplankton of Puzhal Lake. Prior to flooding, the total population of the zooplankton groups was recorded as 81/L that was higher compared to that after the flood which recorded as 31/L. The major zooplankton group was Harpacticoida (30 /L) followed by Rotifera (10 /L) before flood and Rotifera (9 /L) followed by Cladocera (6 /L) after the flood. The diversity of the zooplankton species was higher (14 species) before flood compared to that of after the flood (8 species).The phytoplankton species were more diverse after the flood. Ecological indices indicated obvious changes.

Key Words: Ecological indices, Puzhal lake, Phytroplankton, Zooplankton

The Indian city, Chennai has experienced its most terrible rainfall in November 2015. It recorded rainfall of 1,049 mm is the highest since November, 1918. This massive rainfall led to heavy floods and was called as "worst in a century". The Puzhal reservoir in Chennai (13.1667° N, 80.1715° E) was built in 1876 during the British rule. The storage capacity was extended upto 3,300 mcft and depth 50.20 ft. On 1st of December, 2015 Puzhal recorded 320 mm of rainfall and the reservoir attained the complete storage level and the water was discharged and it was maintained 2 ft below the full level. In an aquatic ecosystem, the planktonic organisms are essential links in the food chain. Zooplankton, the significant member of an aquatic ecosystem forms an indispensable link in a trophic level. They are the most important food for the commercially and economically imperative fish and prawn larvae. They control algal and bacterial populations and also function as bio-indicators (Chatterjee *et al*., 2014; Bhat et *al.,* 2015). Indices of dominance, similarity, species diversity (species richness, evenness index, Shannon index of general diversity) are some of the useful ecological indices of species structure in communities. The present study was an attempt to determine the population structure and dynamics of zooplankton in Puzhal Lake, Chennai before and after floods.

MATERIAL AND METHODS

The sampling was carried out at one location in Puzhal Lake (13°11'8"N, 80°11'13"E), Chennai, India during October 2015 (before the floods) and January 2016 (after the floods). Physico-chemical parameters *viz*., pH, conductivity, dissolved solids, alkalinity, chloride, calcium, magnesium, fluoride, sulphate, phosphate and iron were determined as per the protocol provided by APHA (2005).

The plankton samples were collected using plankton net made up of bolten silk with a pore diameter of 20 µm at the early hours of the day. For qualitative analysis plankton were narcotized with 50% ethanol and preserved in 5% formaldehyde solution, and identified (Michael, 1973; Battish, 1992; Verlecar and Desai, 2004). For quantitative analysis, 100 litres of water was filtered using a plankton net, the zooplankton were preserved and different species were enumerated using a Sedgewick – rafter counting cell under microscope.

The ecological indices *viz*., Dominance, Simpson, Shannon, Evenness, Brillouin, Menhinick, Margalef, Equitability, Fisher-alpha, Berger-Parker and Chao were determined using PAST software package (version 3.11).

RESULTS AND DISCUSSION

The plankton populations are influenced by various environmental factors. It is essential to monitor the physico-chemical parameters to reveal the information regarding the pollution load (Reddi *et al*., 1993).

Majority of the parameters including conductivity, dissolved solids, chloride, magnesium, fluoride, sulphate, phosphate and iron were at a higher concentration before the rainfall than after. It could be due to the dilution of water. However, the pH of the water did not show much difference.

The total zooplankton number was recorded as 81/L before flood that was higher compared to after flood which recorded as 31/L. The major zooplankton group was found to be Harpacticoida trailed by Rotifera before flood and Rotifera trailed by Cladocera after the flood. The assorted qualities of the zooplankton species was higher (14 species)

Table 1. Physico-chemical parameters of water

Parameters	Units	Pre-flood	Post-flood
pH	-	7.0	7.9
Conductivity	µS cm^{-1}	835	225
Dissolved solids	mg L^{-1}	547	136
Alkalinity	mg L^{-1}	67	74
Chloride	mg L^{-1}	42	26
Calcium	mg L^{-1}	41	76
Magnesium	mg L^{-1}	12	7
Fluoride	mg L^{-1}	1.3	0.1
Sulphate	mg L^{-1}	64	9
Phosphate	mg L^{-1}	0.03	0.1
Iron	mg L^{-1}	0.04	0.01

Table 2. Qualitative analysis – Phytoplankton

Species	Pre-flood	Post-flood
Cyanophyceae		
Oscillatoria Sp.	+	+
Nostoc Sp.	+	+
Sp.irulina Sp.	-	+
Microcystic Sp.	+	+
Chroococcus Sp.	+	+
Phormidium Sp.	-	+
Chlorophyceae		
Closteridium Sp.	+	+
Ankistrodesmus Sp.	-	+
Bacillariophyceae		
Fragillaria Sp.	+	+
Synedra Sp.	-	+
Nitzschia Sp.	-	+
Charophyceae		
Nitella Sp.	+	+

Note: + indicates presence, **-** indicates absence

Table 3. Qualitative and quantitative analysis – Zooplankton

Species	Pre-flood (Nos./L)	Post-flood (Nos./L)
Rotifers		
Brachionus calyciflorus	5	5
Brachionus falcatus	3	0
Ephiphanus Sp.	2	4
Cladocerans		
Ilyocryptus spinifer	1	3
Ceriodaphnia cornuta	1	2
Moina micrura	1	1
Ostracod		
Plesiocypridopsis dispar	11	5
Copepods		
Sinodiaptomus indicus	5	1
Mesocyclops aspericornis	5	1
Cletocamptus albuquerquensis	30	3
Nematode worms	4	0
Chironormous larvae	1	0
Tubificid worms	3	0
Encysted eggs	2	0
Developmental stage	7	6

before flood compared to that after the flood (8 species). The phytoplankton species are more varied after the floods (12 species) than before the floods (7 species). This could be due to the dilution of existing water in the reservoir, and a base timeframe is required for the foundation of phytoplankton and consequent progression of zooplankton. Several studies showed a decrease in the population of zooplankton after rainfall (Naveed *et al.,* 2005; Srivastava, 2013; Gayathri *et al.,* 2014). Rotifers occur most predominantly in the sample collected after the flood. It is assumed that rotifers exploit the supplements and phytoplankton more quickly to develop their populace. Subsequent to rotifer populace cladocerans accomplish the larger density this might be likely because of longer time taken by cladoceran to build up than rotifer, furthermore their populace relies on numerous physical parameters, greatness of diatom bloom and rotifer populace.

The fish fry population was high during the later time of sampling. Their utilization of zooplankton in extensive quantity might have also reduced the zooplankton populace. The same condition was also witnessed in the earlier study (Saboor and Altaff, 1995). Nematode and tubicifid worms are the pointers of dirtied water that were available in insignificant quantity after heavy rainfall. Encysted eggs in high numbers are the indication of protecting act from the antagonistic condition (Saboor and Altaff, 2005). They are found in higher number before the floods.

Preceding flood, the copepod masses are prevailing, the household waste containing the natural matter that drove into the lake may have upheld the development of microscopic organisms that could have favored the foundation of copepod whereas after the dense rainfall life has to restart and phytoplankton build up using the nutrients and trailed by subsequent succession of zooplankton including rotifer, cladoceran, copepod and ostracod (Naveed *et al.,* 2005).

The stable communities have a high diversity value and vice versa with unstable communities. The stability in diversity is the sign of environmental integrity and well being. The data for ecological diversity is presented in the table 4. For the overall zooplankton, the index of dominance , Shannon, Brillouin, Margalef, Fisher_alpha, Berger-Parker and Chao-1 were higher before the intense rain where as the

Table 4. Species diversity indices of zooplankton in Puzhal Lake before and after floods

Zooplankton	Diversity indices	Values of diversity indices for zooplankton	
		Before floods	After floods
Rotifera	Individuals	10	9
	Dominance_D	0.38	0.51
	Simpson_1-D	0.62	0.49
	Shannon_H	1.03	0.69
	Evenness_e^H/S	0.93	0.99
	Brillouin	0.78	0.54
	Menhinick	0.95	0.67
	Margalef	0.87	0.46
	Equitability_J	0.94	0.99
	Fisher_alpha	1.45	0.80
	Berger-Parker	0.50	0.56
	Chao-1	3.00	2.00
Cladocera	Individuals	3	6
	Dominance_D	0.33	0.39
	Simpson_1-D	0.67	0.61
	Shannon_H	1.10	1.01
	Evenness_e^H/S	1.00	0.92
	Brillouin	0.60	0.68
	Menhinick	1.73	1.23
	Margalef	1.82	1.12
	Equitability_J	1.00	0.92
	Fisher_alpha	0.00	2.39
	Berger-Parker	0.33	0.50
	Chao-1	6.00	3.00
Copepoda	Individuals	40	5
	Dominance_D	0.59	0.44
	Simpson_1-D	0.41	0.56
	Shannon_H	0.74	0.95
	Evenness_e^H/S	0.70	0.86
	Brillouin	0.65	0.60
	Menhinick	0.47	1.34
	Margalef	0.54	1.24
	Equitability_J	0.67	0.87
	Fisher_alpha	0.75	3.17
	Berger-Parker	0.75	0.60
	Chao-1	3.00	4.00
Ostracoda	Individuals	11	5
	Dominance_D	1.00	1.00
	Simpson_1-D	0.00	0.00
	Shannon_H	0.00	0.00
	Evenness_e^H/S	1.00	1.00
	Brillouin	0.00	0.00
	Menhinick	0.30	0.45
	Margalef	0.00	0.00
	Equitability_J	0.00	0.00
	Fisher_alpha	0.27	0.39
	Berger-Parker	1.00	1.00
	Chao-1	1.00	1.00
others	Individuals	17	6
	Dominance_D	0.27	1.00
	Simpson_1-D	0.73	0.00
	Shannon_H	1.43	0.00
	Evenness_e^H/S	0.84	1.00
	Brillouin	1.14	0.00
	Menhinick	1.21	0.41
	Margalef	1.41	0.00
	Equitability_J	0.89	0.00
	Fisher_alpha	2.39	0.34
	Berger-Parker	0.41	1.00
	Chao-1	5.00	1.00

Cont...

Overall zooplankton	Individuals	81	31
	Dominance_D	0.18	0.13
	Simpson_1-D	0.82	0.87
	Shannon_H	2.16	2.13
	Evenness_e^H/S	0.58	0.84
	Brillouin	1.91	1.76
	Menhinick	1.67	1.80
	Margalef	3.19	2.62
	Equitability_J	0.80	0.93
	Fisher_alpha	5.42	5.12
	Berger-Parker	0.37	0.19
	Chao-1	17.00	11.50

other indices Simpson_1-D, Evenness_e^H/S, Menhinick, Equitability_J were higher in the later collected sample. Before floods, the dominance was most noteworthy in the order, ostracods > copepods > rotifers > cladocerans > others. Simpson and Shannon was in the dropping sequence, others > cladocerans > rotifers > copepods, and evenness was in the order, cladocerans > rotifers > others > copepods. After floods, the dominance and evenness was in the descending order, ostracods > others > rotifers > cladocerans > copepods. Simpson and Shannon was in the order, cladocerans > copepods > rotifers. Dominance shows reverse association with diversity. The same condition was found in the earlier study (Saboor and Altaff, 2005). The contamination or stress or tough physico-chemical limiting factors do not support the establishment of all species, only the tolerant species that adopt the conditions are subsequent in predominance (Manickam *et al.,* 2015). With reclamation measures by avoiding undesirable anthropogenic activities, the quality of the water can be improved and the stability and productivity of the water body can be enhanced.

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Farmers Adaption Strategies in the Climate Vulnerable Agro-Climatic Zones of Tamil Nadu, India

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***Abstract*:** This paper examined the agricultural vulnerability for six agro-climatic zones of TamilNadu and identified the farmers' coping strategies with respect to the perceived climate change in the most vulnerable zone. Results indicated that among the six zones, Southern zone was highly vulnerable to climate change. The climate change impact in the study region was mostly related to increased water stress. Among different coping strategies, majority of the respondents (54.44%) were found to adopt drought tolerant/resistantcrop varieties that could withstand water stress meanwhile maintaining crop productivity. Another major strategy adopted to cope with the increased water stress was growing of alternative crops. It could be concluded that appropriate crop improvement strategies and relevant crop insurance policies could protect the interest of the farmers in vulnerable regions growing crops.

***Key Words*:** Climate change, Agro-climatic zones, Vulnerability, Adaption strategies

The global warming (climate change) has been a phenomenon experienced since the beginning of the industrial era in the late 1800s (Houghton *et al.*, 2001; Santer *et al.*, 2003). Over the past 100 years, the earth's surface has warmed by approximately 0.6°C (Walther *et al*., 2002). Moreover, as determined by the IPCC (IPCC, 2001a) the rate of global warming over the past 50 years (0.23 ± 0.05°F per decade) has almost been doubled that of the past 100 years (0.13 ± 0.04°F per decade). The IPCC (2007b) projected that temperature increase by the end of this century is expected to be in the range of 1.8 to 4.0°C.These climatic changes present an additional burden on the world's economy, especially on agricultural and natural resource systems which are already coping with the growing food demand driven by population growth and higher purchasing power in developing countries. The challenge is compounded by the uncertainty and pace of climate change and its regional effects. It has been increasingly clear that climate change affects agricultural productivity (IPCC, 2007a,). The impacts on agriculture due to climate change has received considerable attention in the world which is closely linked to the malnutrition, poverty and food security of a vast majority of the population. (Kurukulasuriya and Rosenthal, 2003; Carraro and Sgobbi, 2008; Kameyama *et al.,* 2008).

In India, the southern region (Tamil Nadu) is one among the most vulnerable region to the projected climate change. In addition, the projected major food grain production will decline in these regions during the period of 2020, 2030 and 2050 respectively from the current level of production (ICAR, 2009, Arumugam *et al.,* 2014, Arumugam *et al.,* 2015).Changes in temperature and precipitation that accompany climate change will require farmers to adapt it, but precisely where and how much is uncertain.The adaptations strategies that help to decrease the impacts from climate change (Kurukulasuriya *et al.,* 2006; Kurukulasuriya and Mendelsohn 2008; Seo and Mendelsohn, 2008) has been classified as long term and short term developments. The long term developments would require government and institutional coordination such as irrigation, crops varieties, pest management and animal breed's developments to cope with changing climatic conditions (Mendelsohn, 2000; Kelly *et al.,* 2005, Arumugam *et al.,* 2014). Adjusting planting and harvesting dates, changing crop varieties are short-term developments that can be used by farmers.The mitigation and adaptation to climate change are necessary to ensure food and energy security, which are the pre-requisites for sustainable economic development. Against this background, this study attempts to evaluate how small and medium farmers cope with adaptation strategies with respect to climate change in the most vulnerable zone of Tamil Nadu.

MATERIAL AND METHODS

According to IMD report, Tamil Nadu is classified into eight agro climatic zones namely North East, North West, Western, Cauvery Delta, South, Southern, High Precipitation and High Altitude (IMD, 2011). Among these eight zones, the

first six zones have been selected and excludes high precipitation and hilly zones which occupy only less than four per cent of the geographic area. Of the six zones, the North East Zone and South Zone occupies the first two places with 24 per cent and 20 per cent of the total area followed by Cauvery delta (15%), North West (14%) Southern (12%) and Western Zone (12%).

Hence, it is important to identify the most vulnerable zones to climate variability in Tamil Nadu. Accordingly the index was constructed to assess the climate vulnerability of agricultural zones in Tamil Nadu following Iyenger and Sudarshan(1982). The index was used to rank the zones in terms of their vulnerability to climate variability. In this method the variables that contribute to climatic vulnerability are first identified. The Tables1 shows the variables contributing to climatic vulnerability and sources of data for the period of 1980-81 to 2009-10.

Since, these variables are in different units of measurement and have positive or negative impact on vulnerability, the identified variables are standardized by using the following formula. If the variables are positively related to vulnerability, the formula is;

$Y_{id} = (X_{id} - \text{Min } X_{id}) / (\text{Max } X_{id} - \text{Min } X_{id})$ ……..(3.1)

If the variables are negatively related to vulnerability, the formula is

$Y_{id} = (\text{Max } X_{id} - X_{id}) / (\text{Max } X_{id} - \text{Min } X_{id})$.....(3.2)

Where, Y_{id} is the i^{th} standardized variable in d^{th} zone and X_{id} is the i^{th} variable in the d^{th} zone. Obviously these standardized values lie between 0 and 1. The level or stage of vulnerability of d^{th} zone is assumed to be a linear sum of Y_{id} as

$$y_d = \sum_{i=1}^{m} w_i y_{id} \quad \text{.....(3.3)}$$

where, w_i' are ($0<w<1$ and $\sum_{i=1}^{m} w_i = 1$) such that the weight determined by $w_i = \frac{k}{\sqrt{\text{var}(y_i)}}$ and

$$K = \sum_{i=1}^{n} \frac{1}{\sqrt{\text{var}(y_i)}} \quad \text{.....(3.4)}$$

The choice of the weights assigned in this manner would ensure that large variation in any one of the variables would not unduly influence the contribution of the rest of the variables and distort inter zone comparisons. Higher the value of Y_{id}, higher will be the vulnerability. Among the six zones of Tamil Nadu, the highly vulnerable zone was selected to study the coping behaviour and adaptation strategies of selected farm households with respect to climate change. The field level data from 180 samples were collected in the most vulnerable zone by using a well-structured and pre-tested interview schedule. The primary data were collected from the sample respondents during the first quarter of 2012.

RESULTS AND DISCUSSION

Agricultural vulnerability indices: In general, the climatic variables were major contributors to agricultural vulnerability. The prime variables included the rainfall, C.V of rainfall, maximum temperature and gross irrigated area to access the agricultural vulnerability. The climatic changes that alter temperature and precipitation patterns may pose serious threats to agricultural production. The results shows that the values of the vulnerability indices varied from 0.2038(North East Zone) to 0.9302 (Southern Zone). It is revealed that among the six zones of Tamil Nadu, Southern Zone is the most vulnerable Zone to climate change followed by western Zone, Cauvery delta Zone, Northwest Zone, South Zone and North East Zone, respectively. Hence, Southern zone was purposively selected to study the coping behaviour and adaptation strategies of farm households with respect to climate change (Table 2).

Socio-economics Characteristics of Farm Households in the Southern Zone: In Southern Zone, 48.33 per cent were in the age group of 36-45 years, whereas 39.44 per cent of sample farmers were more than 45 years of age. Nearly 12.20 per cent were in the age group of less than 35 years (Table 3). The average age of the head of the farm household was 43.58 years. More than half of the respondents (61.67%) had four to

Table 2. Agro-climatic zone wise vulnerability indices and rank

Agro climatic zones	Vulnerability score	Rank
Southern zone	0.9302	1
Western zone	0.6435	2
Cauvery delta zone	0.5521	3
North West zone	0.4625	4
South zone	0.4173	5
North East zone	0.2038	6

Table 1. Variables Contributing to Climatic Vulnerability

Variable	Unit of measurement	Relation to vulnerability	Data source
Rainfall	Millimeter	Negative	Indian Meteorological Department, Pune
Gross irrigated area	Hectare	Negative	Season and Crop Report, Tamil Nadu.
Maximum temperature	Celsius	Positive	Indian Meteorological Department, Pune
C.V. of rainfall	Percentage	Positive	Estimated

Table 4. Perception on climate change

Particulars	Numbers	Percentage to total
More frequent drought	96	53.33
Delayed on-set rainfall	102	56.67
Erratic rainfall pattern	84	46.67
Too much rain	7	3.89
Low rain	46	25.56
Higher temperature	164	91.11
Earlier on-set of rainfall	9	5.00

eight members in their family while 37.22 per cent of the respondents in Southern Zone had a family size of less or equal to four members. Whereas household with more than eight members was very less. The average household size for the selected sample farms was 4.87 members. In Southern zone, nearly 11 per cent of the head of sample farms were illiterate. About 26 per cent and 45 per cent had studied up to primary and high school level, while about 13 per cent were educated up to higher secondary level, respectively. Nearly four per cent of the household heads had collegiate education.

It was observed that in Southern zone, 38.33 per cent of the farmers had 16-30 years of experience, while about 31 per cent of farmers had less than 15 years' experience. About 28 per cent had 31-45 years and only 1.11 per cent of farmers had above 45 of experience in farming. The average number of years of farming experience was 21.94, respectively.

In Southern Zone, about 35 per cent of the respondents were marginal farmers owning less than one hectare followed by about 28 per cent of the respondents in small farmer category owning between 1 to 2hectare, about 21per cent are in medium farmers category (2-4 ha) and 14 per cent in large farmers category (< 4 ha). The average land holding size of the sample farms was 2.68 ha. The 54. 44 per cent of farmers had an annual income of less than Rs.75, 000 followed by about 32 per cent with Rs.75, 000- Rs.1 lakh. Nearly nine per cent of farmers had an annual income between Rs. one lakh to Rs.1.5 lakhs and only 3.89 per cent had an annual income of more than Rs.1.5 lakhs (Table 3).

Farmer's Strategies for Adapting to Climate Change

Most of the respondents (91.11 per cent) reported to have experienced higher temperature than the normal temperature (Table 4). About 56 per cent of the respondents observed delay on set of rainfall, which affected agriculture through delayed sowing, and lower crop yields. More frequent drought and erratic rainfall was reported by 53.33 and 46.67 per cent of respondents, respectively. One forth of respondents perceived the receipt of low rain (25.56%) and very few stated too much rain (3.89%) and earlier on-set of rainfall (5%).

Table 5. Perception on the consequences of climate change

Particulars	Numbers	Percentage to total
Decline in crop yield	89	49.44
Decline in livestock yield	112	62.22
Increase in crop yield	42	23.33
Death of livestock	94	52.22
Water scarcity	172	95.55
Food shortage/ insecurity	69	38.33
Increase in pest and diseases	38	21.11
Changes in weed regime	78	43.33
Changing ecosystem	7	3.89
Soil degradation	38	21.11

Note: Multiple responses from some respondents

The death of livestock is important consequence as reported by 52.22 per cent of the respondents due to the adverse climatic condition, which is not suited for the survival of livestock. About fifty per cent of respondents said that crop yield has been declined due to climate change. Food shortage as a consequence of climate change was reported by 38.33 per cent of respondents. Few respondents (23.33%) reported that their crop yield increased as an outcome of climate change. Increases in pests and diseases infestation and soil degradation were perceived as a consequence by equal per cent of respondents (21.11%) and meager proportion of respondents cited changing ecosystem (3.89%) in the study region.

Majority of the respondents (54.44%) adopted drought tolerant / resistant crop varieties which could withstand the increased water stress and maintain the crop productivity. The next important strategy to cope with increased water stress was growing alternative crops which are comparatively tolerant to water stress (50.56%). About 26 per cent of the sample respondents shifted their focus from crop to livestock production, 20 per cent of sample farmers started non-farm activities, 6 per cent of sample respondents started new land management practices *viz,* leveling, FYM application and summer ploughing and 23 per cent of sample respondents did nothing to address the change in climate (Table 6).

CONCLUSION

A major share of farmers have experienced higher than the normal temperature, delay in onset of rainfall, frequent drought, low and erratic rainfall. The major impact was felt in increased water stress. Accordingly, farmers have adopted drought tolerant/resistant crop varieties that can sustain water stress, while maintaining average crop productivity. Other sort of coping-up behavior observed was shifting to alternate crops, diversification towards livestock

rearing, shifting to non-farm activities, etc. Focusing policies on developing varieties that can withstand different climatic aberrations would retain the farmers into farming. Developing alternate cropping patterns that ensure better profit, accessible crop insurance, subsidized inputs, extension services and field demonstrations that train farmers in knowledge updation to changing climate would further help to cope up with the changing environment.

Table 3. Socio economics characteristics farm households

Particulars	Numbers	Percentage to total
Age distribution(years)		
< 35	22	12.20
36- 45	87	48.33
Above 45	71	39.44
Total	180	
Average	43.58	-
Educational level of the farm households		
Illiterates	19	10.56
Up to primary	47	26.11
Up to high school	82	45.55
Up to higher Secondary	25	13.89
Up to collegiate	7	3.89
Total	180	
Experience in farming		
Up to 15	57	31.67
16-30	69	38.33
31-45	52	28.89
above 45	2	1.11
Total	180	
Average	21.94	
Household size of sample respondents		
4	67	37.22
4- 8	111	61.67
>8	2	1.11
Total	180	
Average size	4.87	-
Size of land holding of sample farmers		
Marginal (< 1ha)	64	35.56
Small (1-2 ha)	51	28.33
Medium (2-4 ha)	39	21.67
Large (>4 ha)	26	14.44
Total	180	
Average (Ha.)	2.68	-
Annual income levels of the sample farmers		
Up to 75000	98	54.44
75000 to 1 Lakh	59	32.78
1 Lakh to 1.5	16	8.89
Above 1.5	7	3.89
Total	180	

Source: Survey, 2012

Table 6. Adaptation to climate change

Particulars	Number of responses	Percentage to total
Growing alternative crop	91	50.56
Adopted drought tolerant / resistant crop varieties	98	54.44
Giving more importance to livestock rearing	48	26.67
Started non-farm activities	36	20.00
Started using new land management practices	11	6.11
Did nothing	42	23.33

Note: Multiple responses from some respondents

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Demand for Forest Products in India-Role of Institutions

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***Abstract*:** In the present study, demand for forest products are projected incorporating the influence of forest institutions (FCA, 1980 and NFP 1988) and economic institution (economic liberalization) in the institutional consumption framework. The framework establishes functional relation between consumption of forest products, gross national income and institutions captured through intercept dummy and slope dummy. Secondary data on consumption of forest products and gross national income at constant prices were collected from FAO and RBI websites from the year 1971 to 2009. The relative strength of autonomous consumption and induced consumption (due to income, interaction of income with institutions) were assessed for forest products. In addition, how marginal propensity to consume varies between pre institutional (1971-1990) and post institutional period (1991-2009) was also assessed. The consumption of forest products using institutional consumption framework has been projected upto 2020. The result of the study indicated that the Marginal propensity to consume (MPC) increases over time with real national income irrespective of the influence of institution and falls in the post institutional period signifying the presence of good governance. The magnitude of autonomous consumption overweighed the magnitude of consumption induced by income and institution for five forest products out of sixteen (31%) and for the rest of the forest products (69%) the magnitude of consumption induced by income and institutions surpassed the magnitude of autonomous consumption in inducing consumption. This precisely reflected the role of forest and economic institutions in facilitating increased consumption. The percent deviation in projection was lower using the institutional framework compared with the log linear model deployed in the other studies reflecting the forecasting ability of the model.

Key Words: Economic liberalization, Economic institution, Forest products

The role of institutions, technologies, markets and governance in shaping the demand for forest products in India is crucial. In the Keynesian framework, the consumption of forest products considered as the effective demand is a function of real national income. In the institutional framework, consumption of forest product is hypothesized to be influenced by institutions. In India, two crucial forest institutions : Forest Conservation Act, 1980 (FCA) and National Forest Policy, 1988 (NFP) play a critical role in addressing supply side of forest products by imposing ban on clear and green felling as also by halting supply of raw materials to forest based industries at concessional rates. This triggered the development of technologies and substitutes in forestry sector. Although, NFP liberalized imports of forest resources and products, due to forces of demand, forest resources continued to be plundered in different parts of India. The economic liberalization (EL) of 1991 gave a fillip to imports of raw materials addressing the demand side.

This study is a sequel to the study by Kiran *et al.* (2013) where forest institutions, economic institution and real national income have been proved to have perceptible influence on consumption of forest products. While the FCA came into force from 1980, the NFP from 1988, and the EL from 1991, considering the gestation period, it is hypothesized that these institutions came to force in letter and spirit from 1991. This study focuses on projection of consumption of forest products incorporating the influence of forest and economic institutions. Prior to deploying institutional framework for projection, relative contribution of autonomous consumption, consumption induced by national income devoid of institutional interventions and induced consumption due to stringent forest institutions and liberalized imports (good governance) was assessed. In addition to this, the year of institutional break from which the effect of MPC surpasses that of autonomous consumption for various products were also assessed to ascertain the impact of good governance.Accordingly, three hypotheses were formulated (1) the marginal propensity to consume forest product (MPC) increases with real income over time; (2) MPC falls in the post institutional period (i.e. after 1991), due to good governance and economic liberalization and (3) the demand projections for forest products is shaped by real national income, institutions and their interaction.

MATERIAL AND METHODS

In order to test the first two hypotheses, the study uses the model

$C = á + âY + ä_1 D + ä_2 DY$ ----(1),

Here C = apparent consumption of forest product,

Y = real national income,

D = dummy variable (taking value of 0 for the period 1971 to 1990 representing the pre-institutional period and taking the value of 1 from 1991 onwards representing the post-institutional period,

á = autonomous consumption of forest product,

â = Marginal propensity to consume a forest product in the pre-institutional period,

$ä_1$= the shift in the autonomous consumption of the forest product due to Forest Conservation Act, National forest policy and economic liberalization,

$ä_2$= rate at which consumption is increasing (or decreasing) in the post institutional period due to rise in the real national income

Good governance: In order to halt rapid deforestation and inevitability to bring 1/3rd of India's geographical area under forest cover two crucial forest institutions such as Forest Conservation Act, 1980 (FCA) and National Forest Policy, 1988 (NFP) were enacted. These institutions were enacted to ensure ban on green felling, clear felling, and for empowering the State Forests to halt supply of forest raw materials at concessional prices to forest based industries. NFP was also entrusted to liberalize imports of raw materials to reduce pressure from demand side. Good governance is reflected in decreasing marginal propensity to consume for forest products in post institutional period. In the institutional framework the sign and magnitude of $ä_2$ coefficient reflects the presence of good governance. Negative sign and higher magnitude reflects the presence of good governance.

Accordingly model (1) gives rise to two marginal propensities to consume, one for the pre-institutional period for 1971 to 1990 and the other for the post-institutional period of 1991onwards.

The MPC of a forest product in the pre-institutional period = â, gives the rate at which consumption is increasing (or decreasing) per rupee of real income irrespective of the period, depending upon the relationship of consumption of forest product with real national income.

The MPC of a forest product in the post-institutional period = â + $ä_2$, implying that in the post institutional period, the MPC of forest product is increasing (or decreasing) per rupee of real income irrespective of the period plus the rate at which consumption is increasing (or decreasing) in the post institutional period, depending upon the governance. Thus, depending upon the rate at which the consumption is increasing (or decreasing) in the post institutional period, the MPC will rise or fall. If the post institutional period had an apparent impact on consumption, due to good governance of institutions and the effect of economic liberalization, the MPC will fall from the rate at which consumption is increasing per rupee of real income irrespective of the period, otherwise, would rise.

Component decomposition: The consumption of forest products according to the model used in the study as influenced by real national income and institutions are decomposed into two components. The first component is one which is strongly influenced by autonomous consumption and the second component is influenced by the marginal propensity to consume which varies over time period due to the absence/presence of institutions. The first component reflecting the effect of autonomous consumption is obtained by adding intercept coefficient and coefficient of intercept dummy = (á+$ä_1$). This autonomous consumption is hypothesized to be shaped by technological innovations, efficient utilization of raw materials and finished products, effective recycling of wastes, evolution of substitutes for forest products and their effective diffusion of technologies. The second component reflecting the effect of MPC is the consumption induced by MPC + consumption induced by institutions = ($âY_t + ä_2Y_t$).

Method for demand projection: In this study, for the sake of projection of demand, institutional framework of consumption described in equation (1) was used. The results of demand projection for 2005 have been compared with the projections made by Sharma and Kumar (1999) and Malik and Danda (2003). This exercise was undertaken to test how pragmatic the model in equation (1) is when compared with the Log Linear consumption functional framework used in above referred studies. The model used for projection of demand for forest product in those studies was Ln Z_{it} = Ln $á_o$+ $á_1$Ln Y_t+ $á_1$ T+ Ln u_{it}, where $Z_{it}$is the apparent consumption, Y_t is the real national income at 1980-81 constant prices and T is the time trend.

RESULTS AND DISCUSSION

The autonomous consumption of all forest products has shifted to the right, except for plywood, paper + paper board (NES) and wood-based panels. With the exception of paper + paper board (NES) and household + sanitary paper, for all other forest products (Table 1), the consumption is increasing per rupee of real income irrespective of the period (as indicated by positive sign for â) and the consumption is falling in the post-institutional period (as $ä_2$ the coefficient of slope dummy variable < 0). The results prove the hypotheses of the study for all except for two of the forest products -paper and paper board (NES) and household and sanitary paper, highlighting the role of good governance of forest and economic institutions in shaping the consumption of forest products in India. For the forest products such as industrial round wood, dissolving wood pulp, sawlogs + veneer logs,

round wood and sawnwood + sciages, the autonomous consumption was impressive. Autonomous consumption underscores the role of domestic science & technology research and development, relative prices of forest products and their substitutes. The autonomous consumption (Table 2) of industrial roundwood was 24936000m^3, dissolving wood pulp (242000 tonnes), sawlogs + veneer logs (16804000 m^3), round wood (277240000 m^3) and sawnwood + sciages (16291000 m^3).

For the forest products such as paper and paper board (NES) onto wood pulp, the contribution of MPC is more than that of autonomous consumption (Table 3). Thus, their consumption and their projection is influenced more by real income and its interaction with economic and forest institutions. Further for these products the year of structural/ institutional break was found. The year of structural/ institutional break refers to the year where the MPC times the real national income exceeds the autonomous consumption showing the relative importance of force of real income and its interaction with forest and economic institution over technology, efficient use of raw materials, recycling of wastes, and substitutes.

Consumption triggered by economic liberalization: The share of imports of forest products in the total consumption for four successive decades highlighted the perceptible influence of economic liberalization in facilitating increased consumption of various forest products. This apparently reiterates that EL has played a greater role in the demand/ consumption of forest products in India than the forest institutions of FCA and NFP (Table 4).

Table 2. Forest products relatively influenced by autonomous consumption

Forest products	Rationale
Industrial round wood ('000M^3)	For these forest products, autonomous consumption over time is relatively constant. Thus, consumption is consistently projected to increase due to rise in real income and its interaction with economic and forest institutions
Dissolving wood pulp ('000 tonnes)	
Sawlogs + veener logs ('000M^3)	
Round wood ('000M^3)	
Sawnwood + Sciages ('000M^3)	

The forest institutions such as NFP and FCA have constrained domestic supplies and led to reduction in domestic consumption of forest products. The result was in corroboration with the outcome of Forest Sector Report, ICFRE, India, 2010 indicating that the timber production from Government forests have declined gradually with increasing restrictions imposed by the central Government on felling (ban on green and clear felling above 1000 m in hills) of trees during 1980's for biodiversity conservation and bringing more area under protected area network. The NFP, 1988 have also emphasized on conservation of forests and biodiversity and discouraged production of timbers for industries. The annual production of timber from forests had declined to about 4 million M^3 by 1990. From 1998, the total annual production of

Table 1. Estimated linear consumption function of forest products

Forest Products	á = autonomous	â = MPC	ä1 intercept	ä2 slope	$?^2$	F
Industrial Round wood ('000M^3)	5034	0.02146	19898	-0.0211	0.9	121.03
Chemical wood pulp ('000 tonnes)	-290	0.00094	794	-0.0006	0.96	326.64
Dissolving wood pulp ('000 tonnes)	34 NS	0.0002	208	-0.0002	0.85	72.94
Wood pulp ('000 tonnes)	-466	0.00161	1229	-0.0011	0.98	541.49
Sawlogs + veener logs ('000M^3)	3081	0.01651	13723	-0.015	0.91	124.14
Round wood ('000M^3)	110806	0.16356	166434	-0.1477	0.96	327.54
Other Paper + paper board ('000 tonnes)	-241 NS	0.00115	768	-0.0005 NS	0.88	96.98
Printing + writing paper ('000 tonnes)	65 NS	0.00084	547	-0.0004 NS	0.88	98.16
Newsprint ('000 tonnes)	-127 NS	0.00063	346	-0.0003	0.95	221.85
Paper + paper board ('000 tonnes)	-7 NS	0.00206	1180	-0.0006 NS	0.92	152.82
Wrapping + packing paper + board ('000 tonnes)	-596	0.00142	1165	-0.0009	0.87	88.61
Plywood ('000M^3)	-158 NS	0.00055 NS	-591	0.0002 NS	0.86	80.7
Paper + paper board (NES) ('000M^3)	285	-0.00023	-352	0.0004	0.83	152.82
Wood-based panels ('000M^3)	-208 NS	0.00073	-644	0.0002 NS	0.89	106.36
Sawnwood + Sciages ('000M^3)	-6059	0.02522	22349	-0.0259	0.63	22.59
Household + sanitary paper ('000 tonnes)	68	-0.00005	-43	0.0001	0.18	3.85

All the regression coefficients are statistically significant at 5 % level, except for those marked as NS (non-significant)Dummy variable was used to capture the influence of forest and economic institutions. Dummy variable was assigned zero value for the pre-institutional period (1971-1990) and value of one for post institutional period. Slope dummy was used to capture the effect of rate of change in real income on consumption of forest products.

timber from Government forests declined to about 2 million M^3**.** The National Forest Commission also admits the alarming picture of imbalanced demand-supply situation in the country. The domestic demand for timber estimated at 64 million M^3 in 1996 rose to 82 million M^3in 2006. However, supplies from natural forest reduced following the directive of NFP, 1988 which discouraged harvesting of natural stand for commercial use and require prior approval of the working plans for harvesting the forests. The commission also indicated that only 12 million $M^3$of total demand of 64 million M^3 of timber can be sourced from forest, while 31 million M^3 has to be sourced from farm forestry and other sources including imports. The remaining 21 million $M^3$is estimated to be sourced from unrecorded removal from plantations and natural forests.

Open general license: The major policy initiative of Government of India permitted wood import by classifying wood under Open General License (OGL) in 1996 with a view to ease out the wood shortage, as also to reduce pressure on natural forests. However, the tariff structureis biased in favour of imports of logs and a conscious attempt has been made to keep out the import of processed wood and products to protect the domestic wood processing industry. Due to economic crisis during the course of major economic liberalization, imports have declined from 1.3 million M^3 in 1990 to 0.28 million M^3 in 1994. Later, economic liberalization facilitated the trade by increasing the volume of imports from 0.28 million M^3 in 1994 to 4.04 million M^3 in 2006. The share of imports to domestic production has increased from two per cent in 1994 to 17 per cent in 2006. Currently, India is the net importer of forest products by a big margin. In terms of value, in 2001, imports were ten times more than exports. In 1995, imports were US $ 0.5 billion and doubled to US$ 1 billion in 2001. Here, Industrial roundwood accounted for 42 per cent, paper and paper board 33 per cent, wood pulp 10 per cent, recovered paper 12 per cent and wood based panels 3 per cent. Imports of wood have continuously increased in the last two decades except for a slight dip in 2002 to 2003. There

Table 3. Forest products relatively influenced by autonomous consumption, MPC and institutions

Forest products	Year of structural/ institutional break	Autonomous consumption = (á + $ä_1$)	Consumption induced by MPC + consumption induced by institutions =($âY_t$ + $ä_2Y_t$)
Paper + paper board (NES) ('000M^3)	1971	285.19 - 351.93 = - 66.74	- 109.27 + 190.04 = 80
Household + sanitary paper ('000 tonnes)	1975	67.72-42.6 = 25.12	-27342 + 54.82 = 27.4
Newsprint ('000 tonnes)	1981	-126.97+346.15 =219.18	426.50 - 203.09 = 223.41
Paper + paper board ('000 tonnes)	1985	-7.45+1179.65 =1172.20	1667.6 - 485.72=1181.88
Other Paper + paper board ('000 tonnes)	1986	-241.19+767.91 =526.72	970.66 - 422.02 = 548.64
Wood-based panels ('000M^3)	1988	-208.45-644.43 = -852.88	699.25 + 191.57 =890.82
Plywood ('000M^3)	1989	-157.74-591.48 = -749.22	559.07 + 203.30 =762.37
Wrapping + packing paper + board ('000 tonnes)	1992	-595.66+1164.77 =569.11	1516.12-960.93=555.19
Printing + writing paper ('000 tonnes)	1996	64.7+547.37 =612.07	1253.62-596.96=656.66
Chemical wood pulp ('000 tonnes)	1996	-289.93+794.42 =504.49	1402.80-895.44=507.35
Wood pulp ('000 tonnes)	1997	-465.59+1229.03 =763.44	2511.98-1716.26 =795.72

Note: Dependent variable is consumption of forest products

Table 4. Share of imports of forest products in consumption (%)

Year	Industrial round wood	Wood based panel	Wood pulp	Chemical wood pulp	Dissolving wood pulp	Paper and paper board	Newsprint	Printing and writing paper	Paper + paper board (NES)
1981	0.08	0.00	18.27	6.15	33.80	17.74	83.15	1.93	9.88
1991	3.03	2.00	22.36	19.28	35.74	10.80	44.44	0.60	47.44
2001	10.41	14.80	13.82	11.82	16.39	12.24	36.31	5.26	21.21
2009	7.29	8.12	22.26	24.56	39.72	14.40	49.11	16.45	13.79

was a sudden increase in the imports by 60 per cent in 1997-1998 after liberalization policy. The current level of imports of wood is about 6 million M^3 of which round logs alone constitute more than 93 per cent. Value of imported wood and wood products has gradually increased from Rs. 3222 crores in 2003-04 to Rs. 7688 crores in 2009-10 (Forestry sector report, ICFRE, 2010).

Paper and paper based forest products: The imports of paper and paperboard have been growing at more than 8 per cent during 1981 to 2010. The rate of growth in imports of paper and paper products during liberalization period (1991-2000) was 16.77 per cent. In the last decade the rate of growth in its imports declined to 12.26 per cent. To have a better insight about the magnitude of imports, import intensity was calculated using appropriate procedure (Import Intensity = Import quantity/domestic consumption * 100). The Import intensity of paper has witnessed fluctuations during the past three decades. It has seen the worst slippage from 17.28 per cent in 1981 to 4.28 per cent in 1990 because of the rise in domestic production using non-conventional raw materials. Later the import intensity increased to 12.25 per cent in 2000 and again declined in 2010 to 9.55 per cent on account of substantial increase in the domestic production after liberalization.

From demand side, the import of industrial and cultural grades paper, such as, other paper plus paperboard, wrapping plus packaging paper plus board have been swelling. The import growth of newsprint and printing plus writing paper in contrast fell substantially. The major chunk of India's import of paper and paperboard originated from Australia, Belgium, China, France, Italy, Malaysia, Korea, Sweden, Thailand and UK from 1997 to 2008. On the other hand, the import of newsprint rose from Belgium, China, Japan, Poland, UK and United States of America. Although, India is a net importer of paper and paper products, its exports have also been swelling since liberalization (Sandeep,2009).

Andrew *et al*. (2003) indicated that India's forests have increased after decades of forest decline. Considering the trends in forest area and forest cover between 1880 and 1999, forest cover declined from 20 percent of total land in India in 1880 to about 16 percent in 1950. The proportion of land designated as forest land increased from 12.3 percent in 1951 to 23 percent in 1999. The tree coverage based on satellite imagery for a national sample of Indian villages since 1971indicated increase in proportion of land covered by forests, from around 10 percent in 1971 to over 24 percent in 1999. The findings established that economic growth is consistent with afforestation and deforestation can be reversed even at low levels of national income. The article opines that increases in aggregate demand due to income and population growth are leading to afforestation in forest products such as fuelwood, furniture and paper.

Plywood: India produces three categories of plywood according to the “Federation of Indian Plywood and Panel Industry” (FIPPI): commercial plywood, decorative plywood and block board & flush doors. Commercial plywood constitutes 90 per cent of the total plywood production. According to FIPPI, India's annual plywood production capacity is 124 million square meters, but the industry generally produces at half of its capacity. India predominantly relies on domestic production to meet domestic demand. Only 4 per cent to 7 per cent of annual consumption of plywood is met from imports. India is a net exporter of plywood. The value of plywood imports ranged from US$ 3.7 million to US$ 5.4 million between 1999 and 2004. Imports of plywood dropped gradually between 1999 and 2002 before increasing in 2003 and 2004. In 2004, the value of plywood imports from the US was less than US$ 2,000. The annual imports from US to India have declined sharply over the last six years from US$ 75,820 in 1999 to US$ 1,979 in 2004. India's plywood imports from China have increased significantly over the last six years from US$ 0.3 million in 1999 to US$ 1.9 million in 2004(Indroneil and Ivan, 2007).

Woodbased panel: The Indian wood panel industry is domestic production oriented. However, in recent years market increasingly relies on imports in the case of veneer sheets and fibreboard. Increasing demand, coupled with a projected drop in domestic production due to shortage of raw material will likely to result in increased Imports. The imports of wood based panels steadily increased from 1999 to 2004, with a temporary slump in 2002 resulting from the global economic recession. The rates of increase in India's imports of wood based panels have been impressive since 2003. It may be noted that fibreboard and particleboard imports have become increasingly important. Plywood and the veneer imports have remained relatively constant over the past six years.

A miniscule percentage of India's veneer consumption is met by imports**.** The percentage domestic consumption of veneer met by imports was less than 1%. The total value of imports of veneer sheets and sheets for plywood in 2004 totaled US$ 4.9 million. In 2000, the value of veneer products imported by India dropped by almost 40 per cent, although, the quantity of imports dropped by 26 per cent. Italy was the major source of imports in 1999 and in 2000 veneer imports became inexpensive (by almost 50 per cent) compared to the previous year. Since 2002, Myanmar and Thailand have increased their exports to India.

Myanmar's veneer exports to India increased from 127 metric tons in 1999 to almost 3,180 metric tons in 2004. The price of veneer imports from all the countries has declined over the past six years. India produces most of its domestic particle board requirements. The particle board industry is not export oriented and India is a net importer of particle board. In 2004, India imported a total of US$ 15.3 million worth of particle board and oriented strand board (OSB) while total exports in the same year were US$ 5.4 million. Indian imports of fibreboard are dominated by High Density Fibreboard (HDF), popularly known as 'hardboard'. The total value of HDF imported from Malaysia and Thailand by India was US$ 7.9 million in 2004, and is almost 50 per cent of the total value of fibreboard imported during the year. Medium density fibreboard imports increased from US$ 1.4 million in 1999 to US$ 3.9 million in 2004. India's imports of (low density) insulation board was relatively constant between 1999 and 2003 and increased substantially in 2004 (Indroneil and Ivan, 2007).

Saw logs and veneer logs: Log imports account more than 92 per cent in India's wood product imports. In 2004 the total import of logs was almost US$ 802 million. From 1999 to 2004, the total value of log imports by India almost doubled from US$ 418 million in 1999 to US$ 802 million in 2004. Malaysia and Myanmar are the largest exporters of logs to India in terms of both value and volume. In 2004, the total volume of logs imported from Malaysia was 1.6 million m^3 with a value of US$ 323 million. The total volume of logs imported from Myanmar in the same year was 0.53 million M^3, with a value US$ 208 million. Indonesia, Nigeria, Ivory Coast and New Zealand are also the large exporters of logs to India. Most of India's log imports comprised of tropical hardwood species. However, since the beginning of 2000, Indian imports of temperate softwood species have been increasing (Indroneil and Ivan, 2007).

Industrial round wood and round wood: Imports of industrial roundwood to India have grown at 20 per cent annually over the recent five-year period, reaching a volume of over 2 million M^3. However, this is still a small share (under 5%) of the national consumption of coniferous and non-coniferous logs. The tropical industrial roundwood has dominated over other industrial roundwood in Indian imports, i.e., of non-coniferous industrial roundwood. The import of tropical industrial roundwood has achieved a double-digit growth rate (10% per annum) over the last 10 years with a negative growth rate in the case of other industrial roundwood.

Industrial roundwood form bulk of India's wood imports: The bulk of timber and timber product imports mainly of tropical hardwoods, comprising about 90% of total import of wood and wood products, excluding paper and pulp. Changes in the supplies of industrial wood to India are even more dramatic. In 1997, 95 percent of India's roundwood supplies were obtained from many countries (due to small quantity sourced from each, these countries were aggregated as others'). However, by 2007, New Zealand and Australia collectively supplied 85 percent of India's roundwood and chip imports, while the share of 'others' declined to about 1 percent. Russia has also became an important supplier of industrial roundwood to India, accounting for 14 percent of imports in 2007. A significant trend is that major wood-importing countries are increasingly focusing on assured and stable supplies, reducing their reliance on diminishing tropical sources (Maharaj, 2004).

Demand projection: The deviation of the actual consumption from the projections made using equation (1) is the lowest compared with those of the other two studies (Table 5). For instance for 2005, considering wrapping +packing paper + board, the projection made with equation (1) is only 30 per cent away from the actual consumption, while in the other two studies, the deviation exceeds 140 per cent. Similarly, in the case of Industrial round wood, the extent of deviation in projection from actual, using equation (1) was a modest of -3 percent, while the deviation exceeds 38 per cent in the other two studies. Thus, considering empirical results as well as the strength of the econometric model equation (1) is a better forecasting model, compared with those of the other two studies. The demand for various forest products are projected upto 2020 considering institutional framework (Table 6).

CONCLUSIONS

The result indicated that for forest products such as industrial round wood, dissolving wood pulp, sawlogs + veneer logs, round wood and sawnwood + sciages, the autonomous consumption was impressive and underscored the role of domestic science technology research and development, substitutes and the relative prices of forest products and their substitutes. For rest of the 11 forest products from paper and paper board (NES) onto wood pulp, the contribution of MPC was more than that of autonomous consumption reflecting the profound influence of real income and its interaction with economic and forest institutions. This precisely indicated the role of forest and economic institutions in facilitating increased consumption. The projection of demand of forest product is being shaped by the interplay of real income, forest and economic institutions by comparing the percent deviation of projected consumption from the actual consumption for the year 2005 with the other two studies. The percent deviation in projection was lower

using the institutional framework compared with the Log linear model deployed in the other two studies. This also reflected the forecasting ability of the Institutional consumption model.

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Table 5. Actual and projected demand for forest products for India for 2005, the common year of data for the three studies

Forest Product (unit of measurement)	Actual consumption in 2005	Projected consumption according to					
		This study (2013)	Deviation from actual	Sharma and Kumar (1999)	Deviation from actual	Malik and Danda (2003)	Deviation from actual
Wrapping + packing paper + board	1696	2208	30%	4110	142%	4110	142%
Wood based panels (000M^3)	2685	2103	-22%	1110	-59%	380	-86%
Plywood ('000M^3)	2082	1615	-22%	870	-58%	70	-97.39%
Industrial round wood (000 M^3)	26870	26063	-3%	37610	40%	37080	38%
Newsprint ('000 tonnes)	1324	1343	1.43%	1610	21.60%	1820	37.46%
Wood pulp ('000 tonnes)	2762	2468	-10.64%	3210	16%	3360	21.65%
Round wood ('000M^3)	332415	328337	-1.22%	372130	12%	342060	2.90%
Paper + paper board ('000 tonnes)	5067	5915	17%	4730	-7%	6080	20%
Printing + writing paper ('000	1660	2014	21%	1660	0%	1750	5.42%

Table 6. Projection of demand for forest products

Year	Industrial Round wood ('000M^3)		Dissolving wood pulp ('000 tonnes)		Sawlogs + veener logs ('000M^3)		Round wood ('000M^3)		Sawnwood + Sciages ('000M^3)	
	Actual	Projected	Actual	Projected	Actual	Projected	Actual	Projected	Actual	Projected
1971	13287	15231	63	128	9572	10923	178788	188515	4778	5924
1975	16447	16800	129	143	11524	12130	197678	200475	6798	7768
1980	19765	18810	216	161	14536	13677	220366	215798	10991	10131
1985	23954	22407	181	195	18350	16443	249094	243211	17460	14358
1990	25698	27948	249	246	18350	20705	274972	285438	17444	20870
1995	25229	25415	387	291	18350	18911	285999	299081	17450	15293
2000	21087	25577	321	308	18350	19616	323286	306384	8399	14959
2005	26870	26063	363	358	22390	21734	332415	328337	14846	13956
2009	25007	26495	423	402	22390	23620	333564	347888	14835	13062
2010		26205		372		22353		334759		13662
2011		26280		380		22680		338148		13507
2012		26359		388		23026		341736		13343
2013		26443		397		23393		345535		13170
2014		26532		406		23781		349558		12986
2015		26626		415		24192		353818		12791
2016		26726		425		24627		358329		12585
2017		26832		436		25088		363106		12367
2018		26944		448		25576		368164		12136
2019		27062		460		26093		373520		11891
2020		27187		473		26640		379192		11632

Cont...

Cont...

Year	Paper and paper board (NES)		Household + sanitary paper ('000 tonnes)		Newsprint ('000 tonnes)		Paper + paper board ('000 tonnes)		Wood-based panels ('000M^3)		Plywood ('000M^3)		Wrapping + packing paper + board ('000		Printing + writing paper ('000 tonnes)		Chemical wood pulp ('000 tonnes)		Wood pulp ('000 tonnes)	
	Actual	Projected	Actual	Projected	Actual	Predicted	Actual	Projected	Actual	Predicted	Actual	Projected	Actual	Projected	Actual	Projected	Actual	Predicted	Actual	Predicted
1971	161	174	20	44	247	170	1035	969	179	140	138	102	135	79	463	464	92	155	190	298
1975	109	157	46	41	153	216	1026	1120	153	194	112	142	200	183	507	526	240	224	397	416
1980	163	135	65	36	279	275	1349	1312	224	262	173	193	317	316	524	604	309	312	571	566
1985	27	96	14	28	388	380	1558	1657	426	385	354	285	638	554	725	745	507	469	844	836
1990	48	35	20	15	495	541	2176	2187	437	574	359	426	922	921	914	962	647	711	1144	1251
1995	107	96	30	32	568	699	3231	3199	318	411	222	262	1358	1269	1168	1211	820	945	1506	1492
2000	164	151	36	34	995	860	4528	3877	369	833	70	600	1711	1504	1622	1412	1220	1092	1807	1736
2005	345	315	41	40	1324	1343	5067	5915	2685	2103	2082	1615	1696	2208	1660	2014	1694	1534	2762	2468
2009	494	461	39	46	1500	1773	8546	7730	2774	3235	2168	2520	3581	2834	2932	2551	1862	1928	2965	3121
2010		363		42		1484		6511		2475		1913		2414		2190		1663		2683
2011		388		43		1559		6826		2671		2069		2522		2283		1732		2796
2012		415		44		1637		7159		2879		2236		2637		2382		1804		2915
2013		443		45		1721		7511		3098		2411		2759		2486		1880		3042
2014		473		46		1809		7885		3331		2598		2888		2597		1961		3176
2015		505		48		1903		8280		3578		2795		3025		2713		2047		3319
2016		539		49		2002		8699		3839		3003		3169		2837		2138		3469
2017		574		50		2107		9142		4115		3224		3322		2968		2234		3628
2018		612		52		2219		9612		4408		3459		3485		3107		2336		3797
2019		652		53		2336		10109		4718		3706		3656		3254		2444		3976
2020		694		55		2461		10635		5046		3969		3838		3410		2559		4165

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Comparative Biological Studies of Citrus Leaf Miner on Kinnow and Rough Lemon during different Seasons in Punjab

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Abstract: The biology of citrus leaf miner, *Phyllocnistis citrella* was studied on *Citrus reticulata* (Kinnow) and *Citrus jambhiri* (rough lemon) during different seasons (2013) at Punjab Agricultural University, Ludhiana. During spring season, the average pre-oviposition and oviposition periods lasted for 2.23, 2.14 and 2.10, 2.45 days on Kinnow and rough lemon, respectively. The duration was found to be longer than summer but almost similar to that during autumn season. The total larval duration (1st to 4th instar) of *P. citrella* during summer on Kinnow (9.89 days) and rough lemon (7.40 days) was shorter than that during spring and autumn seasons. The average female longevity was 4.22 and 4.22±0.20 days on Kinnow and rough lemon, respectively and was more than that of male longevity. In summer, the female lived longer than male The adult life span was more on rough lemon than Kinnow during the various seasons. The study indicated that at higher temperature the growth and development of citrus leaf miner was faster than at the lower temperature.

Key Words: Biology, *Citrus jambhiri*, *Citrus reticulate, Phyllocnistis citrella*

The citrus cultivation is facing several difficulties and among them, pest attack is one of the most important problems. About 823 species of insects and mites are known to feed on citrus throughout the world (Ebeling, 1959). Out of these, about 250 species are found in India (Srivastava and Butani, 1999) with only 34 insect and mite species are active under Punjab conditions (Sharma *et al.,* 2011). Among these insect pests, citrus leaf miner, *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae), is a potentially serious pest of citrus and related ornamental plants. *The pest is* distributed in about 70 countries and is considered as the most destructive pest (Batra and Sandhu, 1981, Sharma *et al.,* 2011), which mostly attacks nurseries, young plantations and tender flushes with about 16 overlapping generations during its active period in a year . Kalidas and Shivankar (1994) reported that more than 80 per cent nurseries were infested by this pest in India and of the total damage caused by the pest complex of citrus, 30 per cent can be attributed to *P. citrella* alone. Besides, the curling of leaves after mining by larvae, there is considerable reduction in growth of seedlings (Sharma and Dhaliwal, 2008). In addition, it's attack predisposes the plants to citrus canker with increased incidence and severity (Dhiman *et al.,*2000).

The researchers across the world had worked on biology, behavior, ecology and biological control agents of *P. citrella* to find out weak links in leaf miner populations that could be exploited to curb its infestation. However, an insight of literature in India clearly indicated that information on bioecology of this pest is scanty and old, therefore, the present study was, therefore, planned to study the biology on two hosts during different seasons.

MATERIAL AND METHODS

The various biological parameters of *P. citrella* were recorded on kinnow (*Citrus reticulate*) and rough lemon (*Citrus jambhiri*) during different seasons namely spring (March-April), summer (May-June), rainy (July-August), autumn (September-October) and winter (November-December). The studies were conducted under screen house and laboratory conditions at Entomological Research Farm, Punjab Agricultural University, Ludhiana during 2013.

Raising of test insect: To raise the culture of the test insect, 10 cm twigs of citrus with pre-pupae and pupae collected in February, 2013 from the field were reared in the laboratory for emergence of adults. These twigs were then kept in 100 ml conical flask containing 25 ml water. The conical flask was kept in earthen pot containing soil and was covered with glass chimney (one end of which was fastened with muslin). Care was taken that the leaves bearing pupae did not touch the sides of chimney. The adults emerged in due course were then aspirated with the help of small glass aspirator. Male and female moths were then identified with their typical morphological characters and released in pairs/plant with a set of 5 plants each of Kinnow and rough lemon. After every 24 hrs, the adults were removed and released onto another new plant. This was done for 10 days or till the death of adults in a particular case or replication. The temperature and relative humidity was regularly recorded during the course of study.

Pre-mating period: The pre-mating period was recorded from the time of release of adults on particular plant based on commencement of some activity of adults. This study was made for five caged adults/ plant one after other. The

observations were made after every 2 hrs till the mating activity started in a particular set.

Mating period: Following the commencement of activity of the adults after pre-mating period as described above the adults were carefully watched to note the mating time under covered glass chimneys. The time taken between the first activity and cessation of any movement of adults was considered as the mating period. To study this period, one pair of adults released on a caged plant was observed individually and the observation from 5 such sets were recorded one after other till the cessation of activity in each set.

Pre-oviposition period: The period from the time adults stopped mating (based on cessation of activity) and upto the start of egg laying was taken as pre-oviposition period. This period was ascertained from the serially transferred plants.

Oviposition period and viability of the eggs: The duration of egg stage was determined by the time between the egg laying date and the pin head mine observed on the leaves, whereas, fecundity/viability of the eggs was based on the number of larvae hatched in all the plants of a particular pair of citrus leaf miner.

Larval instar duration: The leaves with pin head larvae on them were marked to study the different larval instar durations. The duration of different instars was based on the exuviae shed by the larvae in the mine. The exuviae looks like brownish black dot in the mine. The time period between shedding of two consective exuviae dots was considered as a larval instar duration. These observations were made daily from 10 plants with 5 larvae /plant.

Adult longevity: The daily observations were taken for the mortality of the adults in a particular caged plant. The duration between the emergence and the death of a particular adult was considered as the longevity period of adults and the observations were recorded separately for male and female adults.

Survival of larvae: The total number of larvae hatched were recorded on each plant. Out of these, the larvae which reached the pupal stage were considered as larval survival.

Number of generations of *P. citrella*: The number of generations of leaf miner was studied on two host plants *C. reticulata* and *C. jambhiri*. The studies were conducted under screen house conditions. A pair of freshly emerged adults (one male and one female) in the month of March (2013) was aspirated and released in a potted plant for 24 hrs and 5 sets of such plants each of Kinnow and rough lemon were maintained. At the end of this period, the adults were removed and serial transformation of the plants of each species was made. The adults so emerged were further released in the same way as given under different headings above till April, 2014. The duration of each generation was recorded based on the release of adults.

RESULTS AND DISCUSSION

Pre-mating and mating period: Before mating, there was a brisk flying activity and just before the start of mating the adults settled down. The pre-mating period varied from 14.80 to 16.35 and 14.90 to 16.37 hrs on Kinnow and rough lemon, respectively during different seasons (Table 1 and 2). Pre-mating period varied 14.18 to 14.90 on Kinnow and 14.19 to 16.37 hrs, respectively on rough lemon.. The average pre-mating period was 14.91 and 14.95 hrs on Kinnow and rough lemon, respectively which are in general agreement with the observation of Das *et al.* (1998). The pre-mating period was longest in winter and shortest in. The mating period varied from 41.32 to 128.36 minutes on Kinnow and 45.32 to 132.50 minutes on rough lemon, during various seasons of the year. Mating occurred on the first day of adult emergence in end to end fashion and lasted for 41.32, and 128.36minutes on Kinnow and 44.48 to 132.5 minutes, respectively on rough lemon during summer and winter seasons, respectively. Maximum mating was noticed at sun set, however, few individuals also copulated during morning hours. Mating period was shortest in summer while it was longest in winter due to low temperature. The average mating period was 68.5 and 71.56 minutes on Kinnow and rough lemon, respectively.

Pre-oviposition and oviposition: Eggs were laid on both the sides of the leaf but the maximum number was on lower side of the leaf lamina near the mid rib and larger veins. There were mostly 2-3 eggs in each leaf. There was no oviposition during December and January due to low temperature (7.4-20.5°C). The pre-oviposition period lasted for 1.96 to 3.50 days Kinnow and 1.98 to, 3.91 days on rough lemo during autumn and winter seasons, respectively. The oviposition period ranged from 1.50 3.90 days on Kinnow and 1.74to 4.00 days on rough lemon during different seasons. The same results were also recorded by Das *et al* (1998). During summer season, the average pre-oviposition and oviposition periods were 1.96, 1.50 and 1.98, 1.74 days on Kinnow and rough lemon, respectively, which was much shorter than all other seasons of the year. The shorter duration of pre-oviposition and oviposition periods during summer might be due to prevailing hot climatic conditions. Pre-oviposition and oviposition period was longest during winter, which could be due to low temperature.

Fecundity/viability: The fecundity varied from 26 to 37 on Kinnow and 29 to 38 on rough lemon during, summer and autumn season, respectively. Highest viability was observed during autumn season being 92.5 and 95 per cent on Kinnow and rough lemon, respectively and lowest during summer

Table 1. Biological parameters of *P. citrella* on Kinnow during various seasons (2013)

Biological parameters	Duration/abiotic factors during different seasons					
	Spring	Summer	Rainy	Autumn	Winter	Mean
	Duration during different seasons					
Pre-mating (hrs)	14.80±0.30	14.18±0.18	14.30±0.13	14.90±0.02	16.35±0.14	14.91±0.86
Mating (minutes)	41.32±0.76	42.48±0.82	49.68±3.19	80.66±0.91	128.36±1.56	68.5±37.08
Pre-oviposition (days)	2.23±0.39	1.96±0.85	2.16±1.31	2.13±0.27	3.50±0.18	2.39±0.63
Oviposition (days)	2.10±0.21	1.50±0.31	2.38±0.45	2.08±0.34	3.90±0.21	2.39±0.90
Fecundity (number)	28.00±4.24	30.00±1.41	27.5±0.71	37.00±1.41	33.5±2.12	29.2±4.01
Larval instar (days)						
1st	3.20±0.15	2.20±0.19	2.74±0.24	4.82±0.46	6.10±0.08	3.81±1.61
2nd	3.63±0.10	2.00±0.084	2.76±0.29	4.94±0.55	8.62±.07	4.39±2.60
3rd	3.20±2.43	2.10±0.05	2.78±0.36	4.10±0.55	7.13±0.04	3.86±1.97
4th	2.90±0.08	1.73±0.15	2.22±0.29	4.24±0.35	8.30±.03	3.87±2.65
Larval survival (%)	85.7	66.67	87.27	64.86	82.09	77.32±10.73
Pupal stage (days)	3.21±0.82	2.86±0.32	3.11±0.69	4.22±0.76	92.67±6.32	21.21±39.95
Adult longevity (days)						
Male	3.50±0.20	1.67±0.14	1.70±0.18	2.30±0.16		2.29±0.86
Female	4.15±0.16	2.07±0.15	2.13±0.22	2.60±0.15		2.74±0.97
	Abiotic factors					
Max Temp (°C)	27.6-34.2	36.6-40.6	33.0-35.0	31.4-33.8	20.0-25.9	
Min Temp (°C)	13.2-18.3	23.0-27.2	26.4-27.7	20.2-24.1	7.4-10.2	
RH (%)	44-72	38-65	72.9-79.5	70.0-73.5	64.5-74.1	

Table 2. Biological parameters of *P. citrella* on Rough lemon during various seasons (2013)

Biological parameters	Duration/abiotic factors during different seasons					
	Spring	Summer	Rainy	Autumn	Winter	Mean
	Duration during different seasons					
Pre-mating (minutes)	14.90±0.35	14.19±0.19	14.35±0.14	14.92±0.03	16.37±0.15	14.95±0.86
Mating (minutes)	45.32±0.54	44.48±1.11	52.00±1.81	83.58±1.06	132.50±0.96	71.56±37.63
Pre-oviposition (days)	2.14±0.32	1.98±0.76	2.72±0.64	2.00±0.16	3.91±0.15	2.55±0.82
Oviposition (days)	2.45±0.32	1.74±0.53	2.72±0.39	2.42±0.47	4.00±0.19	2.66±0.83
Fecundity (number)	29.00±4.24	33.00±1.41	29.5±0.70	38.00±1.40	36.5±2.11	31.00±6.45
Larval instar (days)						
1st	3.11±0.05	2.00±0.12	2.98±0.22	4.74±0.35	6.66±0.56	3.89±1.83
2nd	3.51±0.09	2.00±0.08	2.78±0.03	4.80±0.42	8.92±0.54	4.40±2.73
3rd	3.71±0.37	2.00±0.08	2.76±0.04	4.80±0.42	7.92±0.59	4.24±2.31
4th	2.74±0.18	1.70±0.19	2.12±0.25	4.12±0.28	8.28±0.24	3.79±2.67
Larval survival (%)	93.10	60.60	88.19	71.05	79.45	78.48±13.08
Pupal stage (days)	3.32±0.61	2.92±0.30	3.21±0.82	4.61±0.61	94.37±9.21	21.68±40.64
Adult longevity (days)						
Male	3.7±0.18	1.19±0.15	1.89±0.22	2.00±0.15		2.19±1.07
Female	4.22±0.20	2.22±0.25	2.23±0.17	2.80±0.16		2.87±0.94
	Abiotic factors					
Max Temp (°C)	27.6-34.2	36.6-40.6	33.0-35.0	31.4-33.8	20.0-25.9	
Min Temp (°C)	13.2-18.3	23.0-27.2	26.4-27.7	20.2-24.1	7.4-10.2	
RH (%)	44-72	38-65	72.9-79.5	70.0-73.5	64.5-74.1	

Table 3. Generations (life cycle) of *P. citrella* on Kinnow and rough lemon during different seasons (2013-14)

Season	No. of generations	Duration of Generations (days)		Mean Temperature (°C)	Mean RH (%)
		Kinnow	Rough lemon		
Spring (March 20-April 30)	1st	24.10	24.79	15.7-30.9	58.0
	2nd	17.90	17.21		
Summer (May 1-June 30)	3rd	16.66	16.65	25.1-38.6	51.5
	4th	16.00	15.00		
	5th	14.00	14.00		
	6th	13.34	14.35		
Rainy (July 1-August 31)	7th	23.48	24.82	27.1-34.0	76.2
	8th	20.00	19.00		
	9th	18.52	18.18		
Autumn (September 1-October 31)	10th	14.93	14.61	27.1-34.0	71.7
	11th	17.00	16.00		
	12th	29.07	30.39		
Winter (November 1 –March 10)	13th	*	*	8.8-22.9	69.3

*Not completed due to low temperature

season both on Kinnow and rough lemon. Hot and dry climatic conditions during June alongwith no new leaves could be responsible for low viability.

Duration of the larval stage: The larval duration vary widely during different seasons of the year. The 1st larval instar duration was 3.2 in spring, 2.20 in summer, 2.74 in rainy, 4.82 in autumn, 6.1 days in winter on Kinnow and 3.11, 2.00, 2.98, 4.74 and 6.66 days during these seasons respectively on rough lemon . The results indicated that larval duration from 1st – 4th instars was having similar trend on both the host plants and the temperature could be influencing the duration of these larval instars. The developmental period of the larva was shortest on Kinnow and rough lemon during the summer season, while it was took the longest time during winter season The higher temperature appeared to have an accelerated effect on the rate of development of larvae of *P. citrella*.

Larval survival: The percent survival of the larvae varied from 64-86 to 87.27 and 60.60 to 89. 19 and Kinnow and lemon different seasons. The mortality of the larvae was minimum in spring and maximum in summer indicating that high temperature was detrimental for larvae .

Pupal stage: The pupal period varied from 2.86 to 92.67 days in on Kinnow and 2.92 and 94.37 days on rough lemon during summer and winter season respectively . The average pupal stage duration was 21.21 days on Kinnow and 21.68 days on rough lemon

Adult longevity: During summer season, the male and female longevity was shorter than spring and autumn season. The female longevity during summer (2.07 days on Kinnow and 2.22 days on rough lemon) was more than that of male longevity (1.67 days on Kinnow and 1.19 on rough lemon), which is in agreement to Abo Kaf (2006). The high temperature again proved to be detrimental.

Number of generations: The insect passed through thirteen generations during the course of the study. Starting from spring season (March 20-April 30), average temperature varied from 15.7-30.9 °C and mean relative humidity 40-50 per cent the duration of generations varied from 17.90-24.10 and 17.21-24.79 days on Kinnow and rough lemon, respectively. The duration of generations was maximum during spring and minimum during summer, while the number of generations was maximum during summer and minimum during spring seasons (Table 3). Development of the insect was faster at temperature range of 25.1-38.6 during summer and these observations support the findings of Mogahed (1999).

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Pathogenicity of *Meloidogyne incognita* (Kofoid & White) Chitwood race 2 in Okra, *Abelmoschus esculentus* L.

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***Abstract*:** An experiment was conducted in net house during April-July, 2013 at BCKV, Nadia, West Bengal to determine the pathogenic potential of Meloidogyne incognita race-2 in okra, Abelmoschus esculentus L. The experiment was laid out in Completely Randomized Design with seven treatments and three replications. Healthy seeds of okra cv. OH-152 were directly sown in 15cm earthen pot containing 1000cc of sterilized soil + farm yard manure (1:1) mixture. Three weeks after germination one healthy seedling per pot was kept and inoculated with freshly hatched J2 of M. incognita @ 10, 100, 1000, 5000, 10000 and 15000 per plant per 1000cc of soil. Uninoculated plants were kept as control. Observations were recorded at 60 days after inoculation on final nematode population, plant height, fresh and dry shoot and root weight, root length and root-knot index. Total nematode population in soil was calculated from representatives of 200cc soil/pot. There were significant decreases in all the observed growth attributes of okra at 1000 and above nematodes. A negative correlation existed between initial inoculum density and plant growth parameters. Occurrence of root gall was increased with the increase in inoculum level. The rate of reproduction was inversely related to the inoculum levels and was maximum (35.97) at lowest inoculums level and minimum (1.02) at highest inoculum level. An initial population density of 1000 nematodes per 1000cc of soil can be considered as the minimum density level of *Meloidogyne incognita* race 2 for expression of pathogenic effects on okra.

***Key Words*:** *Abelmoschus esculentus*, *Meloidogyne incognita*, Pathogenicity

Okra, *Abelmoschus esculentus* (L.) is an important vegetable crop of the tropics and sub-tropics. It ranked high amongst the economically important vegetables across the world. Okra crop suffered from infestation of large number of insect pests, diseases and plant parasitic nematodes. Plant parasitic nematode e.g. *Meloidogyne incognita* (Kofoid& White) Chitwood is considered to be the most important. Root knot nematodes (*Meloidogyne* spp.) are potential threat to the vegetable crops across the world and cause losses to the tune of 80% in heavily infested fields. They attack almost all the cultivable plants but vegetable crops are their most preferred hosts (Sasser,1980). The yield of okra, tomato, and brinjal suffered 90.9, 46.2 and 2.3% losses, respectively, due to *M. incognita* infestation at an initial population of 3-4 larvae/g of soil under field conditions (Bhatti and Jain, 1977). In the tropics and sub-tropics, *M.incognita* frequently attacks okra and causes leaf browning, suppression of plant growth, fruit yield and photosynthetic pigments (Khan and Khan, 1994; Khan and Saxena, 1992). Hence, considering the increasing concern of root-knot nematodes as a yield limiting factor of okra an experiment was carried to evaluate the pathogenicity of okra to various level of *M. incognita* race 2.

MATERIAL AND METHODS

A pot experiment was laid out in Completely Randomized Design in net house of Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal during April-July, 2013. Okra seeds (cv. OH-152) were sown directly in 15cm earthen pots containing 1000cc of sterilized soil and farm yard manure mixture (1:1). Three weeks after sowing, one healthy seedling per pot was kept and inoculated with 10, 100, 1000, 5000, 10000 and 15000 freshly hatched active second stage juveniles (J2) of *M. incognita* race 2 pouring around each plant by making three holes. Uninoculated plants were kept as control. Each treatment was replicated thrice and randomized suitably. Irrigation was given as and when required throughout the period of the study. After 60 days of inoculation plants were uprooted and took observation on shoot length, fresh and dry shoot and root weight, root length, and root-knot index in 1-5 scale(where, 1 = no galls/ egg masses, 2 = 1-10 galls/ egg masses; 3 = 11-30 galls/ egg masses; 4= 31-100 galls/ egg masses and 5 = >100 galls/ egg masses per root system). Roots were thoroughly washed in tap water, separated from the plants,2g of roots were gently cut in to small pieces of 2-3cm, stained differentially by NaOCl - acid fuchs in method (Byrd *et al*., 1983)and observe under stereoscopic dissecting microscope(Carl Zeiss- Stemi 2000C) to record immobile stages (spike tail stage, female and egg mass) of *M. incognita* in the root. Motile endoparasitic stages of root-knot nematode (J2) were also extracted from roots after cutting into small pieces of 2-3 cm, split longitudinally and keep on the double layer facial tissue paper and follow the modified Baermann process (Christie and Perry, 1951). This assembly

was kept undisturbed for 72 hours and nematodes in suspension was collected to observe under microscope. Nematodes were also extracted from the 200cc of composite soil sample adopting Cobb's sieving and decanting technique followed by modified Baermann's funnel method (Christie and Perry, 1951) to record final soil population of *M. incognita*. Number of eggs/egg-mass was counted from10 randomly selected egg masses of uniform size followed by immersion in 0.5% solution of sodium hypochlorite for 5 minutes. Reproduction factor was determined by using formula, R=Pf/Pi (where, Pf and Pi represents final and initial nematode population, respectively).

RESULTS AND DISCUSSION

Significant decreases in the growth attributes of okra were observed at 1000 and above inoculum of *M. incognita* race-2 per 1000cc of soil. A negative correlation existed between initial inoculum density and plant growth parameters. There was a gradual decrease in growth attributes of okra with increase in inoculum level of *M. incognita* (Table 1). Maximum reduction in plant height, lengths and weights of root and shoot were recorded at 15000 J2 of *M. incognita* per 1000cc of soil. The minimum reductions were recorded at 10 J2 per 1000cc of soil. It was observed that with an increase in the level of inoculum there was a progressive increase in plant infestation by root-knot nematodes as shown by the number of galls as well as the population of nematodes.

Steady increases in number of galls and egg masses were observed with increase in inoculum levels (Table 2). The total population of juvenile grow up with the enhancement of inoculum level, which was minimum (359.6) at 10 and maximum (15348.7) at 15000 J2 per 1000cc of soil. The line diagram along with regression equation and R-square value of the parameter as displayed in the figure (Fig. 1), showed that total population of *M. incognita*/plant/1000cc of soil were positively correlated with inoculum level. Line diagram along with regression equation and R-square value revealed that reproduction factor of *M. incognita* in okra were negatively correlated with inoculum level (Fig. 2). A significant negative correlation between plant height of okra and inoculum level of *M. incognita* was observed from a line diagram along with regression equation and R-square value (Fig. 3). Line diagrams along with regression equation and R-

Table 1. Effect of different levels of inoculums of *M. incognita* race-2 on okra cv. OH 152

Inoculum level	Plant height (cm)	Fresh weight (g)		Dry weight (g)		Root length (cm)
		Shoot	Root	Shoot	Root	
0	100.7	62.9	16.5	10.6	2.0	31.2
10	98.0	54.7	12.5	9.8	1.7	24.2
100	84.3	51.8	10.4	9.3	1.6	20.5
1000	76.7	39.1	7.7	6.3	1.4	19.5
5000	74.0	38.9	4.3	5.4	1.3	12.8
10000	71.0	31.5	3.2	5.1	0.5	9.7
15000	55.3	18.7	1.4	3.4	0.5	8.3
SEm(±)	1.5	2.23	0.35	0.44	0.08	0.71
CD (p=0.05)	4.55	6.76	1.06	1.33	0.24	2.15

Table 2. Root-knot index and reproductive potential of *M. incognita* race-2 on okra (OH-152)

Inoculum level	Root knot index (1-5 scale)	Nematode population/Plant/Pot		Total Population	Reproduction factor (Pf/Pi)
		Root population (female+juv.+eggs)	Soil Population		
0	1.0	--	--	--	--
10	2.7	161.3	198.3	359.6	35.97
100	3.3	368.3	830.0	1198.3	11.98
1000	4.7	2787.7	3425.0	6212.7	6.21
5000	5.0	3485.3	5240.0	8725.3	1.75
10000	5.0	3262.3	7285.0	10547.3	1.05
15000	5.0	5875.3	9473.3	15348.7	1.02
SEm(±)	0.22	30.44	37.63	32.75	--
CD (p=0.05)	0.67	92.23	114.02	99.23	--

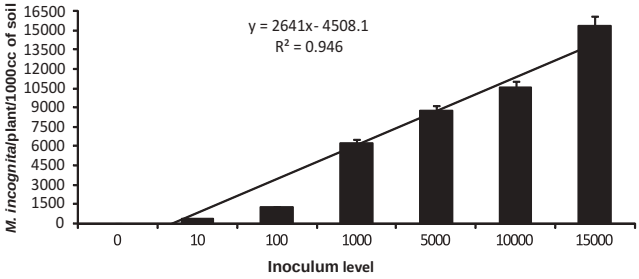

Fig. 1. Effect of inoculum level on total population of *M. incognita*/plant/1000cc of soil

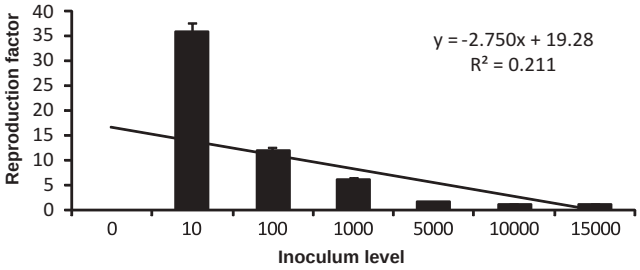

Fig. 2. Effect of inoculum level on reproduction factor (Pf/Pi) of *M. incognita* on okra

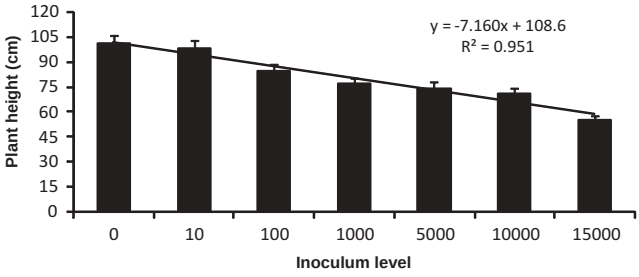

Fig. 3. Effect of inoculum level on plant height (cm) of okra

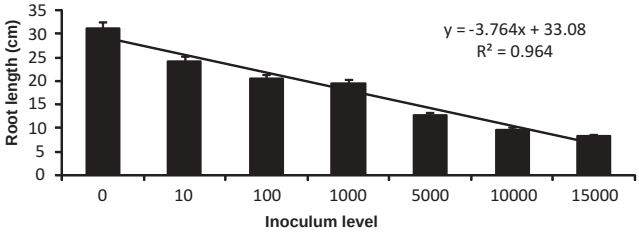

Fig. 4. Effect of inoculum level on root length (cm) of okra

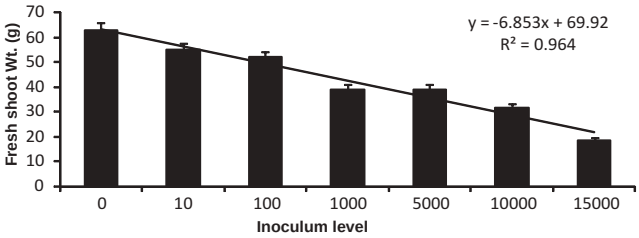

Fig. 5. Effect of inoculum level on fresh shoot wt (g) of okra

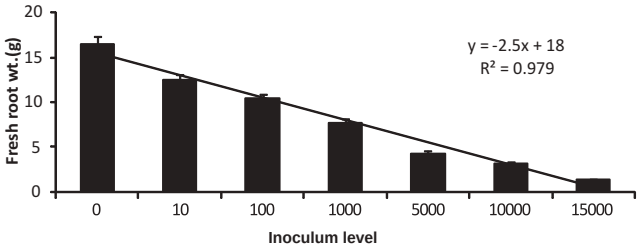

Fig. 6. Effect of inoculum level on fresh root weight (g) of okra

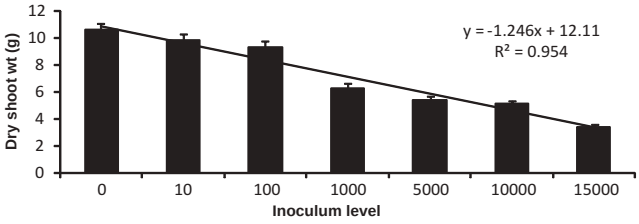

Fig. 7. Effect of inoculum level on dry shoot weight (g) of okra

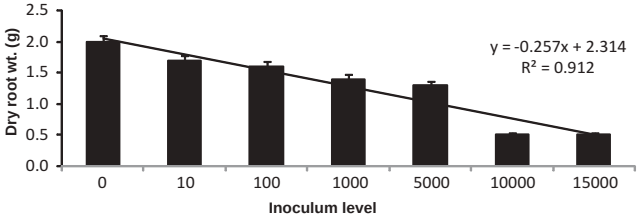

Fig. 8. Effect of inoculum level on dry root weight (g) of okra

square value was computed to understand the interaction between root length, fresh and dry shoot and root weights of okra and inoculum level of *M. incognita*. A significant negative correlation between growth attributes of okra and inoculum level of *M. incognita* was observed (Fig. 4-8).

The reproduction factor was inversely proportional to the inoculum level with the highest being, 35.97 at 10 J2/1000cc of soil and lowest (1.02) at 15000 J2/1000cc of soil (Table 2). This observation on okra crop is in agreement with that of Bhat (2010). At higher inoculation level the rate of reproduction was low, that might be due to competition among the population due to food and space. Scarce availability of space and supply of food at higher inoculum level may lead to reduction of rate of reproduction. The increase in the nematode populations and the subsequent reduction in the yield of crops are directly influenced by the

initial density of the nematodes in the soil (Roy *et al*., 2008; Karmakar *et al*., 2004). The progressive decrease in plant growth and nematode multiplication with the increasing inoculum of root-knot nematode on different crops has also been reported by some earlier workers (Khan and Ashraf, 2006; Khan *et al*., 2006).

Therefore, an initial population density of 1000 nematodes per 1000cc of soil i.e. 1 J2 per cc of soil can be considered as the minimum density level of *M. incognita* race 2 for expression of pathogenic effects on okra.

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Diversity of Springtails (Collembola: Insecta) in Different Tree Ecosystems of Varanasi, India

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***Abstract*:** Diversity of collembola in different tree ecosystems, were investigated in Varanasi, Uttar Pradesh. A total of 2568 specimens of 10 genera belonging to 8 families *viz.,* Isotomidae, Entomobryidae, Paronellidae, Cyphoderidae, Onychiuridae, Hypogastruridae, Sminthurididae, and Katiannidae were recorded. Collembola genera *viz.*,, *Lepidocyrtus* sp.*, Entomobrya* sp.*, Hypogastrura*sp.*, Sminthurinus* sp*, Sminthurides* sp*,* were most common among almost all the ecosystems followed by *Isotomurus* sp.*, Crytopygus* sp.*, Cyphoderus* sp.*, Onychiurus* sp*,* and *Folsomia* sp*.* A Maximum population of 17.71% was recorded during the month of September in Bael ecosystem and minimum in the Aonla ecosystem. In the abundance of collembola in general, there were pronounced seasonal fluctuations of different genera in all the ecosystems. Two peaks in September and October and a fall in December was observed in the population fluctuation. The distribution and abundance of soil fauna was more during monsoon period. These organisms play a functional role in soil ecosystem and there is lack of enough records of these beneficial insects from different ecosystems.

Key Words: Collembola, Ecosystem, Population, Varanasi

Soil biodiversity reflects the mix of living organisms in the soil. These organisms interact with each other, with plants and small animals forming a web of biological activity. Soil is by far the most biologically diverse part of Earth and the soil food web includes virus, bacteria, fungi, tardigrades, rotifers, mites, proturans, collembola, diplurans, pauropods, symphylans, millipedes, pseudoscorpion, spiders, isopods, centipedes and many insects (Cassagnau, 1972). These organisms improve the entry and storage of water, resistance to erosion, plant nutrition, and break down of organic matter. A wide variety of organisms provides checks and balances to the soil food web through population control, mobility, and survival from season to season.These organisms save soil from degradation and desertification and also help our soil to keep fertile. Collembolans are also well-represented group of soil biodiversity. Collembola have well differentiated ecomorphological life-forms and feeding guilds, which enable the functional role that play in ecosystems to be recognised in some degree. Collembola play an important role in plant litter decomposition processes and in forming soil microstructure. They are hosts of many parasitic Protozoa, Nematoda, Trematoda and pathogenic bacteria and in turn are attacked by different predators. They utilise Protozoa, Nematoda, Rotatoria, Enchytraeidae, invertebrate carrion, bacteria, fungi, algae, plant litter, live plant tissues, and some plant pathogens as food.

The study of soil micro-arthropod community in agricultural fields of India was initiated by Singh and Pillai (1975) and found that some of the collembolan community mixes small mineral particles with dead organic matter in their guts and contribute by their faecal pellets to soil microstratum. They play vital role in decomposition and nutrient recycling and potential biological indicators of soil quality and ecosystem health. Brussard*et al*. (1997) mentioned earlier that soil organisms are not just inhabitants of soil but they are part of the soil heavily influencing soil properties. They further mentioned that Collembola contribute to soil microstructures by adding their faecal pellets. Collembolan diversity is very helpful to identify the soil health. Earlier works on Collembola are Singh and Mukharji (1971), Choudhary and Roy (1972). The importance of soil biodiversity including Collembola has been discussed by Tripathi *et al*. (2005), Raghuraman *et al.* (2010), Santeshwari *et al.* (2012) and Toldan *et al.* (2013).

Present research deals with the biodiversity of Collembola with ecological and soil nutrient approaches in different tree ecosystem of Varanasi. Very little work had been done on the biodiversity of Collembola in ecosystem of Varanasi district (UP), (Raghuraman *et al*., 2010; Santeshwari *et al*. 2012). Most of the previous workers confined their studies to several agricultural ecosystems and undisturbed soils. The present study aimed to document these soil arthropods in different tree ecosystems, which were nearer to the agricultural fields since there is lack of records of such organisms regarding their biodiversity and abundance.

MATERIAL AND METHODS

For these investigations, 6 tree-based ecosystem were

selected in inside the Banaras Hindu University, Varanasi. Varanasi is situated at a latitude of 28^0 18 'N and a longitude of 83^0 03 'E with an altitude of 128.93m above the mean sea level in the Eastern part of upper Gangetic plain, which form a district sub-division of India in the State of Uttar Pradesh. Average rainfall of Varanasi is 1110m and the average temperature ranges from 30 °C to 46 °C in summer and 5 °C to 15 °C in winter.

In the ecosystem-I, samples were taken from the Chinese rose gardens. Sample site was covered with different type of annual, biennial, and perennial weeds. In the ecosystem-II, samples were taken from the banana plantation and samples site was covered by different type of annual, biennial, and perennial weeds. The ecosystem – III constituted the samples collected from guava orchard. The ecosystem-IV consisted of the samples taken from the neem plantation. The ecosystem - V consisted of aonla plantation where the samples were collected. Ecosystem- VI consisted of bael trees which were located near agricultural fields just near the irrigation canal. In all the ecosystems, samples were collected thrice a month at ten day interval.

Method of collections: The collections were made by two methods, by Soil sampler and aspirator.

(A) Soil sampler: The samples are collected in every month from the upper layer of soil (0-22.8cm) at regular intervals at ten days interval with an iron sampler of the size 3X4X9 inches (10.0 x 7.5 x 22.5 cm) with 1770cm^{3}in volume.

(B) Mouth aspirator: a simple aspirator made up of glass tube and it size of 0.05cm diameter, was used.

Extraction Method: On the same day, the collected samples were through the Tullgren's funnel method for 24 hrs, for the extraction of the collembolan. The soil was kept on wire mesh in the aluminium funnel (with 30 cm diameter and 3705 cm height) of Tullgren funnel. An 60 Watt electric bulb were suspended over each funnel as for heat source which increase temperature 30°C at the upper soil surface, that repels the collembolan downward through the funnel tube into each collecting glass vials, which were kept beneath the funnel containing absolute alcohol and 1 to 2 drops of glycerol. The initial 12 hours were given less heat and light (40 W and 110 V) and it was increased (40 W and 220 V) light intensity for full extraction of collembolans.

Sorting and preservations: After extraction, sorting has been done under zoom stereo-microscope with the help of doubled haired brush and washes it with pure alcohol. The separated samples were preserved in separate vials containing absolute alcohol and one to two drops of glycerol.

RESULTS AND DISCUSSION

Quantitative composition of Collembola: A total of 2568 Collembola were collected from the six different sampling tree ecosystems in Varanasi. Maximum population (29.98%) was recorded in the month of October. The minimum population (8.13%) was recorded in the month of December from Varanasi. Among the six sampling sites, bael ecosystem had maximum number of population (41.24%) followed by banana ecosystem (24.34%), guava ecosystem (11.99%), neem ecosystem (11.68%), Chinese rose ecosystem (9.35%) respectively. The minimum population was recorded from aonla ecosystem (1.40%).

Qualitative composition of Collembola: Due to shortage of data on Indian Collembola (Santeshwari *et al.* 2015), the present study could not comply with all the taxonomic requirements. It could be regarded as an overall composition of the Collembola in all six different ecosystem. The following list could give an idea about the different genera of Collembola. However, this type of information would give better idea for comparison with other similar investigations. Specific identification were carried out during routine work as far as possible and later confirmed based on the taxonomic keys of Christiansen and Bellinger (1992); Fjelberg (1998, 2007) and the list of species are given and presented in Table.

Seasonal fluctuation in collembola population density and soil parameters

There was a numerical change in the population among different tree ecosystems in different month in Varanasi were observed and described below as:

Banana ecosystem: The lowest population density of collembola was recorded in December 2012 (7.2%) and the highest f population 44.8% was during October (Fig. 1). The number of collembola increase from August to October (44.80%) and decrease to 7.2% in December (The genus which are recorded during the month of August to December are *Sminthurinus*sp. (15.52%), *Sminthurides* sp. (20%), *Lepidocyrtus fimetarius* (21.71%), *Cyphoderus* sp. (4.64%), *Hypogastrura* sp. (13.6%), *Entomobrya* sp. (8.16%) and *Lepodocyrtus curvicollis* (16.32%).

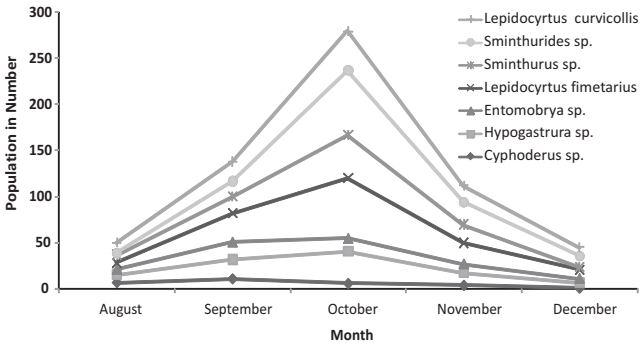

Fig. 1. Relative abundance of collembolain banana ecosystem (Varanasi)

Aonla Ecosystem: The number of collembola were practically low throughout the investigation period. The highest number of population was recorded during the month of December (52.7%) and the lowest was in the month of August (Fig. 2). Only two species i.e *Lepidocyrtus fimetarius* (63.38%) and *Lepidocyrtus curvicollis* (36.11%) were recorded from the aonla ecosystem. These species have been reported from this region in other ecosystems (Santeshwari *et al.,* 2015).

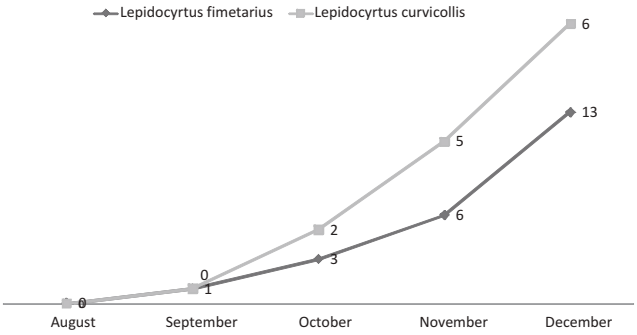

Fig. 2. Relative abundance of collembola in aonla ecosystem

Bael ecosystem: It is evident that the lowest number of mean population density was recorded in the month of December 2012 (4.91%) and the highest number was during the month of September (42.96 %) (Fig. 3).The number of collembolan increase from August to September *i.e.* August (22.85%), September (42.96 %), and decrease in the month of October (17.28%) and then decreased in the month of November (11.99%), and then decreased again in the month of December (4.91%). The genus which are recorded during the month of August to December are *Sminthurinus* sp. (2.9%), *Sminthurides* sp. (1.9%), *Lepidocyrtus fimetarius* (3.11%), *Cryptopygus* sp. (32.20%), *Cyphoderus* sp. (1.51%) and *Entomobrya* sp. (14.35%).

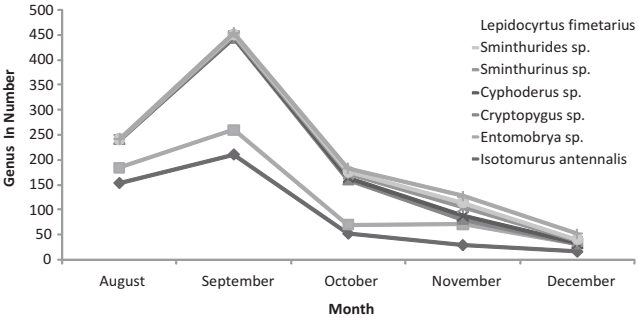

Fig. 3. Relative abundance of collembola in bael ecosystem

Guava ecosystem: The lowest number of mean population density was recorded in the month of August 2012 (8.11%) and the highest number was during the month of October (39.61%) (Fig. 4). The number of collembolan increased from August to October 39.61% and decreased from to 12.98% in November. The genus recorded during the month of August to December are *Sminthurinus* sp. (32.10%), *Sminthurides* sp. (2.9%), *Lepidocyrtus curvicollis* (28.89%), *Lepidocyrtus fimetarius* (14.98%), *Hypogastrura* sp. (15.90%) and *Entomobrya* sp. (5.19%). However, these species have been reported in this region from other ecosystems also (Santeshwari *et al.,* 2015).

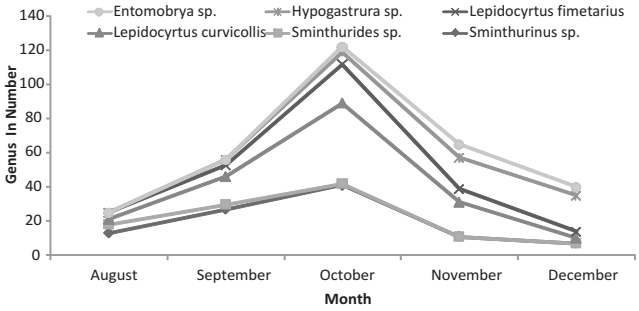

Fig. 4. Relative abundance of collembola in guava ecosystem

Neem ecosystem: The lowest number of population density was recorded in the month of December 2012 (6.6%) and the highest number was during the month of November (32.30%) (Fig. 5). It was investigated that population of collembolan increase from August to November but decrease in December. In August (13%), September (18.66%), October (29.33%) and November (32.3%) of collembolan population were recorded. The genus which were recorded in the ecosystem of Neem are *Entomobrya* sp. (21.6%), *Sminthurinus* sp. (15.33%),*Sminthurides* sp. (2%), *Cyphoderus* sp. (16%), *Hypogastrura* sp. (27.65%), *Folsomia* sp. (11.64%) and *Onychiurus* sp.(5.5%.).

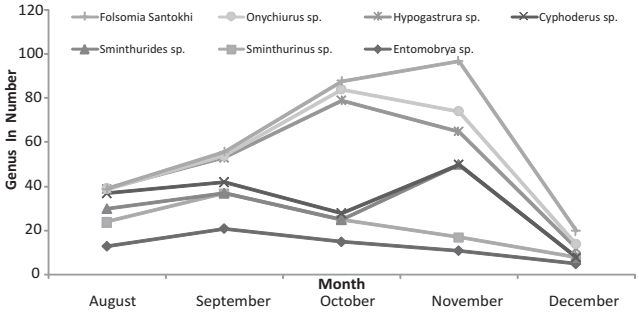

Fig. 5. Relative abundance of collembola in neem ecosystem

Chinese Rose: The lowest number of mean population density was recorded in the month of August 2012 i.e., 6.66 % and in September also the population was low (7.08%).and

the highest number of mean population was during the month of October (49.1%) (Fig. 6). During November, population of collembolan was also high (29.2%), but low in the month of December (7.91%). It was investigated that population was high during the month of September and October. Collembolan genus recorded from the Chinese Rose ecosystem during August to December are *Onychiurus* sp. (13.75%), *Entomobrya* sp. (21.6%), *Hypogastrura* sp. (35.4%), *Lepidocyrtus lignorum* (14.16%), *Lepidocyrtus curvicollis* (7.08%), *Sminthurinus* sp. (7.91%). Raghuraman *et al.* (2010) reported a similar finding in the floral gardens of this region.

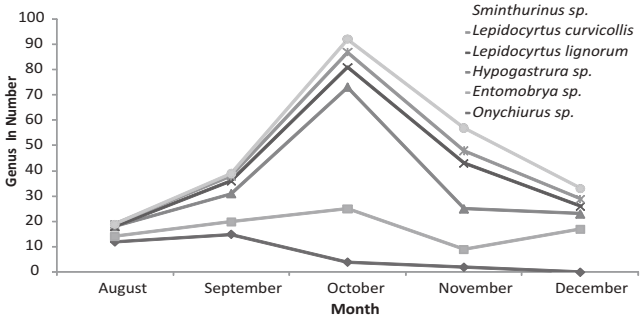

Fig. 6. Relative abundance of collembola in Chinese rose ecosystem

During the present study different genera and species of Collembola were identified by expert and the list of species are given in Table 1.

A total of 10 genera belonging to 8 families' *viz.,* Isotomidae, Entomobryidae, Paronellidae, Cyphoderidae, Onychiuridae, Hypogastruridae, Sminthurididae, and Katiannidae were recorded from Varanasi. Collembola genera like, *Lepidocyrtus* sp.*, Entomobrya* sp.*, Hypogastrura* sp.*, Sminthurinus* sp.*, Sminthurides* sp.*,* are most common among almost all the ecosystems. Cllembolan species like, *Isotomurus* sp.*, Crytopygus* sp.*, Cyphoderus* sp.*, Onychiurus*sp.*,* and *Folsomia* sp*.* were present in more or less amount.

During the investigation period a total of 2568 Collembola of 10 genera were collected from the six different sampling tree ecosystems in Varanasi. The maximum number of Collembola was recorded from the Bael (*Aegle marmelos)* Ecosystem, followed by banana, guava, neem and chinese rose ecosystems. The present findings are on line with Santeshwari *et al.* (2012). and Raghuraman *et al.* (2010) who recorded similar genera and species in different other ecosystems of Varanasi. Gupta and Mukharji (1976), recorded 22 genera in different crops at Varanasi. Among the six sampling sites, bael ecosystem had maximum number of population (41.24%) followed by banana (24.34%), guava (11.99%), neem (11.68%), Chinese rose ecosystem (9.35%) respectively. The minimum population of collembolan was recorded from aonla ecosystem (1.40%). Also, it was found that the maximum population (29.98%) was recorded in October and . minimum population (8.13%) in December.

The most serious problem associated with biodiversity analysis is the lack of documentation of these organisms from different regions and ecosystems. Because these organisms form the feeding guilds, which play a functional role in soil ecosystems, they have to be recognized as important organisms and more studies have to be focussed on them since their diversity and abundance is tremendously getting reduced due to soil acidification, indiscriminate use of pesticies, global climate change and intensive farming.

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Table 1. Classification of Collembola recorded from Varanasi

Sub-order	Section/ super family	Family	Sub-family	Genus
Arthropleona	Entomobryoidea	Isotomidae	Isotominae	Isotomurus sp.
				Isotomides sp.
				Cryptopygus sp.
		Entomobryidae	Entomobryinae	Entomobrya sp.
		Paronellidae	Lepidocyrtinae	Lepidocyrtus sp.
		Cyphoderidae	Cyphoderinae	Cyphoderussp.
	Poduromorpha	Onychiuridae	Onychiurinae	Onychiurus sp.
		Hypogastruridae	Hypogastrurinae	Hypogastrura sp.
Symphypleona	--	Sminthurididae	Sminthuridinae	Sminthurides sp.
		Katiannidae	--	Sminthurinus sp.

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Evaluation of Aqueous Extracts of Certain Botanicals against Two Spotted Spider Mite, *Tetranychus urticae* Koch (Tetranychidae: Acarina) in Okra, *Abelmoschus esculentus* (L.)

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***Abstract*:** Efficacy of aqueous fruit extract of *Sapindus marginatus* L. (10%) (Sapindaceae) and rhizome extract of *Acorus calamus* L. (10%) (Araceae) was compared with neem seed kernel extract (NSKE 5 %) against two spotted spider mite, *Tetranychus urticae* Koch in okra under greenhouse and field. Among the treatments, *S. marginatus* (10%) recorded highest cumulative pooled mean reduction of 73.05 and 69.07 per cent in green house and field conditions followed by NSKE (5%) which recorded 66.07 and 62.17 per cent reduction in mite population, respectively. The next in the order of efficacy was *A. calamus*+ *S. marginatus* (5+5%) and *A. calamus* (10%). The standard check fenazaquin 10 EC (1.5ml L^{-1}) was significantly superior over all other treatments with higher reduction in the mite population of 81.14 and 80.52 per cent, respectively.

Key Words: *Acorus calamus,* NSKE, *Sapindus marginatus, Tetranychus urticae*, Yield

Okra, *Abelmoschus esculentus* (L.) Moench is one of the most important vegetable grown throughout the tropics and warmer parts of temperate zone. One of the most important constraints in production of okra is insect and mite. The sucking pest complex consisting of aphids, leaf hoppers, whiteflies, thrips and mites are major pests and cause 17.46 per cent yield loss in okra (Sarkar *et al.,* 1996). Several species of mites belonging to the genus *Tetranychus* (Srinivasa and Sugeetha, 1999) causes an yield loss of 7 to 48 per cent in okra. Among the genus *Tetranychus*, the two spotted spider mite (TSSM), *Tetranychus urticae* Koch, is an extremely polyphagous pest that has been reported from more than 1200 host species and is described as a serious pest of at least 150 economically important agricultural and ornamental plants including corn, cotton, cucumber, beans, tomato, okra, eggplant, pepper and roses (Baptiste *et al*., 2003; Mondel and Ara, 2006).

Growers heavily rely on chemicals to control TSSM and control of TSSM with conventional acaricides is difficult due to its rapid resistance development (Stavrinides and Hadjistylli, 2009; Badawy *et al*., 2010). TSSM has evolved resistance to more than 80 acaricides till date (Van Pottelberge *et al*., 2009). Therefore, the search for herbal pesticides has gained importance in recent years, which are considered safer and more eco-friendly for pest management. Hence, the present investigation was carried out to explore the possibility of using the aqueous fruit extract of *Sapindus marginatus* L. (Sapindaceae) and rhizome extract of *Acorus calamus* L. (Araceae) in comparison with Neem seed kernel extract (NSKE 5%) *(*Meliaceae) for the management of two spotted spider mite.

MATERIAL AND METHODS

Mass culturing of two spotted spider mite, *T. urticae*, on okra: *Tetranychus urticae* was collected from okra (Mahyco Hybrid 10) fields, mass reared and maintained in the green house by following the method adopted by Jagannath (2009). Okra plants were raised in pots for culturing *T. urticae*. The plants after thirty days of sowing were artificially infested with *T. urticae* with the help of camel hair brush or by placing the already infested leaves on fresh plants in order to transfer the mites. Then freshly potted plants were transferred besides the older plants at periodic intervals to transfer the mites from older one to fresh, so as to maintain the continuous culture of *T. urticae*.

Preparation of fruit extract of *S. marginatus:* Dried fruits of *S. marginatus* were collected from Ooty and Mettupalayam and the seeds were removed to get the pulp portion. Thirty gram of the fruit was soaked in 100 ml of water for overnight. Then the fruits were squeezed by hand to get maximum extract from the pulp. The suspension was filtered through muslin cloth and then the volume was made up to 100ml with water. The filtrate was used as the stock solution. From the stock suspension, the required concentration *viz.,* 2.5, 5.0 and 10.0 per cent were prepared and used for further investigations.

Preparation of rhizome extract of *A. calamus:* The rhizome extract of *A. calamus* was prepared by following the

procedure adopted by Sarmah *et al*. (2009). Rhizomes were dried under shade, powdered and passed through a 20 mesh sieve to obtain fine and uniform dust. Thirty gram of the powder was taken in a 250 ml conical flask and 100 ml of water was added to it and the mixture was shaken in a mechanical shaker for about 8 hours and then kept in room condition for 24 hours. The extract was then filtered through a fine muslin cloth. The filtrate was collected in a volumetric flask and the volume was made up to 100ml. This was considered as the stock solution and from the stock, the required concentrations *viz.,* 2.5, 5.0 and 10.0 per cent were prepared and used for further studies.

Preparation of Neem seed kernel extract (NSKE 5%): Fifty gram of neem seed kernel was purchased and powdered well. The seed kernel powder was placed in individual muslin cloth bags and immersed in 1000ml of water for overnight. Then the bag was squeezed well and taken out. The suspension containing the kernel extract was made up to 1000 ml and used for further bioefficacy studies.

Pot culture experiment (green house conditions): The pot culture experiment was conducted in green house at department of agricultural entomology, Tamil Nadu Agricultural University (TNAU), Coimbatore in Completely Randomized Block Design (CRBD) with *four replications on* okra (Mahyco Hybrid 10). The efficacy of botanicals *viz*., *A. calamus* and *S. marginatus* both at 10 percent alone and in combination (5+5 %) along with NSKE 5% and fenazaquin 10 EC at 1.5 ml/ lit against *T. urticae*.

Three sprays were given at fortnightly intervals. The pre and post treatment observations on live mite populations were assessed on 0, 3, 5, 7, 10 and 14 days after each spraying. The 14th day observation was considered as the pre count for the next spray. Observations on mite populations were recorded from top, middle and bottom leaves from each plant and the average mites per 4 sq. cm was worked out. The mite population was assessed using 10x hand lens.

Field experiment; A field experiment was also carried out with the similar set of treatments at Putthur village of Coimbatore district. The numbers of spray and observation recorded were similar to pot culture experiment. The yield of okra fruits were recorded at the time of harvest.

Statistical analysis: The statistical significance of data was assessed by analysis of variance (ANOVA). Critical difference (CD) was calculated between the treatments under CRBD and RBD using software 'AGRES' to know the efficacy of different treatments in reducing *T. urticae* population in okra plants. Means were then compared using least significant difference (LSD) (at p= 0.05).

RESULTS AND DISCUSSION

Pot culture and field evaluation of selected botanicals against *T. urticae:* The spider mite population before treatment was non significant and after the first round of spraying, *S. marginatus* (10%) and NSKE (5%) recorded the lowest mite population of 14.90 and 16.30 numbers per 4 cm^{-2} leaf area on 3rd day after spraying, respectively, followed by *A. calamus* + *S. marginatus* (5+5%) and *A. calamus* alone at 10 per cent .The standard check fenazaquin 10 EC (1.5ml L^{-1}) was significantly superior to all other treatments and registered mean population of 10.88 in 4 cm^{-2} leaf area. Similar trend was observed after second and third round of sprayings (Table 1).

The application of *S. marginatus* (10%) recorded significantly the lowest cumulative mean mite population of 9.73 in 4 cm^{-2} leaf area with cumulative mean reduction of 73.05 per cent after three rounds of spraying (Table 2). Acaricidal activity of aqueous extract of *S. marginatus* against *T. urticae* has not been reported so far and hence, this is the first observation of its kind in Tamil Nadu.

Table 1. Evaluation of botanicals against *T. urticae* on okra (Mahyco 10) – (Under pot culture)

Treatments	Pre treatment count	No. of mites 4 cm^{-2}											
		First spraying						Second spraying					
		3	5	7	10	14	Mean	3	5	7	10	14	Mean
A .calamus (10%)	29.50	21.50^{c}	19.75^{d}	18.25^{d}	22.00^{e}	23.75^{d}	21.33	19.75^{d}	17.75^{e}	16.20^{e}	18.20^{d}	22.20^{c}	18.82
S. marginatus (10%)	27.15	14.90^{b}	11.65^{b}	9.90^{b}	12.15^{b}	13.90^{b}	12.50	10.20^{a}	8.45^{b}	7.45^{b}	9.70^{b}	11.95^{b}	9.55
A. calamus + *S. marginatus* (5+5%)	27.70	19.70^{c}	17.70^{d}	16.15^{d}	19.05^{d}	20.30^{c}	18.67	16.30^{c}	14.55^{d}	13.30^{d}	15.30^{c}	18.30^{d}	15.55
NSKE (5%)	25.30	16.30^{b}	14.30^{c}	12.80^{c}	14.55^{c}	16.05^{b}	14.80	13.30^{b}	11.30^{c}	10.05^{c}	11.80^{b}	14.55^{b}	12.20
Fenazaquin 10 EC (1.5 ml L^{-1})	27.45	10.88^{a}	8.88^{a}	7.38^{a}	9.38^{a}	10.63^{a}	9.41	8.38^{a}	5.38^{a}	4.18^{a}	6.68^{a}	9.18^{a}	6.76
Untreated check	26.90	28.90^{d}	29.93^{e}	30.68^{e}	32.43^{f}	33.93^{g}	31.17	35.18^{e}	36.28^{f}	36.28^{f}	37.28^{e}	39.03^{e}	36.81
CD (p=0.05)		0.25	0.27	0.31	0.32	0.30	-	0.31	0.28	0.34	0.28	0.37	-

In a column means followed by common letter are not significantly different (p=0.05)

Field experiment: The pre treatment population was in the range of 37.05 to 40.25 mites in 4 cm^{-2} leaf area (Table 3). Application of *S. marginatus* (10%) and NSKE (5%) were more effective and recorded the lowest mean mite population on 7th day after first spraying, respectively. This was followed by the combination of *A. calamus* + *S. marginatus* (5+5%) and *A. calamus* (10%). The standard check fenazaquin 10 EC (1.5ml L^{-1}) significantly effective than other treatments after first round of spraying. A similar trend was also observed after second and third round of spraying (Table 3 and 4). After three rounds of spraying, *S. marginatus* (10%) was significantly superior over other botanicals with a cumulative mean reduction of 69.07 per cent. The next in the order of efficacy were NSKE (5%), *A. calamus* + *S. marginatus* (5+5%) and *A. calamus* (10%) (Table 4).

Yields of okra: Okra fruit yield was significantly higher in all the treatments than untreated check (5.00 t ha^{-1}). Fenazaquin 10 EC (1.5 ml L^{-1}) treated plots recorded the

Table 2. Evaluation of botanicals against *T. urticae* on okra (Mahyco 10) -(Under pot culture)

Treatments	No. of mites 4 cm^{-2}							
	Third spraying							
	3	5	7	10	14	Mean	Cumulative mean	% reduction over control
A .calamus (10%)	17.70^{e}	16.45^{e}	14.70^{e}	15.70^{e}	18.20^{c}	16.55	18.90	47.67
S. marginatus (10%)	7.70^{b}	6.45^{b}	5.45^{b}	7.45^{b}	8.70^{b}	7.15	9.73	73.05
A. calamus + *S. marginatus* (5+5%)	14.05^{d}	13.05^{d}	11.80^{d}	12.85^{d}	15.10^{c}	13.37	15.86	56.08
NSKE (5%)	10.30^{c}	9.05^{c}	7.80^{c}	9.55^{c}	12.15^{b}	9.77	12.26	66.07
Fenazaquin 10 EC (1.5 ml L^{-1})	4.68^{a}	3.43^{a}	3.25^{a}	4.00^{a}	6.00^{a}	4.27	6.81	81.14
Untreated check	38.48^{f}	39.48^{f}	39.98^{f}	41.48^{f}	42.48^{f}	40.38	36.12	-
CD (p=0.05)	0.28	0.29	0.30	0.28	0.30	-	-	-

In a column means followed by common letter are not significantly different (p=0.05)

Table 3. Evaluation of botanicals against *T. urticae* on okra (Sakthi)-(Under field condition)

Treatments	Pre treatment count	No. of mites 4 cm^{-2}											
		First spraying						Second spraying					
		3	5	7	10	14	Mean	3	5	7	10	14	Mean
A .calamus (10%)	29.50	35.25^{e}	32.75^{e}	30.28^{e}	33.13^{e}	35.13^{c}	33.31	31.80^{e}	29.55^{e}	27.80^{e}	28.55^{e}	29.80^{c}	29.50
S. marginatus (10%)	27.15	25.45^{b}	21.75^{b}	19.75^{b}	20.50^{b}	21.75^{b}	21.84	16.50^{b}	13.75^{b}	12.75^{b}	14.25^{b}	15.75^{b}	14.60
A. calamus + *S. marginatus* (5+5%)	27.70	31.50^{d}	29.25^{d}	27.75^{d}	30.50^{d}	32.25^{c}	30.25	26.70^{d}	23.45^{d}	21.45^{d}	22.95^{d}	25.20^{c}	23.95
NSKE (5%)	25.30	29.25^{c}	25.50^{c}	23.25^{c}	24.75^{c}	25.50^{b}	25.67	20.25^{c}	17.75^{c}	16.00^{c}	17.00^{c}	18.50^{b}	17.90
Fenazaquin 10 EC (1.5 ml L^{-1})	27.45	18.97^{a}	15.72^{a}	12.97^{a}	14.22^{a}	15.97^{a}	15.57	9.97^{a}	7.97^{a}	6.47^{a}	7.32^{a}	9.67^{a}	8.28
Untreated check	26.90	39.30^{f}	41.50^{f}	42.75^{f}	44.25^{f}	46.25^{f}	42.81	47.75^{f}	48.75^{f}	49.25^{f}	49.75^{f}	50.75^{f}	49.25
CD (p=0.05)		0.17	0.18	0.16	0.19	0.14		0.15	0.18	0.25	0.22	0.19	

In a column means followed by common letter are not significantly different (p=0.05)

Table 4. Evaluation of botanicals against *T. urticae* on okra (Sakthi) – (Under field condition)

Treatments	No. of mites 4 cm^{-2}								Yield (t ha^{-1})
	Third spraying								
	3	5	7	10	14	Mean	Cumulative mean	% reduction over control	
A .calamus (10%)	25.05^{e}	23.05^{e}	21.30^{e}	22.80^{e}	24.30^{c}	23.30	28.70^{e}	41.59	5.90
S. marginatus (10%)	10.50^{b}	8.50^{b}	7.00^{b}	9.00^{b}	10.75^{b}	9.15	15.20^{b}	69.07	6.70
A. calamus + *S. marginatus* (5+5%)	18.95^{d}	16.70^{d}	14.70^{d}	17.00^{d}	18.50^{c}	17.17	23.79^{d}	51.59	6.20
NSKE (5%)	13.60^{c}	11.75^{c}	10.00^{c}	12.00^{c}	14.00^{b}	12.25	18.61^{c}	62.14	6.50
Fenazaquin 10 EC (1.5 ml L^{-1})	5.27^{a}	3.77^{a}	3.02^{a}	5.27^{a}	7.52^{a}	4.87	9.57^{a}	80.52	7.20
Untreated check	52.25^{f}	53.50^{f}	54.25^{f}	56.75^{f}	58.50^{f}	55.5	49.14^{f}		5.00
CD (p=0.05)	0.19	0.20	0.27	0.26	0.22	-	-	-	

In a column means followed by common letter are not significantly different (p=0.05)

highest yield of 7.20 t ha^{-1} (Table 4). The next highest yield was in plots treated with *S. marginatus* (10%) and NSKE (5%) followed by *A. calamus* + *S. marginatus* (5+5%) and *A. calamus* (10%). Present investigations revealed that the aqueous extract of *S. marginatus* (10%) was highly effective against *T. urticae.* This may be attributed to the presence of active secondary metabolites like saponin and other constituents present in the extract. Further, exploration on the efficacy of this extract against other phytophagous mites occurring on vegetables and ornamentals both under open and protected cultivation may wide open the opportunity for the ecofriendly management of the phytophagous mites. *S. marginatus* can be a better alternative to neem in the management of mites.

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Cultural and Physiological Study of Leaf Spot Diseases on *Aloe vera* (L.) Burm Caused by *Alternaria alternata*

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***Abstract*:** New report of leaf spot diseases on *Aloe vera* (L.) Burm.f. caused by *Alternaria alternata* species from Pantnager India. During 2011-2012, occurrence of leaf spot diseases was observed on *Aloe vera* plants grown in various nurseries of Pantnager, Uttarakhand. Among the fungal pathogens, *Alternaria alternata*, a deuteromycete fungus was encountered in some plantations of this medicinal plant around Pantnagar. The typical disease symptoms were observed on the abaxial surface, tips and spiny margins of leaves. Disease spots were sunken, dry, necrotic, dark maroon to dark brown in colour. Koch's postulate was applied to confirm the causal organisms of the diseases. According to the literature, this is the first report of leaf spot disease on *A. vera* caused by *Alternaria alternata*from Louisiana. Among the Synthetic media, Richard' Agar medium, Czapeck's Dox Agar medium and Kitoniumn Agar medium were best for the growth and sporulation of *Alternaria alternata*. Among the various non synthetic media, maximum growth and sporulation was observed in Oat meal agar medium and Potato Dextrose Agar medium. The diverse response of *Alternaria alternata* to different temperature levels of 15, 20, 25, 30, 35 and 40°C and different pH levels viz., 4, 6, 7, 8 and 9 were tested. Temperature of 25°C showed good growth and excellent sporulation. pH 7 were found congenial for growth and sporulation of *Alternaria alternata*under *in vitro* conditions.

Key Words: *Aloe vera*, *Alternaria alternata*, Deuteromycete, Leaf spot, Pantnagar

Aloe vera(L.) Burm belongs to family Liliaceae, is a perennial, succulent, monocotyledonous plant with an average height of 60-100 cm. There are about 400 species of *Aloe*, but the most commercially cultivated species is *Aloe vera*. It is a native of warm tropical regions, especially North Africa, the Mediterranean region of southern Europe and the Canary Islands. This species was first described by Carl Linnaeus in 1753. *Aloe vera* belongs to a large group of plants known as Xeroids because of its ability to close its stomata completely to avoid loss of water and help in retaining a large amount of water in its tissues (Akinyele and Odiyi 2007). More than 200 chemical components have been identified from the leaf pulp and exudates of *A. vera* (Choi and Chang 2003). Despite its therapeutic and antimicrobial potential, *A. vera* is susceptible to various fungal diseases. Leaf spot is an important disease that not only affect the leaf texture but also reduce the quality and quantity of mucilaginous gel used for medicinal and commercial purposes. Therefore, it was the objective of this study to identify the causal agent of leaf spot symptoms on *A. vera*.

MATERIAL AND METHODS

Sample collection and study of symptoms: The various nurseries in Pantnager was surveyed for the presence of leaf spot diseases on *Aloe vera* during the rainy and winter seasons of 2011 and 2012. Freshly infected leaves of *Aloe vera* exhibiting typical symptoms of leaf spots were collected from Medicinal Research and Development Centre, (MRDC), G.B. Pant University of Agriculture and Technology, Pantnagar and were brought to the laboratory for microscopic examination, isolation and for further studies.

Diseased leaves of *A. vera* were washed thoroughly with running tap water to remove the surface dirt and were cut into small pieces using sterile scalpel blades. These were then surface sterilised with 2% sodium hypochlorite solution (NaOCl) for 2 minutes and washed three-four times in sterile distilled water. These surface sterilised pieces were then placed between blotting papers and aseptically inoculated onto Petridishes containing Potato Dextrose Agar media. The plates were incubated at 25± 2°C for 5 to 6 days, and the growth of fungal colonies were recorded every day.

Characterisation and identification of the pathogens: The isolated fungal species were identified on the basis of morphological and cultural characteristics as described by Ellis (1971) and Gilman (2012). As *Alternaria alternata* on the basis of conidial and morphological characteristics. Slides were prepared in cotton blue and examined under compound microscope (40x) to study the morphological characters of the pathogen.

Pathogenicity test was carried out *in vitro* on the healthy leaves of *A. vera*, according to the method described by Kamalakannan *et al*. (2008). The isolated fungal species

were cultured on potato dextrose agar (PDA) medium at 25±2°C for 8-10 days in an incubator. Conidial concentration was subsequently adjusted to 1×109 per ml by using hemocytometer to make a spore suspension. Healthy leaves were surface sterilized for 1 minutes with 2% sodium hypochlorite solution (NaOCl). Artificial pricks approximately 2 mm deep on the abaxial surface of leaves were made by sterilized needle. Spore suspension of the test organisms was delivered through a sprayer and lined with moist blotting paper. Leaves sprayed with sterile distilled water served as control. Leaves were incubated at 25±2 °C for 8-10 days. The symptoms appeared after 12 days of inoculation. The test pathogen was reisolated from the infected leaves. The procedure was repeated twice to confirm the pathogenicity.

Cultural characters on solid and liquid media: The different synthetic media viz., Czapeck's agar, Richards's agar, Kitonium agar medium,modified Mendel medium andliquid synthetic media also semi-synthetic media including Potato dextrose agar medium (PDA), Oat meal agar medium, Corn meal agar medium, Apple agar medium and radish agar medium were used to find out the best medium for the growth of *Alternaria alternata*. Twenty ml of each medium listed above was poured into 85 mm diameter petri plates. After solidification, 5mm disc of the *Alternaria alternata* were selected from actively growing culture using a cork borer and a single disc was placed at the centre of petri dish. Twenty ml of each medium was poured into 85 mm diameter petri dishes. Such plates were inoculated with 5 mm disc of fungal growth and incubated at 25±1°C. Each treatment was replicated four times. Colony diameter was recorded by averaging the linear growth of the colony in two directions for each plate at 7th day after inoculation.

The growth of fungi was tested at 15, 20, 25, 30 and 40°C. Oat meal agar medium was poured into 85 mm diameter petriplates. After solidification, 5 mm from actively growing culture were cut and inoculated to the media containing Petriplates and incubated for ten days in the incubators adjusted to required temperature levels. Each treatment was replicated thrice. The pH of the medium was adjusted before autoclaving with the help of HCl (0.1 N) and NaOH (0.1 N) using pH meter/litmus paper. After autoclaving, the medium with 4, 6, 7, 8 and 9 pH was poured in sterilized plates and inoculated with the organism. Three replications were maintained, observation recorded for growth and sporulation.

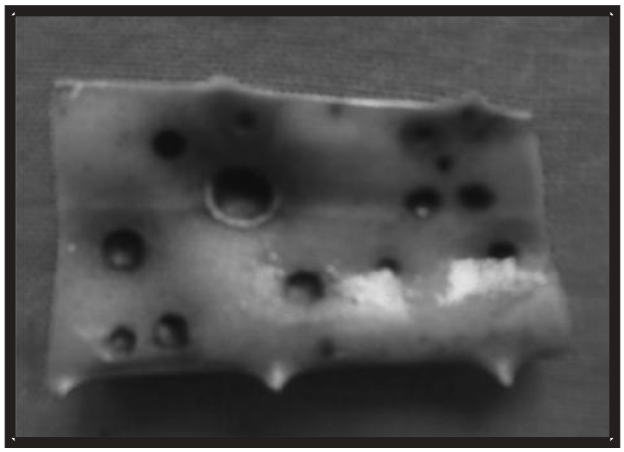
RESULTS AND DISCUSSION

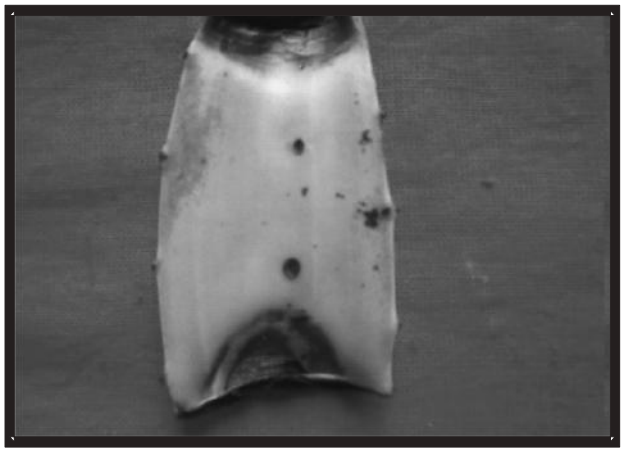
Results of the survey revealed that all the nurseries cultivated only a single species of *Aloe*, i.e.,*A. vera* and none of the nursery was free from leaf spot diseases. Microscopic and cultural analysis of the isolated fungi indicates the association of *Alternaria alternata* species. Isolation result indicates that *Alternaria alternata* isolated from all the infected leaf samples. The disease symptoms and microscopic characteristics of the pathogens are described as follows.

Symptoms of leaf spot diseases: Leaf spot disease caused by *Alternaria alternata* began in the form of circular, water soaked lesions on the tip and abaxial surface of the leaves. Gradually the size of the lesions expands and became light red in color bordered by water soaked tissues. As the disease progressed, the lesions were sunken, maroon color with an average size of 0.5-1.4 × 0.4-1.0 cm. In later stages, lesions became dry, necrotic and turned into dark maroon in color (Fig. 1A & B). The disease was observed during both the rainy and winter seasons. Symptoms of leaf spot disease caused by *Alternaria alternata* appeared as elongated, water soaked lesions, generally occurred on the spiny margins and abaxial surface of the leaves. Progressively, these lesions became sunken and light brown in color. Later, these lesions were enlarged, centre of the lesions dark brown in color with maroon red margins, and measured about 0.7-1.7 × 0.6-1.3 cm in size. In severe infection, the spiny margin of the leaves was twisted inside due to necrosis of the tissues interestingly, the disease was observed only in the winter season.

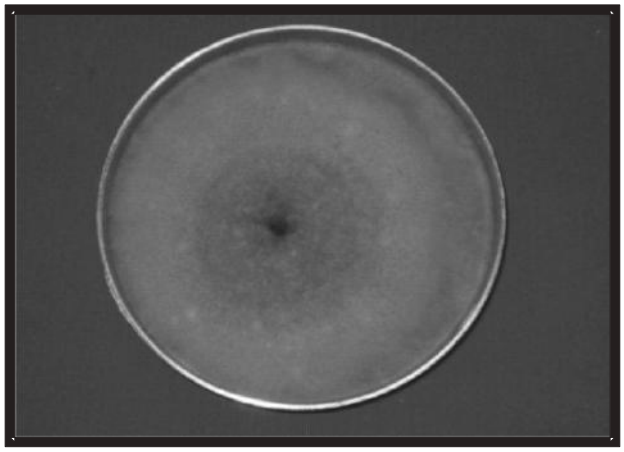
Identification of fungal pathogens: The fungal colony isolated from diseased tissue was sub-floccose, dark olive-gray in colour and on the reverse side was greyish black on oat meal agar (Fig. 2A). Colonies of these isolates were dark olivaceous, fluffy, and 8.5 cm in diameter after 7 days of culture at 28°C.Dark olivaceous fungus with profuse golden brown, branched, and septate hyphae was consistently isolated from the infected tissue on Oat meal agar. The fungus produced conidia with longitudinal and transverse septa, and was morphologically identified as an *Alternaria* sp(Fig. 2B).Conidia were produced in long chains, pale to light brown, obpyriform, with a beak (6.0 ìm long), one to seven transverse and up to three longitudinal septa, and measured 10 to 45 ìm long × 7 to 18 ìm wide. Conidiophores were straight, septate, light to olive golden brown with conidial scar, and measured 35 to 100 ìm long × 2 to 5 ìm wide.These morphological characteristics matched the description of *Alternaria alternata*.

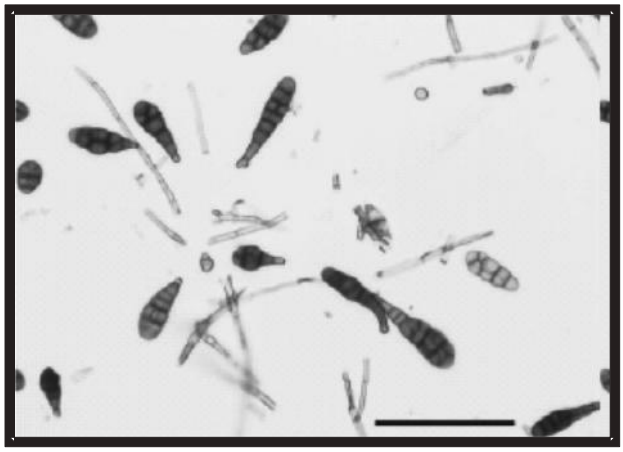
The symptoms of leaf spot diseases recorded during the pathogenicity test were almost similar to the natural symptoms. The symptoms of leaf spot infection appeared on fourth day of infestation. Initially, round, water soaked lesions were appeared on the abaxial surface of leaves. As the infection progressed, spots became sunken





1. (A) **(B)**





2. (A) **(B)**

and reddish maroon in color. On the thirteenth day, the lesions become necrotic and turned into dark brown in color. The fungi were re-isolated from the infected leaves and were compared with the original culture of *Alternaria alternata*.

Cultural characters on solid and liquid media: The effect of different culture media on growth of fungus differed significantly**.** The best growth of the fungus was in Richard' Agar medium (78.75 mm) followed by Czepec Dox agar medium, while minimum growth was in modified Mendel medium and no growth was recorded in liquid synthetic media and on non-synthetic Media The best growth of the fungus was recorded in Oat Meal Agar medium (79.50mm) followed by potato dextrose agar medium (Table 1).

Thetemperature at 25°C recorded maximum growth (77.25mm) and excellent sporulation, pH 7 was good for growth (79.50) and excellent sporulation (Table 2). It indicates the similarity of crop requirement for temperature and relative humidity at milky stage of developments (Tonapi

Table 1. Effect of synthetic media and non-synthetic media on radial growth of *Alternaria alternata* at 26 ±1°C after 10 days of incubation

Synthetic media	Colony diameter (mm)	Non-synthetic media	Colony diameter (mm)
Richard's agar medium	78.75	Potato dextrose agar medium	77.25
Czapeck's dox agar medium	74.50	Oat meal agar medium	79.50
Kitoniumn agar medium	69.25	Corn meal agar medium	60.75
Modified mendel medium	61.50	Apple agar medium	65.00
Liquid synthetic medium	00.00	Radish agar medium	71.00
CD (p=0.05)	1.80		2.07

Table 2. Effect of temperature and pH on radial growth of *Alternaria alternata* after seven days of incubation

Temperature (°C)	Colony diameter (mm)	pH	Colony diameter (mm)
15	14.25	4.0	52.75
20	66.00	6.0	65.25
25	77.25	7.0	79.50
30	45.00	8.0	77.00
35	15.00	9.0	72.50
CD (p=0.05)	1.31		2.31

et al., 2001;Jiang-Ming *et al.*, 2005).

Based on the symptoms, mycelial and conidial characters, the fungus was identified as *Alternaria alternata* (Ellis, 1971). In total, 10 leaf pieces were used in detached leaf assay studies and the pathogen was successfully isolated from all of them. Typical symptoms were produced after 4--7 days on 32 leaves. Fifteen infected leaves were used to reisolate the pathogen. The pathogen was reisolated from all of them. In contrast, the control leaf did not show any symptoms.

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Influence of Foliar Application of Urea and GA_3 on Growth and Nutritional Status of Rough Lemon (*Citrus jambhiri* Lush.) Seedlings under Modified Environment Conditions

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Abstract: The growth performance of rough lemon (*Citrus jambhiri* Lush.) seedlings with respect to plant height, stem diameter, number of leaves and leaf size was recorded better in screen house conditions than shade net house and open field conditions. The seedlings treated with foliar spray of 1.0 per cent urea + 100 ppm GA_3 exhibited maximum seedling height and number of leaves. The chlorophyll content in the leaves of seedlings grown under shade net house condition was higher than grown under screen house and open field conditions. The seedlings in screen house conditions had more N and P, while the seedlings grown under shade-net house conditions had higher leaf K content as compared to other growing conditions. Maximum leaf N was observed with application of 1.5 per cent urea whereas, maximum leaf K was recorded under screen house (1. 78%) in the seedlings when treated with GA_3 100 ppm.

***Key Words*:** Chlorophyll, GA_3, N, P, K, Rough lemon, Screen house

Citrus industry of India is the third largest fruit industry after mango and banana covering an area of 1.08 m ha with annual production of 11.15 million MT (Anon., 2014). In Punjab, citrus ranks first, covering an area of 50,428 ha with an annual production of 1.04 million MT. In Punjab, Kinnow has attained a major commercial significance and it alone occupies 47,101 ha area with an annual production of 1.01 million MT (Anon., 2015). Healthy plant material is one of the main pre-requisite in citrus for higher yield and quality fruit production. Rootstock plays an important role in the propagation of citrus. The successful and rapid means of growing healthy rootstock seedlings is a primary concern of nurserymen and research workers. Availability of sufficient and superior planting material and its effective distribution to the orchardists is one of the major factor to improve the performance of an orchard. In Punjab, there is a heavy demand of Kinnow plants, which are produced by budding on rough lemon (*Citrus jambhiri* Lush.) rootstock. Usually, it takes two to two and half years to produce Kinnow plants in nursery by following conventional methods. Hence; rapid multiplication of quality planting material would benefit nurserymen. The growing conditions, nitrogen and gibberellins play a significant role to enhance the growth of seedlings to become buddable in minimum time. The present study therefore, was planned and focused with the objective to study the effect of foliar GA_3 and urea supplemented alone and/or in combinations on the growth performance and leaf nutrient concentration of rough lemon seedlings grown in screen house, shade net house and open field conditions.

MATERIAL AND METHODS

The experiment was conducted in the Department of Fruit Science, Punjab Agricultural University, Ludhiana. Rough lemon (*Citrus jambhiri* Lush.) seeds were extracted from mature healthy fruits and treated with Bavistin (2 g/kg of seed). The freshly extracted seeds were sown in second fortnight of the month of August in polythene bags of size 12" x 6" and of 250 gauge thickness filled with sterilized farm soil and FYM in the ratio of 2:1 under screen house, shade net house and in open field conditions. After attaining the height of 10 cm, the seedlings were sprayed with urea (1.0 and 1.5 %) and GA_3 (50 and 100 ppm) alone and/ or in different combinations. The treatment combinations were as follows: T_1 (Urea 1%), T_2 (Urea 1.5 %), T_3 (GA_3 50 ppm), T_4 (GA_3 100 ppm), T_5 (Urea 1% + GA_3 50 ppm), T_6 (Urea 1% + GA_3 100 ppm), T_7 (Urea 1% + GA_3 50 ppm), T_8 (Urea 1.5 %+ GA_3 100 ppm) and T_9 (control, water spray only) at fortnightly intervals till the budding stage. The observations on different growth parameters were recorded at the time of budding. The seedling height was measured with meter scale from soil surface to tip of seedlings. The stem diameter was measured 5 cm above ground level by Vernier caliper. For counting leaf number, very young leaves and leaves in senescence with yellow colour were not considered. Leaf size was calculated by using graph paper. For chlorophyll estimation, leave were collected from different plants randomly in each replication, and washed with distilled water and excess of water was removed by folding them in filter paper layer. The leaves were chopped into small pieces and 0.5 g of fresh chopped leaves

were taken and homogenized thoroughly in 80% aqueous acetone using a glass-in-glass homogenizer. The material was centrifuged at 3000 rpm for 10 minutes in dark and clean supernatant was collected in test tube. The pallet was extracted again with 2 ml of 80% aqueous acetone and re-centrifuged. The two supernatants were pooled and the final volume was adjusted to 50 ml by using 80% aqueous acetone. The absorption was recorded at 645 and 663 nm with the help of spectrophotometer to calculate Chlorophyll 'a' and 'b' content (Anderson and Boardman, 1964).

Fourth and fifth leaf from terminal end from each seedling was collected at random to determine the foliar status of macro (N, P and K) nutrients. The leaf samples were cleaned and oven dried at 65°C for 48 hours after washing with ordinary water, then 0.1 N HCl solution and finally with distilled water twice. The dried leaves were grounded and then kept in butter paper bags for analysis. Before the leaves were analyzed, they were again dried for an hour at 65°C temperatures. Oven dried leaves were analyzed for Nitrogen (N), Phosphorus (P) and Potassium (K) by Kjeldhal's Method, Ammonium–molybdate-vandate and Flame Photometer methods, respectively. The data was statistically analyzed as per the procedure for split plot design of Panse and Sukhatme (1985)

RESULTS AND DISCUSSION

Plant height: Among all treatments, the plant height in all the foliar applications was maximum in the seedlings grown under screen house conditions, followed by shade net house conditions and minimum in seedlings grown in open field conditions (Fig. 1). The mean height of the seedlings grown in screen house was significantly higher (50.04 cm) than those grown under shade net house (48.57cm) and in open field conditions (46.65cm). Among foliar treatments mean seedling height was maximum (54.26 cm) in urea 1.0% + GA_3 100 ppm treatment. Under screen house conditions, the maximum seedling height (55.80 cm) was observed in urea 1.5%+ GA_3 100 ppm, whereas, under shade-net house and in open field conditions the maximum seedling height (54.19 cm and 52.84 cm) was recorded in urea 1.0%+ GA_3 100 ppm, respectively. The minimum mean height (35.98 cm) of the seedlings was observed in control treatment. Increment in height of the seedlings might be due to the modification in the environmental factors like temperature and humidity which were favourable in screen house. Also there was less insect pest damage under screen house conditions. The open field conditions may had more or less, harmful effect on seedling growth due to high temperature. Singh (2003) and Kumar (2004) observed maximum height of rough lemon (C. *Jambhiri* Lush.) seedlings grown under screen house conditions as compared with seedlings grown in open field conditions. The increment in seedling height with urea 1.0 per cent + GA_3 100 ppm foliar spray might be due to enhanced vegetative growth mediated by these chemicals. Urea caused higher synthesis of nucleic acid and amino acids which triggered the new cell synthesis, whereas, GA_3 stimulates cell elongation and cell division, which ascribed for increased plant height. Ram and Bose (1994) also reported that a combination of soil application (400 g $tree^{-1}$) and foliar spray (1.5%) of urea gave maximum plant height in mandarin orange *(Citrus reticulate* Blanco). Patil *et al.* (2013) recorded maximum seedling height in rangpur lime with GA 200 ppm plus urea 1 % spray plus neem cake 20g per seedling.

Stem diameter: The stem diameter of the rough lemon seedlings grown under screen house conditions was significantly more as compared with those grown in shade-net house and in open field conditions in all treatments (Fig. 2). The mean stem girth of seedlings grown under screen house conditions (0.49 cm) was significantly higher than those grown under shade net house and open field

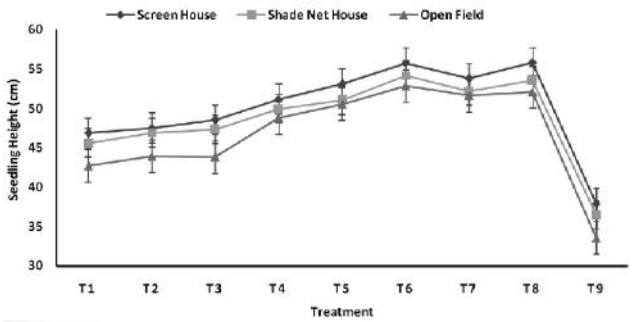

Fig. 1. Effect of foliar application of urea and GA_3 on foliar seedling height of rough lemon *(Citrus jambhiri* Lush) seedlings under different growing conditions

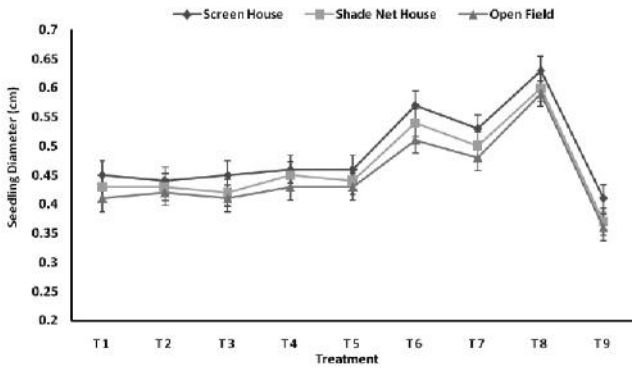

Fig. 2. Effect of foliar application of urea and GA_3 on seedling diameter of rough lemon *(Citrus jambhiri* Lush) seedlings under different growing conditions

conditions. Maximum stem girth of 0.63 cm (screen house), 0.60 cm (shade net house) and 0.59 cm (open field) was recorded in urea 1.5 per cent+ $GA_3$100 ppm foliar treatment. The minimum stem diameter was in control, where it was as 0.41 cm, 0.37 cm and 0.36 cm under screen house, shade net house and open field conditions, respectively. Similar trend was observed for mean stem diameter of rough lemon seedlings with maximum (0.61 cm) in urea 1.5%+ GA_3 100 ppm followed by urea 1.0%+ GA_3 100 ppm foliar treatment (0.54 cm). The minimum mean stem diameter (0.38 cm) was recorded in control plants. Stem diameter of seedlings grown under screen house conditions was significantly higher than the seedlings grown in shade net house and open field conditions. This might be due to favourable temperature and moisture conditions inside the screen house. Singh (2003) and Kumar (2004) also reported an increase in plant diameter in rough lemon seedlings grown under screen house conditions as compared to open field conditions. The increment in stem thickness in 1.5% urea + 100 ppm GA_3 treatment might be due to the growth promoting effects of urea and GA_3. This behaviour can be explained by the fact that it is a builder of proteins and forms the main constituents of protoplasm in plants. Thus, with an increase in nitrogen supply, the synthesis of protein in plants is accelerated, which is indirectly exhibited by increase in stem diameter. This was more pronounced in foliar spray because citrus leaves could absorb and utilized maximum of urea nitrogen in a very little time. Increase in cell division with GA_3 application resulted in improved stem girth (Muller and Young, 1982). Maximum diameter of seedling in rangpur lime was recorded in GA 200 ppm plus urea 1 % spray plus neem cake 20g per seedling (Patil *et al*., 2013). Kannan *et al* (2000) reported the maximum diameter of rough lemon seedlings when treated with 1.5% urea.

Number of leaves: The rough lemon seedlings grown under screen house produced more number of leaves than those grown in shade-net house and open field conditions (Fig. 3). Maximum mean number of leaves (28.27) was produced by the seedlings when grown in the screen house followed by those grown in shade-net house. Similarly, maximum mean number of leaves (29.40) with urea 1.0%+ GA_3 100 ppm foliar treatment. The highest number of leaves, under screen house, shade net house and open field conditions were produced in the seedlings with urea 1.0%+ GA_3 100 ppm foliar treatment, The interaction effect between growing conditions and different foliar sprays was non significant. More number of leaves was produced by the seedlings grown under screen house conditions than those grown under shade-net house and open field conditions. Kannan *et al.* (2000) also reported increase in number of leaves of rough lemon *(Citrus jambhiri* Lush.) seedlings when treated with 1.5% foliar application of urea. In rangpur lime, maximum number of leaves was recorded with GA 200 ppm plus urea 1 % spray plus neem cake 20g per seedling (Patil *et al*., 2013)

Leaf size: The screen house grown rough lemon seedlings produced large sized leaves as compared to seedlings grown in shade-net house and open field conditions (Fig. 4). Mean leaf size of seedlings grown under screen house conditions (21.44 cm^2) was significantly higher than those grown under shade-net house (18.83 cm^2) and open field conditions (17.51 cm^2). Maximum leaf size of 23.66 cm^2 and 21.63 cm^2 was observed under screen house and shade-net house, respectively, in urea 1.5% application. However, under open field conditions the maximum leaf size (20.41 cm^2) was recorded in urea 1.5%+ GA_3 50 ppm. The minimum leaf size was recorded in GA_3 100 ppm foliar treatment, irrespective of the growing conditions. Amongst all the foliar applications, maximum mean leaf size (21.88 cm^2) was recorded in urea 1.5% treatment. Minimum mean leaf size (17.71 cm^2) was observed in GA_3 100 ppm foliar spray which was significantly lower than all other foliar treatments. Larger leaf size of

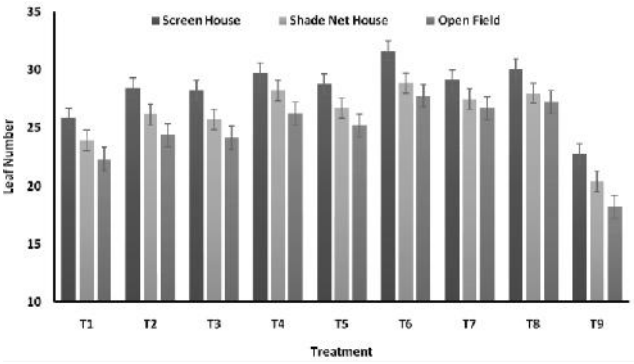

Fig. 3. Effect of foliar application of urea and GA_3 on leaf number of rough lemon *(Citrus jambhiri* Lush) seedlings under different growing conditions

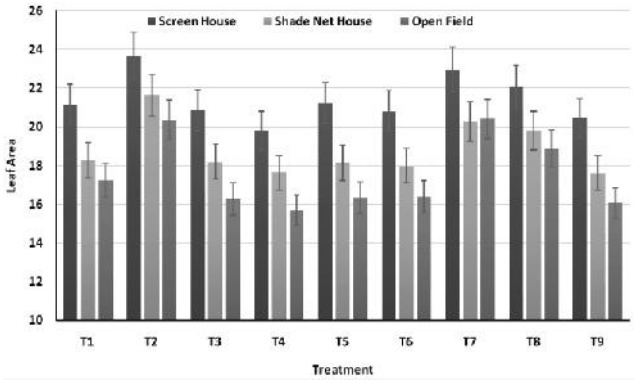

Fig. 4. Effect of foliar application of urea and GA_3 on leaf number of rough lemon *(Citrus jambhiri* Lush) seedlings under different growing conditions

seedlings grown in shade-net house and open field conditions may be due to favourable conditions for the seedling growth and less damage of insect pests in screen house than in shade-net house and open field conditions. Singh (2003) and Kumar (2004) also reported that screen house conditions help to boost up the growth of rough lemon seedlings in terms of leaf size in nursery. More leaf size with urea 1.5% application might be due to more absorption and utilization of nitrogen in very little time. Also the increased concentration of urea appears to be responsible for an overall increase in the actively growing tissues of the plants, resulting in an increase in the number as well as the size of individual cells. The decrease in leaf area with GA_3 application may be attributed to the rapid rate of stem elongation which failed to keep pace with the availability and subsequent uptake of nutrients for leaf growth. Patil *et al.* (2013) also recorded maximum leaf area in rangpur lime with GA 200 ppm plus urea 1 % spray plus neem cake 20g per seedling. Similar results were reported by Vu and Yelenosky (1988) in rough lemon seedlings.

Chlorophyll 'a' and 'b': The chlorophyll 'a' content in the leaves of rough lemon seedlings grown under shade net house conditions was more as compared to those grown in screen house and open field conditions (Table 1). Maximum mean chlorophyll content (0.81mg g^{-1} of fresh weight) was produced in the seedlings grown under shade net house conditions. Similarly, among foliar treatments, mean chlorophyll 'a' was significantly higher (0.86 mg g^{-1}) in 1.5% urea followed by 0.84 mg in urea 1.5% + 50 ppm GA_3. Chlorophyll 'a' content of 0.89 mg was obtained with urea 1.5% foliar spray treatment in the seedlings grown under shade-net house. The minimum mean chlorophyll 'a' content of 0.73 mg g^{-1} and 0.76 mg g^{-1} was recorded in the seedlings grown inside screen house with 100 ppm and 50 ppm GA_3, respectively. Higher chlorophyll 'a' content in leaves of seedlings grown under shade net house might be due to the fact that in open field conditions, chlorophyll was destroyed due to the full sun light or higher light intensity, whereas, shade-net house and screen house provides shady environment to the seedlings.

The chlorophyll 'b' content in the leaves of rough lemon seedlings grown under shade-net house conditions was more as compared to those grown in screen house and open field conditions (Table 1). The maximum mean chlorophyll 'b' content (0.66 mg g^{-1} of fresh weight) was produced in the seedlings grown under shade net house conditions than in screen house (0.64 mg g^{-1}) and open field conditions (0.63 mg g^{-1}). Foliar treatment of nitrogen and GA_3 also affect the mean chlorophyll 'b' content significantly. It was maximum (0.72 mg g^{-1}) in urea 1.5 % foliar treatment followed 0.70 mg g^{-1} in urea 1.5 % + 50 ppm GA_3 foliar treatment. The minimum mean chlorophyll 'b' content of 0.56 mg g^{-1} was recorded with 100 ppm GA_3 foliar treatment. Among all treatments maximum mean chlorophyll 'b' content (0 .73 mg g^{-1}) was observed with urea 1.5 % foliar treatment under shade net house conditions. Less chlorophyll 'b' content in screen house might be due to destruction of chlorophyll 'b' content under higher light intensity in screen house as compared to shade net house conditions. These findings are in agreement with the findings of Tomer and Singh (1988) and Izumi *et al.* (1990) who found higher chlorophyll content in leaves of citrus. Singh (2003) and

Table 1. Effect of foliar application of urea and GA_3 on chlorophyll content of rough lemon *(Citrus jambhiri* Lush) seedlings under different growing conditions

Foliar application	Chlorophyll 'a' (mg/g fresh weight)				Chlorophyll 'b'(mg/g fresh weight)			
	Screen house	Shade net house	Open field	Mean	Screen house	Shade net house	Open field	Mean
T_1 (urea1.0%)	0.82	0.85	0.81	0.82	0.68	0.70	0.65	0.68
T_2 (urea1.5%)	0.85	0.89	0.84	0.86	0.72	0.73	0.70	0.72
T_3 (GA_3 50 ppm)	0.72	0.81	0.76	0.76	0.59	0.59	0.58	0.59
T_4 (GA_3 100 ppm)	0.73	0.76	0.70	0.73	0.56	0.57	0.54	0.56
T_5 (urea1.0% + GA_3 50 ppm)	0.81	0.83	0.79	0.81	0.68	0.68	0.63	0.66
T_6 (urea1.0% + $GA_3$100 ppm)	0.78	0.80	0.78	0.78	0.62	0.63	0.63	0.63
T_7 (urea1.5% + GA_3 50 ppm)	0.85	0.85	0.82	0.84	0.69	0.71	0.68	0.70
T_8 (urea 1.5% + GA_3 100 ppm)	0.82	0.86	0.80	0.82	0.66	0.69	0.66	0.67
T_9 (Control; water spray)	0.79	0.81	0.79	0.79	0.63	0.62	0.60	0.62
Mean	0.79	0.81	0.78		0.64	0.66	0.63	
CD (p=0.05) Foliar sprays		0.012				0.014		
Growing conditions		0.020				0.018		
Interaction		0.025				0.025		

Kumar (2004) also found higher chlorophyll content in the leaves of rough lemon seedlings grown inside the screen house. The higher chlorophyll content in urea 1.5% under all the three growing conditions might be due to nitrogen induced growth of seedlings as nitrogen is an important inorganic constituent of chlorophyll. Similar results were reported by Monselise and Halevy (1962). Kannan *et al.* (2000) also reported the maximum total chlorophyll content in the leaves of rough lemon (C. *jambhiri* Lush) seedlings which were sprayed with 1.5% urea.

Leaf nutrient content: The seedlings grown under screen house conditions resulted in more nitrogen content than open field and shade-net house conditions (Table 2). Mean N content of the seedlings grown under screen house conditions was 2.38%, which was significantly higher than those grown under shade-net house (2.35%) and in open field (2.31 %) conditions. Amongst all foliar treatments, maximum N content (2.82%) was recorded in urea 1.5 %. Under shade-net house and open field conditions, maximum leaf nitrogen (2.86%) was observed with urea 1.5%, while minimum N content of 1.74% was recorded with GA_3 100 ppm foliar treatment in the seedlings grown in open field conditions. The higher leaf N content under screen house than open field conditions might be due to more favourable temperature, moisture and shade which prevent the loss of nutrients from the leaves of the seedlings in the screen house conditions. The results of these findings are in line with Kannan *et al.* (2000).

The seedlings grown under screen house conditions resulted higher leaf P content than shade-net house and open field conditions (Table 2). Mean leaf P content of the seedlings grown under screen house conditions was 0.19%. Maximum mean leaf phosphorus content of 0.22% was recorded in control. Amongst all the treatment maximum mean leaf P content (0.22%) was observed in seedlings kept under screen house and shade net house conditions, while, minimum of 0.16% mean leaf P was observed with 100 ppm GA_3 urea 1.5 % + 50 ppm GA_3 and urea 1.5% + 100 ppm GA_3 foliar treatment, which was significantly lower than all other foliar treatment. The higher leaf phosphorus content under screen house might be due to more favourable environmental conditions. The maximum leaf P content was observed in seedlings kept in control treatment under all the environmental conditions. The application of urea and GA3 accelerate the plant growth. So there is quick utilization of this phosphorus for accelerated growth. These findings are in agreement with the results of Kannan *et al.* (2000).

The seedlings grown under shade-net house conditions resulted in more leaf K content than those grown in screen house and open field conditions (Table 2). Mean leaf K content of the seedlings grown under shade-net house was 1.66%. The seedlings treated with 100 ppm GA_3 and urea 1.0% + 100 ppm GA_3 foliar sprays exhibited maximum K content of 1.78 and 1.77%, respectively. Minimum leaf K (1.49%) was recorded in control seedlings. Amongst all treatments and environmental conditions maximum K content (1.82%) was recorded in 100 ppm GA_3 and urea 1.0% + 100 ppm GA_3 treatments in shade net house conditions while, minimum of 1.42% of mean leaf K was observed in

Table 2. Effect of foliar application of urea and GA_3 on foliar nutrient content of rough lemon *(Citrus jambhiri* Lush) seedlings under different growing conditions

Foliar application	Nitrogen (%)				Phosphorus (%)				Potassium (%)			
	Scree	Shade net house	Open field	Mean	Scree	Shade net house	Open field	Mean	Screen house	Shade net house	Open field	Mean
T_1 (urea1.0%)	2.66	2.62	2.49	2.59	0.21	0.21	0.19	0.20	1.62	1.61	1.73	1.64
T_2 (urea1.5%)	2.81	2.86	2.80	2.82	0.19	0.17	0.17	0.18	1.56	1.58	1.58	1.57
T_3 (GA_3 50 ppm)	1.82	1.78	1.80	1.80	0.21	0.19	0.18	0.19	1.59	1.66	1.61	1.62
T_4 (GA_3 100 ppm)	1.78	1.76	1.74	1.76	0.17	0.16	0.16	0.16	1.80	1.82	1.72	1.78
T_5 (urea1.0%+ GA_3 50 ppm)	2.57	2.54	2.40	2.50	0.18	0.20	0.18	0.19	1.79	1.82	1.70	1.77
T_6 (urea1.0%+ $GA_3$100 ppm)	2.39	2.39	2.36	2.38	0.19	0.19	0.17	0.18	1.76	1.72	1.72	1.73
T_7 (urea1.5%+ GA_3 50 ppm)	2.82	2.75	2.72	2.76	0.17	0.16	0.16	0.16	1.52	1.59	1.53	1.55
T_8 (urea 1.5%+ GA_3 100 ppm)	2.71	2.70	2.70	2.70	0.18	0.15	0.16	0.16	1.51	1.58	1.59	1.56
T_9 (Control; water spray)	1.89	1.80	1.82	1.84	0.22	0.22	0.21	0.22	1.52	1.54	1.42	1.49
Mean	2.38	2.35	2.31		0.19	0.18	0.17		1.63	1.66	1.62	
CD (p=0.05) Foliar sprays		0.05				0.012				0.028		
Growing conditions		0.03				0.007				0.023		
Interaction		NS				NS				0.048		

control treatment in open field conditions. Higher leaf K content under shade-net house might be due to more favourable conditions of temperature, moisture and shade which protect the loss of potassium content from the leaves of the rough lemon seedlings grown in shade-net house conditions. More K content in 100 ppm GA_3 treatments might be due to the fact that gibberelic acid tends to increase the potassium content of the leaves through dilution effect. These results are in agreement with the findings of Randhawa and Iwata (1966) also reported the increase in potassium contents in the citrus leaves upto 200 ppm GA_3 and then decreases with increasing GA_3 concentration.

CONCLUSION

The growth of seedlings was found best under screen house conditions as compared to shade net house and open field conditions. Maximum seedling height and leaf numbers were obtained in seedlings treated with 1.0 per cent urea + 100 ppm GA_3. Chlorophyll content in the leaves of seedlings grown under shade net house condition was better and it increased with urea 1.5% foliar treatment. The seedlings grown under screen house conditions resulted in more N and P content than open field and shade-net house conditions, while, the seedlings grown under shade-net house conditions resulted in higher leaf K content than other growing conditions.

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Assessing Organic Nutrition Sources for Sustainable Soil Health of Kiwifruit Orchard

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***Abstract*:** Organic nutrient sources, namely, farm yard manure (FYM), vermicompost (VC), biofertilizers (BF), green manure (GM), and vermiwash (VW), were evaluated in different treatment combinations. The treatment combination of FYM 15 kg/vine, GM, VC 15kg/vine, BF 50 g/ vine and VW 2%/vine significantly improved soil physico-chemical and biological properties when compared to recommended dose of chemical fertilizers i.e. nitrogen–phosphorus–potassium (N–P–K). Available N, P, and K content recorded maximum as 315, 99.4 and 279 kg ha^{-1}, respectively. Diethylenetriaminepentaacetic acid–extractable micronutrients (Fe, Cu, Zn, and Mn) were recorded maximum as 65.4, 2.7, 1.9, and 51.7 mg kg^{-1}, respectively. Microbial biomass of Pseudomonas spp., Azotobacter chroococcum, actinobacteria, soil fungi was recorded maximum as 98.0, 105.0, 80.0, 92.0 cfu, respectively, and highest arbuscular mycorrhizal (AM) fungi 1413/50g soil.

Key Words: Biofertilizer, FYM, Green manure, Organic nutrients, Vermiwash

Green Revolution technologies are known to have enhanced agricultural production and productivity. Farmers using these technologies have to depend upon the purchased agrochemicals, fertilizers etc. The highly energy intensive production of nitrogenous fertilizers and fastly depleting reserves of phosphatic and potassic fertilizer sources, pose a great cause of concern for the developing countries where energy security is still to be achieved. In view of the fast diminishing energy sources combined with their increasing cost, it is likely that in future, for developing countries like India, energy will become a limiting factor for increasing the production of inorganic fertilizers. Another issue of great concern is the sustainability of soil productivity. Thus, fertilization strategies will need to change over time as the soil changes. This can be in the form of farm yard manures, vermicompost, vermiwash, green manures, and other organic by-products, besides supplementing a large portion of the nutrient inputs. Moreover, organic produce commands and fetch a higher price than traditional commodity and thereby prompting producers to grow fruit crops organically.

Moreover, more than 80 per cent area under fruit crops is rain fed in Himachal Pradesh, India and the organic matter content in the soil has been declined. Rainfed conditions restricted the uptake of nutrients during growing period of crop and become a major limiting factor for enhancement of quality and productivity of crop. So there is an urgent need to increase the organic matter content in the soil which helps to enhance the water holding capacity and porosity of soil. Tillage practices, crop rotations, and use of green manures, biofertilizers and inputs of organic residues, farm yard manure, vermicompost and vermiwash affected organic matter content and physico-chemical and biological properties of soil. Moreover, the organic and biological resources are environment friendly, renewable source of energy and low cost agro-inputs. The present study was carried out to find out the effects of organic sources on soil health. Application of organic sources improved soil nutrient status and microbial count of kiwifruit orchard significantly in comparison to inorganic fertilizers.

MATERIAL AND METHODS

The study was carried out during 2010-2011 in kiwifruit orchard of the Dr YS Parmar University of Horticulture and Forestry, located in Solan, India. The orchard is situated at an elevation of 1260 m above mean sea level (30^{o} 60 $50^{D}45^{DD}$N; 77^{o} $08^{D}30^{DD}$E longitude). The climate is sub-temperate with an annual rainfall in the range between 60 and 100 cm. The experimental soils were classified as sandy loam (Sand: 40.2%, Silt: 30.4%, Clay: 29.7 %) with 6.9 pH, 0.25 dS/m electrical conductivity and 0.85% organic carbon. The initial available nitrogen, phosphorus and potassium contents in the soil were 302, 65 and 266 kg/ha, respectively. DTPA extractable micronutrients namely, iron, copper, zinc and manganese were 57.2, 2.3, 1.8 and 45.6 mg/kg, respectively. The experimental soil also contained an

initial viable microbial population of *Pseudomonas* spp. ($3.5x10^6$ colony forming units (cfu)/g soil), *Azotobacter chroococcum* ($4.10x10^6$cfu/g soil), 550 spores of AM fungi/5g soil, *actinobacteria count* ($4x10^6$cfu/g soil), and total soil fungal count ($1x10^6$cfu/g soil).

The experiment was designed considering five different organic nutrient sources viz., farm yard manure (FYM), vermicompost (VC), biofertilizer (BF), green manure (GM) and vermiwash (VW), applied to determine the optimum and best combination in comparison with the traditional farming practice. The treatments were replicated thrice in a Randomized Block Design. Different inputs of organic sources with different levels in different combinations namely, FYM: 30, 60 kg/vine (FYM_{30}, FYM_{60}), green manure, GM (Sunhemp, *Crotolaria juncea* L.); vermicompost: 15, 30 kg/vine (VC_{15}, VC_{30}); biofertilizer: 50, 100 g/vine (BF_{50}, BF_{100}); vermiwash @ 2% in water v/v (VW_2) at 15 days interval were applied. Different organic treatment combinations were T1: control (recommended dose of NPK fertilizers along with 20 kg of FYM $vine^{-1}$); T2: FYM_{60}; T3: GM; T4: VC_{30}; T5: BF_{100}; T6: VW_2; T7: FYM_{30}+VC_{15}; T8: FYM_{30}+BF_{50}; T9: FYM_{30}+VW_2; T10: VC_{15}+BF_{50}; T11: VC_{15}+VW_2; T12: BF_{50}+VW_2; T13: FYM_{15}+GM+VC_{15}+BF_{50}+VW_2.

The microbial inoculants include the consortia of *Azotobacter chroococcum*, *Pseudomonas* spp. and AM fungi namely, *Glomus fasciculatum* (Thaxtersensu Gerdemann), and were applied in equal proportions as band application at 15 cm depth in the basin of each vine tree being followed by a light irrigation for proliferation of the cultures. The microbial consortium of *A. chroococcum* strain A_{41}, *Pseudomonas* spp. and AM fungi were procured from the Department of Microbiology, Indian Agriculture Research Institute, New Delhi, India. The doses of organic sources in different treatments were based on the nutrient composition of FYM, biofertilizers (bio-inoculants), vermicompost, vermiwash and green manure to compensate the full recommended NPK chemical fertilizers to the trees. Full dose of FYM, vermicompost and biofertilizers were applied in the first week of March in basin of each tree. The nutrient composition of FYM includes 0.47% N, 0.23% P, 0.39% K, 0.005% Zn, 0.0005% Cu, 0.005% Mn, and 0.47% Fe. Vermicompost derived using mature green waste windrowed compost as feedstock to the worm reactors that were manufactured from timber surrounds and steel mesh as the base. Vermicompost used in the experiment contained 1.75% N, 0.87% P_2O_5, 1.25% K_2O, 170.7 mg/kg Fe, 5.69 mg/kg Cu, 23.48 mg/kg Zn and 94.78 mg/kg Mn Liquid formulation namely, vermiwash obtained during vermicomposting process from *Eisenia foetida* used as a foliar spray after 15 to 30 days of fruit set at 15 days interval up to fruit harvest during the late evening hours. The chemical composition of vermiwash contained 7.36 pH, 0.24 dS/m EC, 0.006% OC, 0.03% N, 1.72% P, 22.00 mg/kg K, 0.04 mg/kg Fe, 0.02 mg/kg Cu, 0.03 mg/kg Zn, and 0.55 mg/kg Mn. Sun hemp (*Crotolaria juncea* L.) as green manure crop was grown in the plant basin during the last week of June and was incorporated into the soil after 45 days at the time of flowering. NPK fertilizers used were Urea (46% N), single super phosphate (16% P_2O_5) and muriate of potash (60% K_2O). Nitrogen was applied in two splits by broadcasting method at 30 cm away from the tree trunk in the basin i.e. first half during the first week of March (3 weeks before flowering) and second half 30 days after fruit set. Phosphatic and potassic fertilizers were applied along with FYM/vermicompost during the month of December.

Composite soil samples (30 cm deep), weighed up to one kilogram were collected and taken to the laboratory in polythene bags, stored in refrigerator at 4.0^0C. These soil samples were passed through 2 mm sieve and were then used for analysis of various physico-chemical characteristics using standard methods. Soil pH and EC were measured in a 1:5 (w/v) aqueous solution using a pH meter and an EC meter, respectively. Soil OC was determined according to wet oxidation method (Walkey and Black, 1934). Available nitrogen (N) was estimated by alkaline potassium permanganate method (Subbiah and Asija, 1956), P was extracted with 0.5 M $NaHCO_3$ (pH 8.5) as reported by Olsen *et al*. (1954) and determined calorimetrically by the molybdate-ascorbic acid procedure. Available K content was extracted in 1N neutral normal ammonium acetate using a flame photometer. Available micronutrients viz., Fe, Cu, Zn and Mn were estimated by 0.005 M DTPA extraction method on atomic absorption spectrophotometer model 4141. The samples were also prepared and processed for further microbial assessment according to standard procedures.

The microbial count of the soil samples was determined by using standard methods. Isolation of viable bacterial/ fungal count as pure culture was done by the serial dilution technique on Nutrient agar (*Pseudomonas* spp.), Jenson's medium (*A. chroococcum*), Martin Rose Bengal (soil fungi) and Ken Knight's agar medium (actinobacteria). AM fungal spore population was recovered through wet sieving and decanting method (Gerdemann and Nicolson, 1963). The quantification of AM spores was carried out according to most probable number method (Porter, 1979).

RESULTS AND DISCUSSION

Soil chemical properties: All the treatments had a significant effect on physico-chemical and biological properties of soil. Different treatments of organic sources changed pH of the soil

towards neutral. The maximum pH of 6.78 was in T2. In general, organic sources have tendency towards neutral range pH. The production of organic acids during microbial metabolism in vermicompost process contributed towards decrease of soil pH. The data also indicates that the different organic sources had a non-significant influence on soil electrical conductivity (EC). Similarly, the highest soil OC (1.09%) was in T13, whereas, minimum (0.78 %) was recorded in T5. Verma and Bhardwaj (2005) reported that the improvement in soil OC in the organically treated plots due to the direct addition of organic matter through organic manure and recycling of organic materials in the form of organic residues. Furthermore, higher humus content in vermicompost resulted from decomposition and *Azotobacter* also supplies nitrogen during initial period of decomposition to avoid the immobilization. In this study, available macro- (N, P, K) and micro nutrients (Mn, Cu, Zn, Fe) were quantified to assess the nutritional build up in soil. The wide range (252.3 to 321.7 kg ha^{-1}) of available N content under different organic treatments indicated that different organic treatments exerted a marked influence on the available N in soil. Maximum available N (321.7 kg ha^{-1}) was in T1, whereas, minimum of 252.3 kg ha^{-1} N T6. Similar trend was also observed with respect to the availability of P and K content in soil. Increase in the availability of macronutrients with the incorporation of organic manures into the soil was also reported. The increased nutrient uptake by AM fungal treated plants attributed to the solubilization of elemental compounds, increased surface to volume ratio and permeation by hyphal strands into soil regions inaccessible by root hairs (Sharma *et al.,* 2009; 2011a,b). Moreover, the increased availability of N due to application of organic sources attributed to the greater multiplication of microbes which converted organically bound N to inorganic form. Combined application of FYM or green manures along with inorganic fertilizers recorded significantly higher available N over sole application and control (Marathe *and Bharambe,* 2009). Marufu (2010) observed that there is a rapid increase in soil microbes after a young green manure crop is ploughed down into the soil.

The available soil phosphorus content increased significantly when applied in combination with PSB due to more solubilization of insoluble phosphate in the soil, thus making easily available to the plants. The secretion of phosphotase by phosphate-solubilising bacteria and/or by AM fungi is a mode of facilitating the conversion of insoluble forms of P to plant-available forms and thus enhance plant P uptake has also been reported. The maximum build-up of available N was recorded with multi-inoculation of *Azotobacter* + AM fungi + PSB by Singh *et al.* (2010), who reported that synergism among biofertilizers might have resulted in better N-fixation and increased the availability of P, that might have facilitated the supply of ATP energy which

Table 1. Effect of organic nutrient sources on soil chemical properties in kiwifruit orchard

Treatment		pH	EC (dS/m)	Organic carbon (%)	Macronutrients (kg ha^{-1})			Micronutrients (mg kg^{-1})			
					N	P	K	Fe	Cu	Zn	Mn
T1	Control	6.74	0.25	0.86	321.7	102.5	281.7	63.1	2.6	1.8	48.0
T2	FYM_{60}	6.78	0.22	0.98	295.3	89.8	276.2	61.8	2.5	1.7	49.8
T3	GM	6.73	0.27	0.89	259.3	75.6	245.9	41.9	1.9	1.5	35.2
T4	VC_{30}	6.78	0.21	1.05	304.3	97.5	278.9	64.9	2.7	1.8	51.5
T5	BF_{100}	6.74	0.27	0.78	255.0	74.7	247.0	42.0	1.9	1.5	36.9
T6	VW_2	6.73	0.27	0.81	252.3	72.4	244.1	41.0	1.9	1.5	34.9
T7	FYM_{30}+ VC_{15}	6.78	0.21	1.03	299.7	94.2	278.4	64.2	2.7	1.7	50.7
T8	FYM_{30}+ BF_{50}	6.77	0.22	0.94	291.8	87.6	274.8	60.8	2.4	1.5	49.7
T9	FYM_{30}+ VW_2	6.77	0.23	0.91	291.0	86.3	274.0	59.6	2.4	1.5	48.6
T10	VC_{15}+BF_{50}	6.78	0.21	0.87	299.0	92.8	277.5	63.5	2.6	1.6	50.4
T11	VC_{15}+VW_2	6.77	0.23	0.86	297.0	92.3	277.0	64.0	2.6	1.6	50.2
T12	BF_{50}+VW_2	6.73	0.27	0.81	259.0	75.8	248.2	44.0	1.9	1.5	38.8
T13	FYM_{15}+GM+VC_{15}+BF_{50}+VW_2	6.78	0.21	1.09	315.0	99.4	279.0	65.4	2.7	1.9	51.7
$LSD_{0.05}$		NS	NS	0.04	21.0	5.7	16.0	2.8	0.2	0.1	1.5

FYM_{60}, farmyard manure: 60 kg/vine, GM, green manure (*Crotolariajuncea* L.), VC_{30}, Vermicompost: 30 kg/vine. BF_{100}, Biofertilizer:100 g/vine, VW_2, vermiwash: 2% v/v, FYM @ 30 kg + vermicompost @ 15 kg/ vine, FYM @ 30 kg + biofertilizer @ 50 g/vine, FYM @ 30 kg/vine+ spray of vermiwash at 15 days interval @ 2% v/v, Vermicompost @ 15 kg $vine^{-1}$ + biofertilizer @ 50 g/vine, Vermicompost @ 15 kg/vine+ spray of vermiwash at 15 days interval @ 2% v/v, Biofertilizer @ 50 g/vine+ spray of vermiwash at 15 days interval @ 2% v/v, FYM @ 15 kg/vine+ Green manure + vermicompost @ 15 kg/vine+ biofertilizer (mixed culture @ 50 g/vine) + vermiwash at 15 days interval @ 2% v/v

have been used by free-living bacteria for enhancing the biological nitrogen fixation. The increase in N, P and K uptake owing to organic manures lies in the fact that apart from supply of nutrients it enhanced the availability of these nutrients to the plant. The beneficial effect of organic manures on the availability of K might be due to the reduction in potassium fixation and release of potassium due to interaction of organic matter.

The maximum available Zn (1.9 mg kg^{-1}), Fe (65.4 mg kg^{-1}), Cu (2.7 mg kg^{-1}) and Mn (51.7 mg kg^{-1}) content which was in T13 and was tatistically at par with T4, T7, and T10. The extent of variation among the treatments was similar for Zn, Fe, Cu and Mn the treatments in combination with vermicompost exert a signifdicant effect in all the treatments. The treatment combination of T13 was superior over T1 treatment. In the present studies, higher concentration of Fe, Zn, Mn and Cu were in treatment T13. The increase in nutrient uptake owing to organic manure and biofertilizers lies in the fact that apart from supplying nutrient it enhanced the availability of these nutrients to plants. Increase in DTPA-extractable ions also ascribed to the addition of these micronutrients by organics and their release from native sources on account of solubilizing action of organic acids produced during decomposition process. The higher availability of micro nutrients in vermicompost treated plots was assigned to its inherent capacity to add good amount of organic carbon content to soil which hastens the process of mineralization of organically bound micronutrients present in native soil (Singh *et al.,* 2010). Higher content of micronutrient cations were also obtained with biofertilizers inoculation attributed to increased root colonization, increased root surface area that resulted in absorption and translocation of nutrients from distant area (Sharma *et al.,* 2005). It has been reported that direct mycorrhizal effect on mineral nutrient may be limited to these nutrient ions that have poor mobility and are present in low concentrations in soil solution like Zn and Cu.

Soil microbiological properties: Application of bio-organic combination in T13 recorded maximum ($98.0x10^6$ cfu/g soil) *Pseudomonas* spp. count which was statistically at par with T10, T8, T7 and T4 treatments. The total fungal population in soil was also increased with the application of different organic treatments. Maximum soil fungi population count ($92.0x10^6$cfu/g soil) was recorded in treatment T13 and was statistically similar with T10, T8, and T4 treatments. Maximum *A. chroococcum* count ($105.0x10^6$cfu/g soil) was in T13 and was statistically similar to T10, T8, T4 and T7 (Table 2). **Similarly, total actinobacteria count was** maximum ($80.0x10^6$cfu/g soil) in T13 which was statistically at par with T10, T8, and T4. Maximum AM fungi spore population (1413 per 50 g soil) was obtained with T13 which was statistically similar with T10, T4, T7 and T11 recording 1412, 1408, 1402, 1398 and 1390 per 50 g soil, respectively. The treatment combinations of T2, T3, T5, T9, T11 and T12 increased the *Pseudomonas*, soil fungi, *A. chroococcum* count, *actinobacteria* and AM spore count in rhizosphere of orchard soil over T1 (Table 2). In the present investigation, all of the soil microbiological properties were recorded maximum with treatment combination of T13. These findings are in line with Ram *et al.* (2007) who reported significant increase in microbial population in rhizosphere soil of guava trees with addition of different organic sources. Similarly, Araujo *et al. (*2009) reported that soil microbial activity and biomass was

Table 2. Effect of organic nutrient sources on soil biological properties in kiwifruit orchard

Treatment		*Pseudomonas* ($x10^6$ cfu)	*Azotobacterchroococcum* ($x10^6$ cfu)	Actinobacteria ($x10^6$ cfu)	Soil fungi ($x10^6$ cfu))	AM spore count (per 50 g soil)
T1	Control	2.0	4.0	2.0	2.0	288
T2	FYM_{60}	68.0	77.0	66.0	58.0	1315
T3	GM	47.0	44.0	56.0	36.0	456
T4	VC_{30}	88.0	98.0	74.0	85.0	1402
T5	BF_{100}	42.0	27.0	52.0	30.0	327
T6	VW_2	2.0	1.0	1.0	1.0	251
T7	FYM_{30}+ VC_{15}	90.0	98.0	70.0	86.0	1398
T8	FYM_{30}+ BF_{50}	92.0	101.0	73.0	87.0	1408
T9	FYM_{30}+ VW_2	66.0	77.0	65.0	78.0	1314
T10	VC_{15}+BF_{50}	95.0	103.0	78.0	90.0	1412
T11	VC_{15}+VW_2	67.0	77.0	68.0	80.0	1390
T12	BF_{50}+VW_2	63.0	44.0	60.0	40.0	396
T13	FYM_{15}+GM+VC_{15}+BF_{50}+VW_2	98.0	105.0	80.0	92.0	1413
$LSD_{0.05}$		10	9	7	7	70

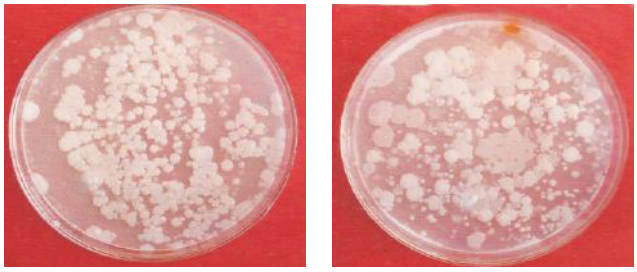

Plate 1a. *Pseudomonas* population count on nutrient agar

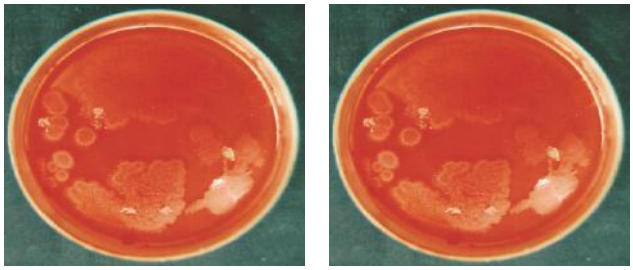

Plate 1b. Fungal population count on Martin's Rose Bengal Medium

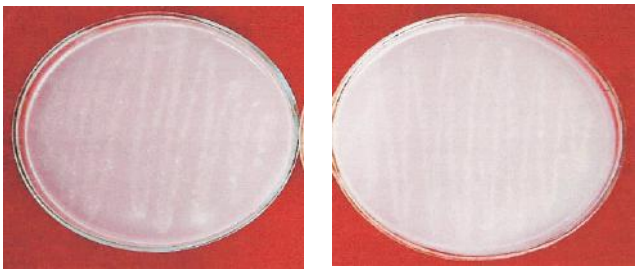

Plate 1c. *Azotobacter* population count on Jensen's Medium

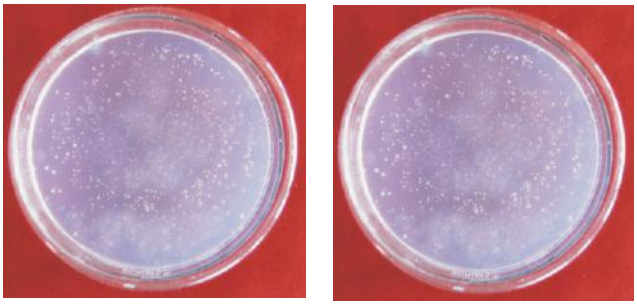

Plate 1d. *Actinomycets* population count on Kenknight and Munaires Medium

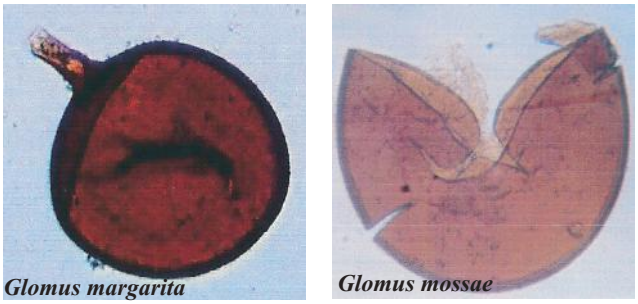

Plate 1e. Arbuscular mycorrhizae spores isolated from rhizosphere of kiwifruit orchard

significantly greater in organics compared with conventional practices. The organic manure provided necessary food and microenvironment for their quicker multiplication and growth (Kumari and Kumari, 2002). Farmyard manure is one of the suitable medium in which microbial inoculants grow to a reasonably higher number with long shelf life. Residue addition provides a stable supply of carbon and energy for rapid growth of microorganisms and this causes an increase in the microbial biomass pool, thereby increasing soil respiration rate. Greater microbial population increase the potential for greater nutrient cycling and large amounts of N are stored in the relatively labile microbial biomass. Soil organic matter degraded with the increased population of soil microorganisms through the production of diverse extracellular enzymes, after the application of vermicompost to the soil (Tejada and Gonzalez, 2008). Arancon *et al.* (2006) observed that an increase in enzymatic activities after the addition of vermicompost to soil. This increase was attributed to the vermicompost containing higher amount of growth promoting substances, vitamins and enzymes, which in turn, increased the microbial population, resulted in higher production of root exudates increasing the beneficial bacteria, fungi and *actinomycetes* population in rhizosphere region. Green manure application significantly increased the bacterial and fungal population in soil (3.36 and 1.46 times, respectively). Increased microbial population in the soil was envisaged to the enhanced organic matter inputs from the green manure (Shah *et al.,* 2010).

CONCLUSION

The study inferred that FYM @ 15 kg/vine+ Green manure + vermicompost @ 15 kg/vine+ biofertilizer (mixed culture @ 50 g/vine) + vermiwash at 15 days interval @ 2% v/v was found to be most effective to improve the physico-chemical and biological soil properties under rainfed agro-climatic conditions of Himachal Pradesh.

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Impact of Evaporation Based Drip Irrigation Schedules on Yield and Quality of Kinnow Mandarin in Kandi Area

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Abstract: To identify the critical stages of irrigation water requirement of bearing Kinnow mandarin through drip irrigation system a field experiment was conducted on 6 years old bearing Kinnow mandarin based on evaporation replenishment (ER) irrigation scheduling during 2013-15. The irrigation water quantity given per day per plant under different treatments in various months varied from 30.2-168.2 liters per plant and 23.5-152.5 liters per plant different months during 2013-15. The highest quantity of water was applied under the irrigation scheduled at 80 % evaporation replenishment (ER) treatment and it varied from 54.1-168.2 liters per plant in 2013-15. The only canopy volume was found significant among the various scheduling treatments. The fruit yield and quality was significantly affected under various evaporation replenishment (ER) based drip irrigation scheduling treatments. The highest TSS, juice per centage and lower acidity was observed under irrigation at 80 % ER in stages I-IV during the study period.

Key Words: Drip irrigation, Evaporation replenishment, Kinnow

The water resources on the earth are limited, with freshwater being estimated at 37 million km^3. Only 0.3% of this amount can be used as renewable resource. The lack of water is the major limiting factor on expansion of irrigated agriculture in the arid and semi-arid land of the world. Establishment of water-saving irrigation technology for irrigation is considered to be one of the efficient ways to improve and to develop agriculture in the 21st century in these regions. Bravdo *et al*. (1993) stated that shoot growth extension varied considerably according to irrigation system. El-Wazzan *et al*. (2001) on Valencia orange improved that irrigation system had announced effect on the yield. The mandarin fruit yield can be increased from 10-11 tonnes ha^{-1} and productivity potential of the mandarins can be enhanced to 16-18 tonnes ha^{-1} with the adoption drip irrigation and frequent schedules, different degree under tree micro-jet irrigation systems (Shirgure *et al.,* 2003) and quality fruits with micro-irrigation. The irrigation water requirement of Kinnow mandarin and other citrus cultivars varies with stage, age and season under different climatic conditions. The growth of plant retards below certain critical level of available moisture depending upon soil type, climatic factor and plant genetic makeup. Irrigation scheduling based on depletion of available water content as 65 per cent in Valencia orange, 40-100 per cent (Moreshet *et al.,*1988) in 'Shamouti' orange and 85 per cent (Peres, 1987) in Valencia have been suggested. Field experiment with a mature 'Valencia' orange trees showed that the water use pattern over the entire season reached a maximum of 87 liters/day in January month. The highest yields (190 kg $tree^{-1}$) and the largest average fruit size with irrigation at a crop factor of 0.9 on a 3 day cycle was obtained (Plessis, 1988). In comparison of five flood irrigation treatments in Vema lemon with daily drip irrigation at 0.475 Epan, it was concluded that the drip irrigation gave higher yields as compared to flood irrigated plants (Sanehez *et al.*, 1989). The objective of this investigation was to identify the critical growth stages of water requirement under pan evaporation based drip irrigation scheduling and effect on water use, plant growth and fruit quality of bearing Kinnow mandarin.

MATERIAL AND METHODS

A field experiment was conducted for identifying the critical stages of water requirement and irrigation scheduling based on open pan evaporation through the drip irrigation at Regional Research Station Ballowal Saunkhri, Punjab Agricultural University Ludhiana with 6 x 6 m spacing on 7 years old Kinnow orchards, during 2013-15. The irrigations were scheduled on per cent of pan evaporation replenishment (ER) in various stages of growth and fruit development. The different stages considered in this study are viz. Stage-I (Jan.-Feb.), Stage-II (Mar-Apr), Stage-III (May-Jun.) and Stage-IV (Jul.-Aug.). The treatments were drip irrigation schedule with T1 - irrigation schedule with 30% ER in stage-I and 80 % ER in stages II to IV,T2 - irrigation schedule with 30% ER in stage-II and 80 % ER in stage I and stages III to IV,T3 - irrigation schedule with 30% ER in stage-III and 80 % ER in stage I, II and stage IV, T4 - irrigation schedule with 30% ER in stage-IV and 80 % ER in stage I-II and III,T5 - irrigation schedule with and 80 % ER in all stages

I-IV with three replications in Randomized Block Design. The irrigation was scheduled and applied to the treatments on per cent pan evaporation replenishment. The texture of the soil was sandy loam and depth of the soil is 40 cm. The composite soil samples were collected for determination of field capacity and permanent wilting point. Volumetric soil moisture content at field capacity (FC) and the permanent wilting point (PWP) soil moisture content was determined using pressure plate method. The FC and PWP of the field under study was 0.3bars and 15bars, respectively. The water holding capacity of the soil was 9.21 cm/m depth of soil. Based on the average weekly open pan evaporation, the irrigation quantities were calculated taking into account of pan factor (0.7), canopy factor (0.8) and crop factor (0.6). Soil-moisture status was recorded periodically from 2013 to March, 2015 with the help of oven dry method. The biometric parameters of Kinnow mandarin plants (plant height and tree spread) were recorded in October, 2013 to 2015. The plant stock girth was taken 15 cm above the soil surface. The canopy volume of the mandarin tree was calculated according to formula suggested by Castle (1983). Fruit yield and quality analysis was also carried out as per procedures described by Ranganna (1986). The data on fruit yield and quality attributing to the different irrigation schedules for 2 years were analysed by Analysis of variance method.

RESULTS AND DISCUSSION

The irrigation water requirement of Kinnow mandarin varied according to the different pan evaporation replenishment based drip irrigation schedules and stages. The daily weather data recorded from Regional Research Station Ballowal Saunkhri observatory was used for irrigation scheduling based on evaporation. The daily maximum open pan evaporation ranged from minimum 0.5 mm per day in January to maximum 12.0 mm per day in June. The average irrigation water requirement of Kinnow mandarin per plant varied from 30.2, 61.3 and 69.4 liters per plant with irrigation scheduling with 30 % ER in stage I, II, III and IV during 2013-14. The same was 90.2, 154 and 168.2 liters per plant with the irrigation schedule at 80 % ER in all the stages during the year 2013-14. The average irrigation water requirement of Kinnow mandarin per plant varied from 23.5, 33.4 and 61.5 liters per plant with irrigation scheduling with 30 % ER in stage I, II, III and VI during 2014-15.

The same was 54.1, 86.2and 152.5 liters per plant with the irrigation schedule at 80 % ER in all the stages during the year 2014-15 (Table 1). The irrigation water requirement of Kinnow mandarin was higher in the year 2013-14 and lower in 2014-15 due to the variation in evaporation rates during the various growth stages. The irrigation was not scheduled during the stages IV due to rains and the evapo-transpiration rate during rainy months was lower than rainfall. The effect of different drip irrigation scheduling based on per cent evaporation replenishment has influenced on the biometric growth of Kinnow mandarin. The observational data on biometric growth parameters of Kinnow mandarin revealed that out of various growth parameters, only canopy volume shown a significant response in relation to irrigation

Table1. Weekly mean irrigation applied (Liters/day/plant) under various treatments in Kinnow mandarin under kandi area

Treatments	Stage I (Jan-Feb)	Stage II(Mar-Apr)	Stage III (May-Jun)	Stage IV (Jul-Aug)
		2013-14		
T1	30.2	154.0	168.2	Rain
T2	90.2	61.3	168.2	Rain
T3	90.2	154.0	69.4	Rain
T4	90.2	154.0	168.2	Rain
T5	90.2	154.0	168.2	Rain
		2014-15		
T1	23.5	86.2	152.5	Rain
T2	54.1	33.4	152.5	Rain
T3	54.1	86.2	61.5	Rain
T4	54.1	86.2	152.5	Rain
T5	54.1	86.2	152.5	Rain

T1 - irrigation schedule with 30% ER in stage-I and 80 % ER in stages II to IV
T2 - irrigation schedule with 30% ER in stage-II and 80 % ER in stage I and stages III to IV
T3 - irrigation schedule with 30% ER in stage-III and 80 % ER in stage I, II and stage IV
T4 - irrigation schedule with 30% ER in stage-IV and 80 % ER in stage I-II and III
T5 - irrigation schedule with and 80 % ER in all stages I-IV

scheduling treatments (Table 2). The growth of mandarin plant (plant height and canopy volume) recorded during October month of the year 2013-14. Data of plant height, plant spread have been used in estimating the canopy volume (Castel, 1983). The plant height is not significant, but canopy volume is significant during the 2 years of the study. A significant difference was observed in canopy volume while non-significant variation was observed in height of the Kinnow mandarin plant (Table 2). The average plant height (4.86 m) was higher in the irrigation schedule having 80 % ER in all four stages. This may be mainly due to the rains and high humid conditions favoring vegetative growth. The various drip irrigation schedules in four stages influenced the canopy volume significantly. The average canopy volume observed was higher 88.35 m^3 in the irrigation schedule with 80% - irrigation schedule with and 80 % ER in all stages I-IV. The canopy volume was lowest in the irrigation schedules of 30 % ER in stages III, II and I during the years of the study. This is mainly due to availability of constant, higher and continuous soil moisture in plant active root zone. The similar observations were also recorded in acid lime (Shirgure *et al.,* 2004) under central Indian conditions. The pan evaporation based drip irrigation scheduled based on pan evaporation replenishment in four different stages had profound effect on the yield and fruit quality of the Kinnow mandarin during 2014-15. The Kinnow mandarin fruits were harvested during first fortnight of January month in the year 2014-15. The average number of fruits per plant, yield, TSS, Juice content, acidity and TSS to acidity ratio was analysed for the study period and pooled data in presented in Table 3. The Kinnow mandarin yield and fruit quality were significantly influenced by the different ER based drip irrigation schedules during the four stages. The number of fruits per plant, fruit yield, average fruit weight, TSS and juice per centage was found significant during 2014-15. The acidity was not found significant may be due to internal maturity condition and internal fruit quality (Table 3). The average number of fruits per plant varied from 448, 432 and 413 in the drip irrigation schedule having 80 % ER in stage I and II and 30 % ER in stage III, in the drip irrigation schedule having 80 % ER in stage I and III and 30 % ER in stage II followed by the drip irrigation schedule having 30 % ER in stage I and 80 % ER II and III respectively. From this it is evident that the stages III, II and I are critical from the point of irrigation water requirement of Kinnow mandarin. The various drip irrigation scheduling treatments significantly influenced the yield of the Kinnow mandarin. The highest mandarin fruit yield was recorded in the drip irrigation schedule with 80 % ER in all stages (93.64 kg $tree^{-1}$) followed by irrigation schedule with 30 % ER in stage -IV and 80 % ER in stage –I, II and III (Table 3). This is clearly indicates

Table 2. Effect of various irrigation treatments on vegetative growth and fruit parameters of Kinnow mandarin under kandi area

Treatments	Tree height (m)	Canopy volume (m3)	No. of fruits	Fruit Weight (g)
T1	4.61	81.69	448	130.2
T2	4.73	84.13	432	120.2
T3	4.68	84.09	413	120.8
T4	4.53	85.23	681	125.3
T5	4.86	88.35	686	136.5
CD (p=0.05)	NS	1.3	42.3	7.2

Table 3. Fruit yield and quality of Kinnow mandarin under the various irrigation scheduling in Kandi area

Treatments	Fruit Yield (Kg/tree)	Juice (%)	Acidity (%)	TSS (° Brix)
T1	58.33	47.4	0.32	11.11
T2	51.93	47.5	0.31	11.18
T3	49.89	48.6	0.39	11.09
T4	85.33	48.3	0.37	11.10
T5	93.64	49.7	0.32	11.20
CD (p=0.05)	38.3	0.3	0.1	0.3

that the stage III (May-June), stage II (March-April) and stage I (January-February) are critical for water need and in order of III, II and I due to increase in summer months and rise in temperature as well as evapo-transpiration demand of the mandarin plants. This clearly indicates that the drip irrigation schedules based on ER maintained higher as well as continuous soil moisture influenced by the water and nutrient uptake resulting into good quality fruits besides enhancing the yield. The highest average fruit weight (136.5 g) and lowest acidity (0.32) is observed in the drip irrigation schedule with 80 % ER in stages I-IV. The TSS (10.20°Brix) and juice per cent (49.7 %) was more in irrigation schedule with 80 % ER in stages I-IV. This ratio was analysed for all the treatments. The highest TSS/acidity (32.0) was found in the irrigation schedule with 80 % ER in stages I-IV and lowest ratio (30.5) was observed the drip irrigation schedule with 30 % ER in stage III and 80 % ER in stages I-II and stages IV. This clearly indicates that water requirement in the stage III (May-Jun.) very essential to get good quality fruits. The similar fruit yield and quality results are observed in mandarin (Shirgure *et al.,* 2001). The critical stages of irrigation water requirement of bearing Kinnow mandarin through drip irrigation system based on evaporation replenishment (ER) was investigated during 2014-15. The effect on water requirement, growth, fruit yield and quality has been studied. The highest quantity of water was applied under the irrigation scheduled at 80 % evaporation replenishment (ER)

treatment and it varied from 69.4 to 168.2 liters/day/plant in 2013-14, 61.5-152.5 liter/day/plant in 2014-15. The only canopy volume was found significant among the various irrigation scheduling treatments. The fruit yield and quality parameters (TSS, juice per centage and acidity) recorded were significantly affected under various evaporation replenishment based drip irrigation scheduling treatments. The highest fruit yield and higher quality fruits can be obtained with drip irrigation schedule with at 80 % ER during January to July month. The highest TSS to acidity ratio could be obtained if the irrigation schedule with 80 % ER in all months to the bearing Kinnow mandarin.

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Genetic Diversity Analysis in Sweet Orange (*Citrus sinensis* Obseck) Genotypes on the Basis of Morphological and Physico-chemical Traits

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***Abstract*:** Morpho-physiological data of 16 sweet orange genotypes were subjected to cluster analysis and the tested genotypes were grouped into four clusters with cluster I and II showing maximum inter cluster distance. Cluster I, cluster II, cluster IV and cluster III showed inter cluster distance of 0.58, 0.55, 0.52 and 0.30, respectively. This indicated dissimilarity for morphological features and performance in these clusters.

***Key Words*:** Citrus, Cluster analysis, Morpho-physiological characters, Sweet orange

Citrus is a subtropical fruit which belongs to family Rutaceae. The north-eastern region has vast diversity for few citrus species. Citrus cultivation is confined within 40◯North-South latitude. The genus *Citrus* has only three basic true species *viz*, Citron (*Citrus medica* Linnaeus), Mandarin (*Citrus reticulate* Blanco) and Pummelo (*Citrus grandis* Obseck) (Swingle and Reece, 1967), while the other citrus species are being considered as hybrid derivatives of any one of these true species (Barrett and Rhodes, 1976, Federici *et al.,* 1998, Nicolosi *et al*., 2000). 17 citrus species including their 52 varieties and seven natural hybrids are being reported to be originated in the north eastern region of India. A recent study on genetic resources of *Citrus* in northeastern India indicated the presence of 23 species, one subspecies and 68 varieties, thus this area acquired a special status as a treasure house of *Citrus* germplasm. Genetic diversity and its classification can be assessed with morphological characterization. Even today, for cultivar identification and diversity assessment, morphological study is being considered as an initial step. Most of the horticultural traits are controlled by multiple genes; Liu and Dang, 2007), which cannot be evaluated through molecular markers hence morphological characterization could be an important tool. A large number of citrus species/progenitors of commercial citrus fruits are believed to be originated in India. Despite of huge genetic diversity, very little work has been done in the past highlighting the distinguishable morphological features. Proper identification of trees is essential to establish trueness-to-name in commercial channels. Keeping in view that availability of wide range of citrus genotypes at Punjab Agricultural University, Ludhiana, the present study was planned to analyze variability in citrus genotypes for different morphological characters.

MATERIAL AND METHODS

The experiment was carried out during the years 2013 to 2015 at Punjab Agricultural University, Ludhiana, Punjab. The sixteen genotypes used for study included: Moro, Mosambi, Rhode Red Valencia, Campbell Valencia, Cutter Valencia, Fukumoto Navel, Itaborai, Olinda Valencia, Ruby Nucellar, Trovia, Westin, Early Gold, Vernia, Crescent Orange, Jaffa and Sanguinelli. Characterization of citrus genotypes was conducted on 16 genotypes for one tree characters (rootstock diameter), three vegetative characters (leaf lamina length, width and length : width ratio), seven floral characters (flower diameter, petal width, length of flower, pedicel, petal, filament and style), seven fruit characters (fruit weight, diameter, length, rind thickness, albedo thickness number of segments per fruit and fruit axis diameter), two physico-chemical characters (total soluble solids and titrable acidity) and four seed characters (seed number, length, width and weight per 20 seeds) on the basis of IPGRI (International Plant Genetic Resources Institute) citrus descriptors (Anonymous 1999). Each genotype was replicated four times with one plant per replication. Data on tree, vegetative and floral characters was recorded from all the four directions of plant. For fruit characters, ten fruits/plant were collected randomly and observation were recorded on each fruit separately. Parameters for length, width, diameter, thickness, were recorded using Digital Vernier Calipers. Total soluble solids content of fully mature fruits was estimated by using Digital Hand Refractrometer. Titrable acidity was calculated by titrating a known volume of pulp juice extracted against 0.1 N Sodium hydroxide (NaOH)

using phenolphthalein as an indicator. Seeds from fruits in each replication were collected by cleaning and washing. Seed number/fruit was counted manually for each fruit. Seed weight was recorded on the basis of average of 20 seeds per replication.

RESULTS AND DISCUSSION

Non-hierarchical cluster analysis was used to group the test genotype into four clusters (Table 1) with variable number of entries in each cluster indicating the presence of genetic diversity in the genotypes. Cluster II contained maximum number of genotypes (eight) followed by cluster I, IV and III three, three and two genotpyes, respectively. The formation of large number of clusters with variable number of entries in each cluster is indicative of diversity. Average distance cluster dendrogram depiciting the dissimilarity among the clusters (Fig. 1) represents different genotypes, which were clustered into four clusters. In addition to grouping, the accessions into different clusters, non hierarchical cluster analysis was used to identify the diverse and desirable genotypes in terms of inter cluster distance and mean performance of characters, respectively. The points considered, while selecting genotypes were: choice of the clusters that are separated by maximum inter-cluster distance and selection of particular genotypes that showed good performance in the selected clusters of the dendrogram. The cluster mean value for five vegetative, seven floral characters, nine fruits characters and four seed characters indicated considerable differences for all the characters among clusters (Table 2, 3, 4 and 5, respectively). Cluster I was characterized by the highest mean value for fruit weight (293.58 g), fruit diameter (84.24 mm), fruit length

Table 1. Grouping of 16 sweet orange genotypes into different clusters on the basis of non hierarchical cluster (analysis)

Cluster number	Number of genotypes	Genotypes
I	3	Moro, Mosambi, Rhode Red Valencia
II	8	Campbell Valencia, Cutter Valencia, Fukumoto Navel, Itaborai, Olinda Valencia, Ruby Nucellar, Trovita, Westin
III	2	Early Gold, Vernia
IV	3	Crescent Orange, Jaffa, Sanguinelli

Table 2. Mean performance of different clusters for different vegetative traits of sweet orange genotypes

Cluster No	Leaf lamina length	Leaf lamina width	Leaf lamina length: width ratio	Rootstock diameter (mm)
Cluster I	108.50	64.91	1.59	100.27
Cluster II	108.40	69.56	1.55	103.81
Cluster III	108.19	70.05	1.44	92.05
Cluster IV	97.29	59.65	1.63	95.23

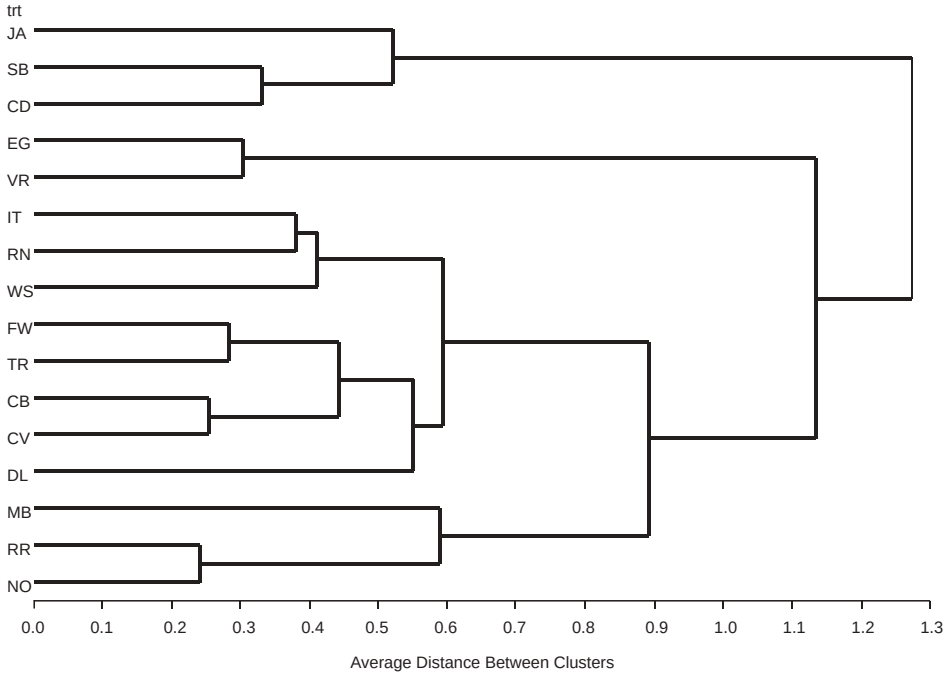

Fig. 1. Dendrogram showing average distance between clusters based on morphological traits among 16 sweet orange genotypes. Where JA, SB, CO, EG, VR, IT, RN, WS, FM, TR, CB, CV, OL, MB, RR and MO tends to Jaffa, Sanguinelli, Crescent Orange, Early Gold, Vernia, Itaborai, Ruby Nucellar, Westin, Fukumoto Navel, Trovita, Campbell Valencia, Cutter Valencia, Olinda Valencia, Moro, Rhode Red Valencia and Mosambi in the dendrogram, respectively

Table 3. Mean performance of different clusters for different flower traits of sweet orange genotypes

Cluster No	Flower diameter (mm)	Flower length (mm)	Pedicel length (mm)	Petal length (mm)	Petal width (mm)	Length of filament (mm)	Length of style (mm)
Cluster I	34.93	22.86	7.95	18.83	7.05	9.80	5.81
Cluster II	33.64	22.54	7.36	18.26	7.94	9.10	5.78
Cluster III	32.10	19.36	6.55	16.51	7.62	8.11	5.17
Cluster IV	31.61	21.22	7.22	17.26	6.85	9.33	5.76

Table 4. Mean performance of different clusters for different fruit traits of sweet orange genotypes

Cluster No	Fruit weight (g)	Fruit diameter (mm)	Fruit length (mm)	Albedo thickness (mm)	Fruit rind thickness (mm)	Number of segments	Fruit axis diameter (mm)	TSS (^{0}brix)	Titrable acidity (%)
Cluster I	293.58	84.24	79.5	2.32	5.82	12.66	11.51	10.04	0.60
Cluster II	231.17	79.25	73.46	2.86	5.71	12.50	11.53	9.13	0.75
Cluster III	200.37	80.28	71.68	2.20	6.69	11.87	12.16	9.28	0.59
Cluster IV	151.41	66.82	66.94	1.78	5.00	12.66	11.62	8.41	0.63

Table 5. Mean performance of different clusters for different seed traits of sweet orange genotypes

Cluster No	Seed number	Seed length (mm)	Seed width (mm)	Seed weight of 20
Cluster I	6.92	8.76	4.05	1.86
Cluster II	10.19	12.99	6.77	2.75
Cluster III	9.87	13.72	5.77	1.91
Cluster IV	9.33	13.00	5.75	2.21

(79.50 mm), fruit rind thickness (5.82 mm) and total soluble solids (10.04^{0}brix), while the lowest mean value was recorded for fruit axis diameter, seed number, seed length, seed width and seed weight. Cluster II was characterized by the highest mean value for albedo thickness (2.86 mm), titrable acidity (0.75%), petal width (7.94 mm), rootstock diameter (103.81 mm), seed number (10.19), seed width (6.77 mm) and seed weight of 20 seeds (2.75 g) and moderate mean values for all other characters. Cluster III had the highest mean value for fruit axis diameter (12.16 mm), leaf lamina length (108.19 mm), leaf lamina width (70.05 mm) and seed length (13.72 mm), while the lowest mean values was recorded for number of segments per fruit, titrable acidity, length of flower, pedicel, petal, filament, style, leaf lamina length : width ratio and rootstock diameter. Cluster IV was characterized by the highest mean value for number of segments per fruit (12.66), fruit axis diameter (11.62 mm) and leaf lamina length : width ratio (1.63), while the lowest mean value was represented by fruit weight, fruit diameter, fruit length, albedo thickness, fruit rind thickness ,total soluble solids, flower diameter, petal width, leaf lamina length and width. Cluster I showed good results with respect to fruit weight, fruit diameter, fruit length, number of segments per fruit, total soluble solids, seed weight. Cluster II showed quality results with respect to pulp flesh colour but was undesirable for late maturity, seed number, seed length and seed width and seed weight per 20 seeds. Cluster III showed desirable results with respect to low titrable acidity, high total soluble solids and higher juice content but also possessed undesirable traits like high seed number and seed weight. Cluster IV showed uniform pulp flesh colour, number of segments per fruit but was undesirable for fruit weight, fruit diameter, fruit length, albedo thickness, total soluble solids and seed weight. There existed a few good genotypes in a cluster that can be further used in hybridization for special trait, e.g. cluster I contained genotype Moro, which possessed red flesh of pulp with large size of fruit, Mosambi with higher total soluble solids and lower titrable acidity and Rhode Red Valencia with less number of seeds and better fruit quality. Cluster II contained eight genotypes among them, Campbell Valencia, Cutter Valencia and Fukumoto Navel possessed less number of seeds; Itaborai, Trovita and Westin with higher juice content, lower titrable acidity and low incidence of granulation. Cluster III had only two genotypes namely Early Gold and Vernia containing more number of fruit per plant with moderate juice content. Cluster IV contained three genotypes with small fruit size. Sanguinelli was better due to red pulp flesh and higher juice content, while Jaffa was better due to higher yield with less incidence of granulation.

The sweet orange genotypes can be successfully used for planning future breeding programmes to obtain hybrids with desired traits. Combination with high heterotic response and superior recombinants may be obtained through hybridization between genotypes across the clusters.

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Development of Process Technology for Making Tomato Powder and its Quality Evaluation

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***Abstract*:** The objective of this study was to analyse the physio-chemical and nutritional quality of a tray dried tomato powder with three chemical treatments namely potassium meta-bisulphite (KMS), calcium chloride ($CaCl_2$) and combination of these two at different concentrations. The results indicated that the moisture content of tomato slices decreased rapidly with the increase in drying time from 1 hr to 10 hr using different concentrations of KMS, $CaCl_2$ and KMS+$CaCl_2$. At 11 hr, the moisture content attained a steady state for all the samples. Further, the quality of processed tomato powder with different KMS, $CaCl_2$ and KMS+$CaCl_2$ concentrations was tested in terms of lycopene (mg/100 gm), ash content (%), dehydration ratio, rehydration ratio, pH, % recovery, and vitamin C along with the raw controlled sample. It is concluded that overall quality of tomato powder was good in combination of KMS+$CaCl_2$ as compared to KMS and $CaCl_2$. Similarly, 0.2g KMS+1.0g $CaCl_2$/100g concentration gave better quality than the 0.1g KMS+0.5g $CaCl_2$/100g and 0.3g KMS+1.5g $CaCl_2$/100g.

Key Words: *Lycopersicon esculantum*, Tomato powder, Drying technology

Tomato (*Lycopersicon esculantum*) is one of the world's most commercially produced and popular vegetable belongs to the family of *Solanaceae and they* are known for the excellent nutritive, medicinal, and food values. Tomato contains large amounts of vitamin-C and A, providing 40% and 15% of the daily value, respectively. Moreover, the lycopene, red pigment contained in tomatoes act as an antioxidant and neutralizing free radicals. There are various research findings on drying characteristics of tomato slices using different pre-treatments, drying methods, and their quality analysis. Goula and Adamopoulos (2006) determined a mathematical model for the reaction kinetics of ascorbic acid degradation to describe the rate of vitamin C loss in a drying process of tomato halves or tomato pulp. Many researchers have studied the processing of tomato powder and its quality analysis with various controlling factors (Alexandre *et al.,* 2008; Shilpa *et al.,* 2008; Akhtar *et al.,* 2014).

Pre-treatments with chemicals before drying have been used in order to minimize adverse changes during drying and subsequent storage of tomatoes. The most common and least expensive method to prevent enzymatic browning in freshly prepared vegetables or tomatoes is by the use of sulphating or salt agents such as meta-bisulphite and or calcium chloride since, they have multiple functions. Another method for introducing of sulphur dioxide into the tomato is by dipping in sodium meta-bisulphite solution. The objectives of this study are to study the effect of KMS, $CaCl_2$ and KMS+ $CaCl_2$ treated tomato slices on tray drying and to evaluate the quality of tomato powder in terms of ash, pH, vitamin-C, Lycopene content, dehydration ratio, and rehydration ratio.

MATERIAL AND METHODS

The various dependent and independent variables identified in making tomato powder are moisture content (% w.b), composition of vitamin-C, Lycopene content, ash content, dehydration ratio, rehydration ratio and KMS concentration (0.1, 0.2 and 0.3g/100g), $CaCl_2$ concentration (0.5, 1.0 and 1.5g/100g), and KMS+$CaCl_2$ concentrations (0.1+0.5, 0.2+1.0 and 0.3+1.5g/100g). The important apparatus used during the study are spectrophotometer for determining the Lycopene content in tomato powder, digital pH meter to test the acidity of tomato powder, muffle furnace for determination of ash content of tomato powder, hot air oven for moisture content determination, and tray dryer.

Pre-treatment and drying: The ripened fresh tomatoes of local variety were procured, which were 60-75 mm of average diameter and 90-110 g of weight. After collection, they were sorted and washed with distilled water to remove dirt and soil. Thereafter, tomatoes were cut into slices (5-7 mm thickness) and tomato slices were pre-treated by dipping in three different chemical solutions at three different concentrations at room temperature for 10 minutes as (a) 0.5, 1 and 1.5 g/100g of $CaCl_2$ solution in water (1:1 w/w), (b) 0.1 g , 0.2g/100 g and 0.3g/100g of KMS solution and (c) 0.5g, 1

and 1.5g/100g of $CaCl_2$ in combination with 0.1g/100 g, 0.2g/100g, 0.3g/100g of KMS in an equal mass of water. Tomato slices were dipped in an equal mass of plain water for 10 minutes at room temperature were considered as controlled sample. The pre-treated tomato slices were dried in the tray drier and placed uniformly on stainless steel trays by spreading the slices as a single layer and experiments were conducted at 68 °C air temperature and at a constant air flow velocity of 0.7 m/s until it attained moisture content up to 6-7% (w.b). For each treatment about 4.8 kg of tomato slices were dried. Weight losses (thus moisture content) of sample during drying process was determined after each one hour interval and continued until no further weight changes were observed. After cooling at room temperature, the dried tomato flakes were grinded by using electrical mixer to produce tomato powder. The tomato powder was then packed in polyethylene bags for further investigation or proximate analysis. The powder obtained was stored in airtight plastic containers. Later, the powder was used for analysing the Lycopene content, rehydration ratio, vitamin-C, pH, ash content and dehydration ratio.

Estimation of moisture content: The moisture content was determined by hot air oven method. Ten grams of sample was accurately weighed into dried moisture boxes and placed in an oven at 105 °C for 1 h. After drying, the samples were removed from the oven and placed in desiccators to cool for about 30 minutes and then reweighed. The weights were measured on electronic digital weighing machine having an accuracy of 0.01g. The process of evaporation, cooling, and weighing process was repeated until constant weight was found. From the initial and the final moisture box weights, the moisture content of samples were determined and expressed in % (w.b) by using the following formula.

$$\% \text{ of moisture content} = \frac{w3 - w2}{w2 - w1} \times 100$$

Where, W_1= weight of empty box (g), W_2= weight of moist sample + weight of box (g), and W_3= weight of bone dried sample + weight of box (g).

Lycopene content of tomatoes: Sample of 5 g of tomato powder was taken and was extracted repeatedly with acetone using pestle and mortar until the residue is colourless. The acetone extracts were pooled and transferred to a separating funnel containing about 20 ml of petroleum ether and gently mixed. About 20 ml of 5% sodium sulphate solution was added and the separating funnel was shaked gently then the petroleum ether extracts were pooled and washed once with little distilled water. The washed petroleum ether extracts containing carotenoids were poured into a brown bottle containing cotton wool. Sodium sulphate slurry was washed with petroleum ether until it was colourless and transferred the washings to the volumetric flask. The volume was made up and measured the absorbance in a spectrophotometer at 503 nm using petroleum ether as blank.

$$\text{mg of Lycopene in 100 g sample} = \frac{31.206 \times 3.1206 \text{ (µg lycopene/ml)}}{\text{Weight of sample (g)}} \times 100$$

Total ash: Sample of 5 g was weighed in a previously cleaned and dried weighed crucible and then it was completely charred until it appeared in grayish-white. Thereafter, it was kept in a muffle furnace at 600 °C for 3h. Thereafter, it was removed from furnace and cooled in desiccators and weighed. The complete ashing was ensured again, when heated in a muffle furnace for 1 h. This was removed from the furnace and cooled in desiccators and weighed again. The total ash was calculated by using the following formula.

$$\text{Total ash} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Sample weight}} * 100$$

Dehydration ratio: Dehydration ratio was calculated as mass of sliced tomato before loading to the drier to mass of dehydrated material at the time of removal from drier.

$$\text{Dehydration ratio} = \frac{\text{Weight of moist tomato slices}}{\text{Weight of dried tomato slices}}$$

Determination of rehydration ratio: Sample of 5 g was taken and transferred into beaker. Distilled water of 100 ml was added to it and boiled for two hours. Thereafter, it was filtered using filter paper and the remaining water was drained and rehydrated sample were collected in crucibles. Finally, the sample was weighed and the ratio between two samples gave the rehydration ratio.

$$\text{Rehydration ratio} = \frac{\text{Rehydrated weight of sample}}{\text{Initial weight of sample}}$$

Vitamin-C: First of all 5 ml of the working standard solution was taken with pipette and transferred to a 100 ml conical flask, where 10 ml of 4% oxalic acid was added and titrated against the dye (V_1 ml). The appearance of pink colour, which persists for a few minutes, was the end point. The amount of the dye consumed was equivalent to the amount of vitamin-C. The sample (0.5-5 mg depending on the sample) in 4% oxalic acid was extracted and make up to a known volume (100 ml) and centrifuge. 5 ml of this supernatant was pipette out followed by addition of 10 ml of 4% oxalic acid and was titrated against the dye (V_2 ml).

$$\text{Amount of vitamin-C, mg/100g samples} = \frac{0.5 \text{ mg}}{V1} \times \frac{V2}{5 \text{ ml}} \times \frac{\text{Volume made}}{\text{Weight of sample}} \times 100$$

pH: pH measurement was performed using a digital pH meter using a glass electrode. The electrode was placed inside the homogenized sample of tomato powder and the value was registered once it had stabilized.

RESULTS AND DISCUSSION

Moisture content: The initial moisture content of tomato slices was 94.03% on wet basis which has been decreased to 7.13%, (w.b) with Potassium Meta-bisulphite (KMS) concentrations of 0.2g/100g, in a total drying period of 12 h (Table 1). The initial moisture content of tomato slices was 93.64% (w.b) and decreased to 7.52% (w.b) with *Calcium chloride* ($CaCl_2$) concentrations of 1.0g/100g. The initial moisture content of tomato slices was 95.92% (w.b) with KMS+$CaCl_2$. The moisture content of tomato slice was decreased from 95.92% to 6.92%, 6.29%, and 6.58% (w.b) with KMS+$CaCl_2$ concentrations of 0.1+0.5g/100g, 0.2+1.0g/100g, and 0.3+1.5g/100g, respectively in a total drying period of 12 h. From Table 1, it is observed that the moisture content of slices decreases with increase of drying time and the moisture content attained a steady percentage from 11th hour. The initial moisture content of controlled sample of tomato slices was 94.52% (w.b) and decreased from 94.52 to 7.56% in a total drying period of 12 h. The moisture content of controlled sample slices decreases with increase of drying time. The moisture content of this controlled sample attained a steady percentage from 11th hour.

Effect of different concentrations of KMS, $CaCl_2$ and combination of both of tomato powder: Lycopene content of tomato powder was highest i.e. about 95 mg/100g at 0.2+1.0g/100g concentration of KMS+$CaCl_2$, whereas the controlled tomato sample showed the Lycopene content of about 89 mg/100g. The foods with highest Lycopene content helps in preventing age related diseases. The ash content, which represents mineral content in tomato powder, was highest i.e. 4.68% with the controlled sample and was second highest of 4.56% at 0.5g/100g of $CaCl_2$ concentration. Generally, the ash content of less than 5% is desirable for most food products. It is observed from the Table 2 that, all KMS, $CaCl_2$, KMS+$CaCl_2$ and control samples showed the ash content less than 5%. Dehydration ratio of controlled tomato sample showed a highest value of 19.18% as compared to different concentrations of KMS, $CaCl_2$, KMS+$CaCl_2$ samples. In contrast to Dehydration ratio, the Rehydration ratio of controlled tomato sample showed a lowest value of 3.64% as compared to different concentrations of KMS, $CaCl_2$, KMS+$CaCl_2$ samples. Vitamin-C content of tomato powder was highest i.e. about 34.20 mg/100g at 0.2+1.0g/100g concentration of KMS+$CaCl_2$, whereas the controlled tomato sample showed the Vitamin-C content of about 29.52 mg/100g. pH of controlled tomato sample showed a highest value of 3.97 as compared to different concentrations of KMS, $CaCl_2$, KMS+$CaCl_2$ samples. All samples showed a pH of less than 4, which indicates that acidic nature of product. The controlled sample showed a high acidic nature. Percentage recovery of tomato powder was highest i.e. about 4.77% at 1.0g/100g concentration of $CaCl_2$, whereas the controlled tomato sample showed the Percentage recovery of about 3.85%.

Table 1. Effect of different concentrations of KMS, $CaCl_2$ and KMS+$CaCl_2$ of tomato powder along with control conditions

Time (Hour)	KMS			$CaCl_2$			KMS+$CaCl_2$			Control
	0.1	0.2	0.3	0.5	1	1.5	0.1+0.5	0.2+1.0	0.3+1.5	
1	94.03	94.03	94.03	93.64	93.64	93.64	95.92	95.92	95.92	94.52
12	7.9	7.13	7.8	9	7.52	9	6.92	6.29	6.58	7.56

Table 2. Effect of different concentrations of KMS, $CaCl_2$ and KMS+$CaCl_2$ of tomato powder

Sample	KMS			$CaCl_2$			KMS+$CaCl_2$			Control
	0.1	0.2	0.3	0.5	1	1.5	0.1+0.5	0.2+1.0	0.3+1.5	
Lycopene (mg/100 gm)	90.25	93.15	91.46	88.18	91.27	89.13	93.24	95.01	94.32	89
Ash content (%)	4.18	3.96	4.06	4.56	4.02	4.34	3.97	3.21	3.76	4.68
Dehydration ratio	18.01	17.24	17.97	17.65	16.41	17.38	17.68	14.67	15.41	19.18
Rehydration ratio	3.98	4.62	4.34	3.96	4.32	4.15	4.46	4.91	4.62	3.64
pH	3.819	3.897	3.841	3.917	3.852	3.944	3.86	3.801	3.821	3.969
% Recovery	3.21	3.41	3.15	4.33	4.77	4.46	3.72	4.25	3.84	3.85
Vitamin C	31	33.32	32.26	30.12	32.76	31.42	31.53	34.2	32.26	29.52

CONCLUSION

The moisture content of controlled tomato sample, different concentrations of KMS, $CaCl_2$ and combination of KMS+$CaCl_2$ samples decreases with the increase of drying time from one to tenth hour. At 11 hr, the moisture content attained a steady state. Lycopene content and vitamin-C of tomato powder were maximum at 0.2+1.0g/100g concentration of KMS+$CaCl_2$. Ash content and dehydration ratio of controlled tomato sample showed highest values as compared to different concentrations of KMS, $CaCl_2$, KMS+$CaCl_2$ samples. In contrast to dehydration ratio, the rehydration ratio of controlled tomato sample showed a lowest value. All samples showed a pH of less than 4 and controlled sample indicated a high acidic nature. Percentage recovery of tomato powder was highest i.e. at 1.0g/100g concentration of $CaCl_2$. It was finally concluded that overall quality of tomato powder was good in combination of KMS+$CaCl_2$ at 0.2/100g as compared to KMS and $CaCl_2$.

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Detection of Components of Genetic Variation in Triple Test Cross Families in Bread Wheat

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Abstract: Forty-eight progeny families were produced by crossing 16 wheat varieties with three male testers (WH 1105, WH 283 and their F_1) in a triple test cross fashion to detect epistasis and estimate additive and dominance components of genetic variation. Epistasis was present for all the seven metric traits in both environments. Testers were also found to be adequate for all the traits. Though both the additive (D) and dominance (H) components were significant for all the traits in both the environments (except dominance component for 1000-grain weight (g) in both the environments) the D component was relatively more important in all the cases. Hence, high estimates of additive component and larger mean squares due to i type epistasis for yield and its component traits further indicated that such characters can be improved by using simple selection procedures. However, homozygous genomic heterosis which contributes towards non-additive genetic variation which is fixable, can be increased through alien gene transfer for increasing and stabilizing yield potential in wheat.

Key Words*:* Additive, Bread wheat, Dominance, Epistasis, Genetic variation, Triple test cross

For detection and estimation of components of genetic variation, a number of experimental designs are available. Among all, the triplet test cross method as described by Singh and Pawar (2005) is the best procedure for the unambiguous detection of epistasis and unbiased estimation of additive and dominance components if epistasis is absent (Viana, 2005; Roy, 2000). If epistasis is present in the material investigated, one can obtain better estimates of additive and dominance components by this method as compared to other method (Chahal and Singh, 1974; Pooni *et al.*, 1978). Additionally, this method is independent of allelic frequencies, gene correlation and mating system and requires relatively less experimental efforts. Further, in addition to practical role played by gene action in phenomenally increasing maize production in USA in the early 1950s, the relative role of additive and dominance components has helped in providing proof for the genetic basis of heterosis (Jinks and Pooni *et al.,* 1986). Further, they have clearly demonstrated that accumulation of dominant favourable genes dispersed in the two parents and not the overdominance was mainly responsible for positive heterosis in F_1 for plant height in *Nicotiana rustica*. Similar results have been found in maize also (Sprague, 1983). The present study aims to detect epistasis alongwith unbiased estimation of additive and dominance components of variation under different dates of sowing for seven metric traits in bread wheat.

MATERIAL AND METHODS

The material for the present study consisted of 48 triple test cross families and 16 homozygous varieties/lines of bread wheat (*Triticum aestivum* L. em Thell) namely DPW 621-50, HD 2967, Tobari, WH 1080, DBW 17, PBW 550, Aus 15854, WH 1021, WH 542, Veery's, WH 730, Raj 3765, Raj MR-1, WH 595, WH 147 and WH 711. These varieties/lines were randomly chosen from the wheat germplasm collection maintained by the Department of Genetics & Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University, Hisar. Of these, two agronomically superior varieties, namely, WH 1105 and WH 283 (which differed phenotypically for most of traits) and their F_1 (WH 1105/ WH 283) were crossed as male testers (L_1, L_2 and L_3 respectively) to each of the remaining 16 varieties/lines in a triple test cross fashion. The forty eight families thus produced alongwith the 16 parents were raised during 2013-14 in a randomized block design with three replications in two environments (timely sown and late sown) with the respective date of sowings 15-11-2013 and 16-12-2013. Each progeny family was sown in 2.5 long paired row plots with row- to- row distance of 20 cm and plant-to- plant distance of 10 cm. Observations were recorded on five randomly chosen plants in each row for seven metric traits namely days to heading, plant height (cm), tiller no per plant, grains per ear, 1000-grain weight (g), biological yield per plant (g) and grain yield per plant (g). Observations were subjected to statistical analysis as described by Singh and Pawar (2005).

RESULTS AND DISCUSSION

The progeny families differed significantly for all the seven metric traits in both the environments indicating that

there was enough genetic variability present in the material under investigation.

Epistasis and adequacy of testers: Two tests $?_{1i} + ?_{2i} - 2?_{3i}$ and $?_{1i} + ?_{2i} - P_i$ were applied simultaneously to determine whether the failure of the simple additive-dominance model was because of the presence of epistasis or attributed to the inadequacy of the testers. The presence of epistasis in all the traits in both the environments (timely sown, E1 and late sown, E2) indicated an important role played by epistasis in the control of these traits and in all these cases epistasis is expected to cause bias in the estimate of additive and dominance components (Table 1). Several other investigators (Noori and Sokhansanj, 2004; Zafar *et al*., 2008; El-Nahas (2015) and Dawwam *et al*., 2015) also found epistasis as an important element for several wheat traits. The partitioning of epistasis into 'i' type epistasis and 'j' and 'l' type epistasis indicated that 'i' type epistasis was significant for all the traits i.e. days to heading, plant height (cm), tiller number per plant, grains per ear, 1000-grain weight (g), biological yield per plant (g) and grain yield per plant (g) while 'j' and 'l' type epistasis was found to be non-significant for 1000-grain weight and grain yield per plant (g) in both the environments. Therefore, out of total seven cases, 'i' type epistasis was significant in all the cases in both the environments and 'j' and 'l' type epistasis were significant for days to heading, plant height (cm), tillers number per plant, grains per ear, biological yield per plant (g) and grains yield per plant (g). Thus, epistasis in the present material may be mainly attributed to the presence of fixable component in all the traits and unfixable component in 5 out of 7 traits. The fixable component of genetic variation (additive genetic component and 'i' type epistasis) can easily be exploited in a highly self-fertilized crop like wheat. The mean squares due to adequacy of testers as well as epistasis were significant for all the traits in both the environment (Table 2). Therefore, no trend could be detected about the adequacy of testers as epistasis was present in all cases. However, testers seemed to be the two phenotypic extremes for yield and its component traits. Similar results were mentioned by Noori and Sokhansanj, 2004 in their study related to salinity tolerance in wheat crosses.

Additive and dominance components and their interaction with environments: The significant values of the item sums and differences for all the seven metric traits in both sowings indicate that both the additive and dominance gene effects played a significant role in controlling these characters in the present material (Table 3 to 5). Similar results were obtained by Sarmah and Pawar (2000) for tiller number per ear, grains per ear, total biomass per plant (g) and grain yield per plant (g), by Noori and Sokhansanj, 2004 for grains per ear in saline condition and final plant height (cm) in control condition, by El-Nahas (2015) for heading date (days), plant height (cm), no. of spikes per plant, spike length (cm), spike yield (g) and 1000-kernels weight (g). Days to heading, plant height (cm), tiller number per plant, grains per ear, biological yield per plant (g) and grain yield per plant

Table 1. Mean squares for the test of epistasis for seven metric traits of wheat triple test cross families grown in different environments, Environment 1 (timely sown) and Environment 2 (late sown)

Source	Environment	d.f.	Days to heading	Plant height (cm)	Tiller number per plant	Grains per ear	1000-grain weight (g)	Biological yield per plant (g)	Grain yield per plant (g)
Epistasis	1	16	29.11**	59.80**	24.44**	118.04**	123.90**	224.96**	81.80**
	2	16	22.26**	37.26**	23.50**	63.42**	118.26**	99.23**	58.62**
'i' type	1	1	379.51*	81.72**	143.92**	185.05**	67.08**	383.56**	96.60**
	2	1	255.36*	78.36**	119.00**	147.27**	39.54**	344.83**	88.89**
'j' and 'l' type	1	15	267.17**	60.29**	73.81**	95.03**	33.35	336.39*	89.83
	2	15	249.66**	47.66**	63.53**	81.59**	27.71	235.68*	74.55
Replicate error	1	32	10.73	17.12	7.91	34.26	33.21	81.88	26.18
	2	32	6.58	12.58	3.49	19.78	22.81	32.06	13.40
'i' type x replication	1	2	15.12**	28.53	20.71	36.18	18.02	92.86	13.99
	2	2	13.32**	22.32	19.53	22.36	11.84	85.32	12.97
'j' and 'l' type x	1	30	14.77**	21.03	11.06	11.83	17.69	19.48**	14.00
	2	30	9.34**	13.34	9.55	7.94	15.17	11.28**	13.43
Within family error	1	576	3.14	12.25	15.37	9.83	17.54	9.05	13.26
	2	576	2.23	8.93	13.54	6.09	14.92	5.10	12.06

*, ** Significant at 5% (p = 0.005) and 1% (p = 0.001) level, respectively.
Where, i = additive type of epistasis, j and l = non-additive type of epistasis

Table 2. Mean squares for the adequacy of testers for seven metric traits of wheat triple test cross families grown in different environments, Environment 1 (timely sown) and Environment 2 (late sown)

Source	Environment	d.f.	Days to heading	Plant height (cm)	Tiller number	Grains per ear	1000-grain weight (g)	Biological yield per	Grain yield per plant
Families ($\bar{L}_{1i} + \bar{L}_{2i} - \bar{P}_i$)	1	15	59.62**	53.32**	79.25**	252.42**	98.32**	1206.79**	256.79**
	2	15	34.15*	39.15*	32.13**	172.02**	89.10*	628.89**	56.80*
Families ($\bar{L}_{1i} + \bar{L}_{2i} - \bar{P}_i$) x replications	1	30	21.69**	18.27**	17.16**	79.03**	44.93**	362.02**	41.24**
	2	30	15.46**	15.46**	8.34**	63.42**	41.22**	131.87**	23.14**
Within family error	1	576	4.23	5.56	4.28	22.48	23.01	85.32	12.22
	2	576	3.45	3.45	3.49	21.01	16.05	72.30	8.96

*, ** Significant at 5% (p = 0.005) and 1% (p = 0.001) level, respectively

Table 3. Mean squares for sum ($\bar{L}_{1i} + \bar{L}_{2i} + \bar{L}_{3i}$) for seven metric traits of wheat triple test cross families grown in different environments, Environment 1 (timely sown) and Environment 2 (late sown)

Source	Environment	d.f.	Days to heading	Plant height (cm)	Tiller number per plant	Grains per ear	1000-grain weight (g)	Biological yield per plant (g)	Grain yield per plant (g)
Replication	1	2	19.58	30.48	162.11	1241.33	126.44	2332.01	335.02
	2	2	12.17	12.17	33.29	200.60	111.56	415.98	92.92
Sums ($\bar{L}_{1i} + \bar{L}_{2i} + \bar{L}_{3i}$)	1	15	69.02**	110.87**	66.47**	505.96**	88.48*	2259.53**	427.67**
	2	15	43.28**	69.02**	45.66**	181.69**	38.29**	1110.05**	130.89**
Sums x Replications	1	30	23.56**	38.28**	21.73**	143.83**	34.92**	427.50**	94.98**
	2	30	12.63**	23.56**	9.29**	57.05**	14.49**	154.34**	27.06**
Within family error	1	576	10.14	9.25	5.37	25.83	17.16	58.05	13.26
	2	576	3.93	3.96	3.54	20.09	11.30	37.03	9.06

*, ** Significant at 5% (p = 0.005) and 1% (p = 0.001) level, respectively

Table 4. Mean squares for sums ($\bar{L}_{1i} + \bar{L}_{2i}$) for seven metric traits of wheat triple test cross families grown in different environments, Environment 1 (timely sown) and Environment 2 (late sown)

Source	Environment	d.f.	Days to heading	Plant height (cm)	Tiller number per plant	Grains per ear	1000-grain weight (g)	Biological yield per plant (g)	Grain yield per plant (g)
Replication	1	2	11.72	11.58	48.37	149.31	27.79	925.96	133.07
	2	2	3.38	3.38	14.45	82.97	24.22	242.52	69.67
Sums ($\bar{L}_{1i} + \bar{L}_{2i}$)	1	15	62.95**	86.21**	59.01**	211.72**	69.74**	1683.88**	342.87**
	2	15	37.60**	44.60**	37.19**	110.11**	41.33**	764.56**	153.44**
Sums x Replications	1	30	19.40**	14.48**	13.17**	29.86**	22.10**	91.40**	54.26**
	2	30	9.00**	10.00**	8.04**	17.76**	13.55**	64.39**	20.41**
Within family	1	384	9.16	5.74	4.51	14.60	12.21	10.74	12.43
	2	384	3.70	3.70	3.72	11.84	7.26	8.48	9.07

*, ** Significant at 5% (p = 0.005) and 1% (p = 0.001) level, respectively

(g) in both sowings were governed by all the three kinds of gene effects (additive gene effect, dominance gene effect and epistatic gene effect) whereas 1000 grain weight (g) (in timely sown) is governed by additive and epistatic effects. However, in all the seven cases in both sowings for which there was evidence of epistasis, the estimates of additive and dominance components of variation were biased to an unknown extent due to the presence of epistasis.

The estimates of D component and H components varied greatly for all the seven metric traits in both the environments. The values of the degree of dominance obtained for the two sowings for all the characters studies

were quite comparable except for 1000 grain weight (g), biological yield per plant (g) and grain yield per plant (g). For both sowings i.e. timely sown and late sown, the degrees of dominance values obtained by two methods (using D values obtained through the $L_{1i} + L_{2i} + L_{3i}$ and $L_{1i} + L_{2i}$ analysis) were also comparable except for 1000- grain weight (g) (Table 6).

The low degree of dominance for 1000-grain weight (g), biological yield per plant (g) and grain yield per plant (g) indicated a considerably higher role played by the additive gene effects in the control of these characters than the dominance gene effects.

In the present study, the additive components of genetic variation were found to be more important in both environments for all the traits. Further, epistasis was an important element for all the traits. The dominance component was also significant for all the traits in both the environments except for 1000-grain weight (g). However, the estimates of the D component were greater than those of H component indicating greater role of additive component of genetic variation in the control of all the seven characters. Similar results have also been reported by several other workers (Sarmah and Pawar, 2000 and others). Conventional pedigree selection procedures or its suitable modifications will be effective as there is presence of fixable (additive and additive x additive) component of genetic variation to an appreciable extent (Table 6). However in addition to above approach, one or more cycles of selective intermating inbetween selfing series and subsequent simple selection for reduced compensation effects among main component traits would also prove more effective as it can minimize adverse effect of successive selfing i.e. fixation of linkage blocks in conventional pedigree selection (Singh and Pawar, 2006). Further, dominance component of genetic variation in wheat is of two types i.e. inter-genome

Table 6. Estimates of additive (D), dominance (H) components and degree of dominance for seven metric traits of wheat triple test cross families grown in different environments, Environment 1 (timely sown) and Environment 2 (late sown)

Components	Environment	Days to heading	Plant height (cm)	Tiller number per plant	Grains per ear	1000-grain weight (g)	Biological yield per plant (g)	Grain yield per plant (g)
D($\bar{L}_{1i} + \bar{L}_{2i} + \bar{L}_{3i}$)	1	20.20**	32.26**	19.88**	160.95**	23.80*	814.23**	147.86**
	2	13.62**	20.20**	16.16**	55.39**	10.57	486.98**	46.15**
D ($\bar{L}_{1i} + \bar{L}_{2i}$)	1	19.35**	31.88**	20.37**	80.83**	21.17**	1061.65**	192.40**
	2	12.70**	15.37**	12.96**	41.04*	12.35**	311.18**	88.69**
H ($\bar{L}_{1i} - \bar{L}_{2i}$)	1	13.60*	34.12**	21.07**	63.29**	2.48	101.57*	36.76**
	2	12.88*	12.88**	13.06**	27.20**	3.54	32.33*	23.98**
$(H/D)^{1/2}$ ($\bar{L}_{1i} + \bar{L}_{2i} + \bar{L}_{3i}$)	1	0.82	1.03	1.03	0.63	0.32	0.35	0.50
	2	1.04	0.80	1.01	0.88	0.32	0.31	0.44
$(H/D)^{1/2}$ ($\bar{L}_{1i}$ +)	1	0.84	1.03	0.89	0.70	0.76	0.25	0.72
	2	1.00	0.91	1.00	0.81	0.53	0.32	0.52

*, ** Significant at 5% (p = 0.005) and 1% (p = 0.001) level, respectively

Table 5. Mean squares for difference ($\bar{L}_{1i} - \bar{L}_{2i}$) for seven metric traits of wheat triple test cross families grown in two environments, Environment 1 (timely sown) and Environment 2 (late sown)

Source	Environment	d.f.	Days to heading	Plant height (cm)	Tiller number per plant	Grains per ear	1000-grain weight (g)	Biological yield per plant (g)	Grain yield per plant (g)
Replication	1	2	81.58	154.74	121.09	429.84	94.78	642.76	324.66
	2	2	59.52	119.52	44.72	237.051	56.24	564.76	111.50
Differences ($\bar{L}_{1i} - \bar{L}_{2i}$)	1	15	39.97*	76.48**	44.52**	139.48**	53.45	286.98*	79.35**
	2	15	34.15*	34.15**	28.29**	96.66**	23.84	145.10*	55.90**
Difference x Replications	1	30	19.56**	25.30**	12.94**	44.54**	49.72**	134.93*	24.21**
	2	30	14.83**	14.83**	8.71**	35.46**	18.52**	96.59**	19.92**
Within family error	1	384	6.16	5.74	4.51	20.60	22.21	76.74	12.43
	2	384	2.70	3.70	3.72	19.84	9.02	54.47	9.07

dominance variation and intra-genome dominance variation. Inter-genome dominance component is as good as additive component, is exploitable by developing pureline wheat varieties. However, intra-genome dominance component can be exploited only by developing hybrid varieties. Since, the development of hybrid wheat varieties has not been successful at commercial scale, best way to increase magnitude of dominance variation in wheat is to increase magnitude of homozygous genomic heterosis i.e. inter-genome heterozygousity which is non-additive genetic variance but this is fixable, therefore, can be easily exploited. It helps in increasing and stabilizing yield potential in wheat.

Hence, one way is to increase extent of homozygous genomic heterosis by transferring alien genes from wild relatives (*Secale cereale, Triticum tauschii, Agropyron elongatum,* etc.).

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Multivariate Analysis of Genetic Diversity Using Agro-morphological and Quality Traits in Different Accessions of Aromatic Rice (*Oryza sativa* L.)

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***Abstract*:** The present study was undertaken with an objective to identify principal discriminatory traits, and to estimate the extent of genetic diversity for their utilization in crop improvement. A total of 100 aromatic rice accessions including five checks were evaluated for 20 traits using Augmented Design. The first six principal components explained about 80.41 % of the total variation. The PC1 showed 38 %, while PC2, PC3, PC4, PC5 and PC6 exhibited 14.42, 8.21, 7.64, 6.46 and 5.69 % variability, respectively. Results of PCA revealed that the traits such as panicle length, plant height, number of filled spikelets per panicle, grain (length and breadth), kernel (length and breadth), kernel length after cooking and kernel elongation ratio were the principal discriminatory traits. Seven clusters including three monogenics were obtained based on UPGMA cluster analysis. The pattern of group constellation proved the existence of significant amount of variability. Genotypes Bas Sufaid 187, Nagra and PKV-HMT hold great promise as a parent to obtain a promising high heterotic response. The aromatic rice accessions showed considerable variability for most of the traits observed, which can be exploited in crop improvement programmes.

Key Words: Aromatic rice, Cluster analysis, Genetic diversity, PCA, Quality traits

Rice (*Oryza sativa* L.), the second most widely grown cereal crop provides the staple diet for more than half of the world's population especially for people in Asian countries (Wu *et al.*, 2013). There are several defined classes of rice, based on the physical appearance of milled rice, the cooking properties and the aroma of rice. Aroma in rice considered one of the most important grain quality traits, as it is a key factor in determining market price and related to both local and national identity. Assessment of genetic diversity is an integral part of crop improvement as exploitation of genetic diversity helps the plant breeder to develop new varieties. Although rice germplasm evaluation and diversity analysis has been done by several workers, limited information is available on the aromatic rice, particularly land races of basmati and non-basmati types. Many studies on genetic diversity using agro-morphological traits have been conducted to enable the pattern of variation of landraces of rice, and to identify major traits contributing to the diversity of landraces (Sinha and Mishra, 2013; Sarawgi *et al*., 2014; Sharma *et al*., 2014).

Multivariate statistical techniques which simultaneously analyze multiple measurements on each individual under investigation have found extensive use in summarizing and describing the inherent variation among crop genotypes irrespective of whether it is morphological, biochemical or molecular marker-based, and subsequently classification of germplasm collections. Among the multivariate techniques, Principal Component Analysis (PCA) is a powerful tool that characterizes the distinctness among selected genotypes (Chakravorty *et al*., 2013). It reduces the dimensionality of the data while retaining most of the variation in the data set. PCA accomplishes this reduction by identifying directions, called principal components (PCs), along which the variation in the data is maximal (Maji and Shaibu, 2012). The cluster analysis, another multivariate statistical tool is an appropriate method for determining family relationships. Various algorithms have been used in studying of genetic diversity in cluster analysis of which, UPGMA and Ward's methods are the most popular approaches. Of the algorithms, UPGMA applied for cluster analysis and exploring genetic diversity and grouping of genotypes (Mohammadi and Prasanna, 2003).

Keeping in view the importance of aforesaid aspects, the present investigation was carried out to identify the principal discriminatory traits, and to estimate the extent of genetic diversity in order to contribute to a greater understanding of the diversity for their utilization in crop improvement by taking into account several characteristics.

MATERIAL AND METHODS

The experiment was carried out at Research cum Instructional Farm, Department of Genetics and Plant Breeding, College of Agriculture**,** Indira Gandhi Agricultural University, Raipur (Chhattisgarh), India. The experimental

materials comprised 100 aromatic rice accessions including five checks *viz*., Tarori Basmati, Pusa Basmati 1, Pusa Basmati 1121, Sugandhamati and Badshahbhog (Table 1). Nurseries were raised by taking seeds from single panicle in a single row for each accession. Twenty-one day's old seedlings were subsequently transplanted into the field using Augmented Design in *Kharif* 2014. The experimental material was transplanted in five blocks and each block comprised twenty-four genotypes. Each entry was transplanted in four rows of 2m length at a spacing of 20 cm between rows and 15 cm between plants. The checks varieties were randomized within a block. Gap filling was done within a week in order to maintain uniform plant population. The standard agronomic practices were adopted for normal crop growth.

Variables considered in the descriptive and multivariate analyses were phonological *viz*., days to 50% flowering (DTF); agro-morphological *viz*., panicle length (PL), plant height (PH), effective tillers per plant (ET), number of spikelets per panicle (NOS), number of filled spikelets per panicle (NOFS), spikelet fertility per cent (SFP), 1000 grain weight (TGW), grain yield per plant (GYPP); and grain quality traits *viz.*, grain length (GL), grain breadth (GB), hulling % (H %), milling % (M %), head rice recovery % (HRR %), kernel length (KL), kernel breadth (KB), kernel length breadth ratio (KLBR), kernel length after cooking (KLAC), kernel breadth after cooking (KBAC) and kernel elongation ratio (KER). Single plant observations for both yield and quality traits were recorded on five randomly selected plants from the central row for each accession except days to 50 % flowering, where observations were recorded on a plot basis. Grain and raw kernel dimension were measured using grain shape tester, whereas cooked kernel dimension and kernel elongation were measured on graph paper. Hulling % and milling % was recorded using SATAKE laboratory Sheller. The observations recorded were statistically analyzed using XLSTAT 2014 software. In order to identify the patterns of morphological variation, Principal Component Analysis (PCA) was performed. Cluster analysis was carried out based on genetic distance matrix applying the UPGMA (Unweighted Pair-Group Method with Arithmetic Mean) clustering method.

RESULTS AND DISCUSSION

Principal component analysis (PCA): The result of PCA explained the genetic diversity of the aromatic rice accessions. In the present investigation, PCA was performed for twenty agro-morphological and quality traits in aromatic rice accessions and presented in Table 2. As per the criteria set by Brejda *et al*. (2000), the PC with eigen values >1 and which explained at least 5 % of the variation in the data were considered. The PC with higher eigen values and variables, which had high factor loading were considered as best representative of system attributes. Out of twenty, only 6 principal components (PCs) exhibited more than 1 eigen value, and showed about 80.41 % cumulative variability among the traits studied. So, these six PCs were given due importance for further explanation. The PC1 showed 38 %, while PC2, PC3, PC4, PC5 and PC6 exhibited 14.42, 8.21, 7.64, 6.46 and 5.69 % variability, respectively among the accessions for the traits under study (Table 2). The first PC accounts for as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variability as possible.

Within each PC, only highly loaded factors or traits (having absolute values within 10% of the highest factor loading) were retained for further explanation. Rotated component matrix revealed that the PC1 which accounted for the highest variability (38 %) was mostly related with traits such as kernel length (0.90), grain length (0.88), and kernel length after cooking (0.83) (Table 2). The second principal component accounted for 14.42% of total variance. Variables highly and positively correlated with PC2 were grain breadth (0.94) and kernel breadth (0.92). As a result, the first two components differentiated rest of the accessions on the basis of grain dimension. The third principal component which accounted for 8.21% of the variability was highly loaded with two important yield contributing traits *viz.*, number of spikelets per panicle (0.94) and number of filled spikelets per panicle (0.91). The PC4 was positively more related with hulling per cent (0.95), milling per cent (0.94) and head rice recovery per cent (0.80), while PC5 was highly loaded with panicle length (0.90) and plant height (0.73). Thus, PC 4 differentiated those accessions that have high milling recovery. The PC6 which account for only 5.69 % variability was highly loaded with kernel elongation ratio (0.95) which is one of the most important cooking quality traits. From the first six PCs, it is clear that the PC1, PC2, PC4 and PC6 mostly related to quality characters, while PC3 and PC5 mostly associated with yield contributing traits.

The results of PCA revealed that traits such as panicle length, plant height, number of spikelets per panicle, number of filled spikelets per panicle, grain (length and breadth), hulling per cent, milling per cent, kernel (length and breadth), kernel length after cooking and kernel elongation ratio were the principal discriminatory characteristics. The prominent characters coming together in different principal components and contributing towards explaining the variability have the tendency to remain together, which may be kept into consideration during utilisation of these

Table 1. List of aromatic rice accessions and their grain type

Accessions Name	Grain type	Accessions Name	Grain type
Moongphali B	SB	IGSR- 2-1-46	SB
Dindli	MS	Dhan Prasad	MS
Maguraphula	SB	NDR 8497-2	LS
Jala	LS	PTB 13	SB
Basuabhava	SB	Basmati Kamon	ELS
Juhibengal- A	MS	Bas Sufaid 187	SB
Kapura Kranti	SB	Bas Surkh 112	SB
NDR IRRI 67	MS	Basmati 11	ELS
Neelabati	SB	Khaskani	MS
AS GPC -19	SB	Mohan Bhog	SB
Dhuba Mua	LS	Gayasu	MS
Dudh Nag	SS	Aypeyaung	MS
Ganjo	LS	Daw Leuang	MS
Raja Bhog	SS	Du Thom Thai Binh Hai Phong	SB
Loung Choosi B	SS	Hung-Mi-Hsiang-Ma-Tsan	MS
Bantha Phool A	SB	Longku Labat	MS
Champaran Basmati 1	LS	Niaw Hawn	SB
Champaran Basmati 2	LB	Padi Bawang	SB
Champaran Basmati 3	LB	Popot	SB
Govind Bhog	SB	Xiang Geng Li	LS
Kamini Joha	SB	Begami T1	MS
KDML 105	ELS	HBC 30	LS
CO ACC 167	SB	Kalimooch (Raipur)	MS
Pusa Sugandh- 2	LS	HKR 240 IET 12021	ELS
Bindli	SB	JJ 92	LS
Pant Sugandh - 15	ELS	Malagkit Sung Song	LS
Improved Sarbati	ELS	Sharbati	LS
Laldhan	ELS	Bahurupi	SB
Lal Basmati	ELS	Dudhsar	LB
Super Basmati	ELS	Nagra	SB
Kadam Phool	SB	Maccha Kanta	SS
Tulsi Manjari	SB	Hari Shankar	LB
Loktimachi	SB	Kusuma	LB
Dubraj	LS	Kerela Sundari	SB
Shital Bhog	ELS	PKV HMT	SS
Tedesi	ELS	Acharamati	SB
Domsiah	ELS	Bishnu Bhoga	SB
Basmati 564	ELS	Dahana Prasad	SS
Pusa Sugandh- 5	ELS	Jaipulla	MS
GR- 104	LS	Karpura Basa	MS
GAR-1	LS	Leela Bati	SB
GR- 6	LS	Muigai	SB
Basmati 370	ELS	UPR 3565-10-1-1	ELS
Vasumati	ELS	IET 21665	ELS
Bas Kamon	ELS	Bas 837	LS
Jasmine Scented	LS	Tarori Basmati (Check 1)	ELS
R- 1498-778-388-1-1	SB	Pusa Basmati- 1 (Check 2)	ELS
Kanak Jeera	SB	Pusa Basmati- 1121 (Check 3)	ELS
Dhaniya B	MS	Sugandhamati (Check 4)	ELS
Tarun Bhog	SB	Badshahbhog (Check 5)	SB

Abbreviation: ELS- Extra Long Slender, LS- Long Slender, LB- Long Bold, MS- Medium Slender, SB- Short Bold, SS- Short Slender

characters in breeding programme. Through PCA we could identify the number of plant characters, which are responsible for the observed genotypic variation within a group. Our results are in agreement with the findings of Ashfaq *et al.* (2012); Kumar *et al*. (2013); Sinha and Mishra (2013) and Nachimuthu *et al*. (2014). Chakravorty *et al*. (2013) identified six principal components with eigen value greater than 1.0 and that explained 75.9 % of the total cumulative variance within the axes further strengthen current results.

Cluster analysis: Analyses performed by the UPGMA using Euclidean distance as dissimilarity measure grouped 100 accessions into seven clusters (Fig. 1) at a normalized maximum distance of 0.6 with 34 accessions in cluster I, 33 in cluster II, 18 accessions in cluster III, 12 accessions in the cluster IV, whereas cluster V, VI and VII had only one accession each. The pattern of group constellation proved the existence of significant amount of variability. The cluster mean performances showed a wide range of variations for all the traits undertaken in the study (Table 3). Cluster I comprised 34 genotypes mainly attributing to grain length, kernel length and kernel length breadth ratio. Cluster II comprised 33 genotypes showing more panicle length. The genotype Bas Sufaid 187 forming a separate cluster V had maximum mean value for number of spikelet per panicle (269.60), number of filled spikelets per panicle (233.00), spikelet fertility per cent (86.42 %), 1000 grain weight (24.40 g), grain yield per plant (29.10 g), grain breadth (2.65 mm), kernel breadth (2.27 mm) and kernel elongation ratio (1.75). Genotype Nagra formed cluster VI with highest mean value for days to 50 % flowering (115 days), hulling per cent (85.33 %), milling per cent (78.15 %), head rice recovery per cent (74.62 %) and kernel breadth after cooking (2.95 mm). Cluster VII with single genotype PKV-HMT, had the highest value for effective tillers per plant (9.40). Thus, genotypes Bas Sufaid 187, Nagra and PKV-HMT hold great promise as a parent to obtain a promising high heterotic response. Visualizing the mean performances of individual clusters in identifying the parental lines based on trait studied, no single cluster may be suitable for all the traits. Since, selection and choice of parents mainly depend on the

Table 2. Eigen value, percentage of variability explained and factor loadings for the principal component axes

	1st	2nd	3rd	4th	5th	6th
	Principal Component (PC)					
Eigen value	7.60	2.88	1.64	1.53	1.29	1.14
Variability (%)	38.00	14.42	8.21	7.64	6.46	5.69
Cumulative (%)	38.00	52.42	60.63	68.27	74.73	80.41
Traits	Factor loadings after Varimax rotation					
Days to 50% flowering	-0.40	0.04	0.12	0.42	0.30	-0.32
Panicle length (cm)	0.03	-0.05	-0.06	-0.02	**0.90**	0.15
Plant height (cm)	-0.33	0.05	-0.02	0.30	**0.73**	-0.16
Effective tillers per plant	-0.10	-0.07	0.03	-0.03	0.08	0.06
Number of spikelets per panicle	-0.22	0.10	**0.94**	0.14	-0.04	-0.02
Number of filled spikelets per panicle	-0.20	0.17	**0.91**	0.14	-0.03	0.01
Spikelet fertility %	-0.04	0.24	0.24	0.11	0.03	0.03
1000 grain weight (g)	0.78	0.35	-0.03	-0.23	-0.06	-0.01
Grain yield per plant (g)	-0.15	0.09	0.03	0.10	-0.08	-0.15
Grain length (mm)	**0.88**	-0.20	-0.16	-0.25	-0.08	-0.02
Grain breadth (mm)	-0.01	**0.94**	0.01	-0.03	-0.02	0.01
Hulling %	-0.17	0.06	0.10	0.95	0.04	0.04
Milling %	-0.23	0.06	0.10	0.94	0.04	0.02
Head rice recovery %	-0.46	0.59	0.13	0.85	0.10	-0.13
Kernel length (mm)	**0.90**	-0.23	-0.19	-0.22	-0.06	-0.04
Kernel breadth (mm)	-0.19		0.08	0.10	-0.01	-0.04
Kernel length breadth ratio	0.76	-0.54	-0.17	-0.23	-0.05	0.01
Kernel length after cooking (mm)	**0.83**	-0.26	-0.18	-0.20	-0.03	0.34
Kernel breadth after cooking (mm)	-0.27	0.76	0.29	0.10	-0.01	-0.24
Kernel elongation ratio	0.04	-0.19	0.01	-0.01	0.07	**0.95**

Values in bold represent highly loaded factors in respective PC

Table 3. Cluster mean performances of seven clusters for 20 agro-morphological and quality traits based on UPGMA

No. of cluster	No. of accessions	Cluster mean performances for different traits																			
		DTF	PL	PH	ET	NOS	NOFS	SFP	TGW	GYPP	GL	GB	H %	M %	HRR	KL	KB	KLBR	KLAC	KBAC	KER
I	34	89.67	26.60	120.64	7.84	129.91	93.31	71.99	22.69	16.89	9.45	2.42	75.47	67.88	61.66	7.10	1.92	3.84	11.99	2.65	1.68
II	33	113.03	27.62	158.16	8.50	144.90	110.27	76.37	18.61	19.53	7.63	2.42	79.73	71.99	68.81	5.61	1.99	2.84	8.99	2.82	1.61
III	18	107.33	26.36	137.44	7.91	187.18	139.71	74.90	20.03	19.88	8.06	2.38	78.67	70.91	67.52	6.03	1.96	3.14	9.25	2.80	1.54
IV	12	108.67	26.53	145.49	8.00	225.93	187.45	83.37	19.40	19.24	6.99	2.58	79.58	72.18	69.18	4.97	2.17	2.32	8.35	3.18	1.67
V	1	81.00	20.87	106.12	7.00	269.60	233.00	86.42	24.40	29.10	7.12	2.65	76.23	68.66	57.43	5.24	2.27	2.31	9.16	3.26	1.75
VI	1	115.00	23.26	109.93	8.20	262.40	190.80	72.71	17.50	17.09	7.12	2.58	85.33	78.15	74.62	4.96	2.22	2.23	8.28	2.95	1.67
VII	1	105.00	20.85	91.75	9.40	202.80	162.00	79.88	21.80	18.25	7.88	2.18	73.58	66.07	61.87	5.08	1.67	3.04	8.65	2.62	1.70

contribution of characters towards divergence. Hence, accessions falling under distant clusters may be hybridized to get the higher heterotic responses. Chanbeni *et al*. (2012); Sanni *et al*. (2012); Shiva Prasad *et al*. (2013) and Kumar *et al*. (2014) also reported similar findings from cluster analysis of the rice germplasm for agro-morphological traits diversity. The accessions possessing extreme phenotype may also be utilized in the development of mapping population for identification of quantitative trait loci (Nachimuthu *et al*., 2014).

The generated information may be helpful in reducing the overall time required to screen large populations for potential breeding stock. The accessions with early flowering, longer panicle with more filled spikelets per panicle, higher 1000 grain weight, grain yield per plant and effective tillers per plant might be served as potential donors for increasing grain yield of predominant rice varieties. Similarly, accessions with longer and fine grain type along with high milling recovery might be used as potential donors for quality improvement of existing high yielding rice varieties. Based on cluster mean value, it would be possible to point out some potential combinations, subject to the condition that environment maintain the relative expression of characters with regards to genotypes. The potential combinations were found to be Bas sufaid 187 x Nagra, Bas sufaid 187 x PKV-HMT, Bindli x Nagra, Bindli x Huang-Mi-Hsiang-Ma-Tsan, Nagra x Popot, Nagra x AS GPC 19 and Kapoor Kranti x AS GPC 19. These combinations should result in higher number of useful segregants during the process of selection.

CONCLUSION

From this study, it may conclude that the aromatic rice accessions showed considerable variability for most of the traits observed. For each and every trait, these variations could be exploited in crop improvement programmes. The study also suggests direct selection of the traits like panicle length, number of spikelets per panicle, number of filled spikelets per panicle, spikelets fertility percent, 1000 grain weight, grain length, grain breadth, kernel length, kernel breadth, kernel length breadth ratio and kernel elongation ratio to achieve the desired improvement in yield and quality of rice. Multivariate clustering pattern could also suggest the breeder about the suitability of different accessions of aromatic rice as potential donors for future breeding programme.

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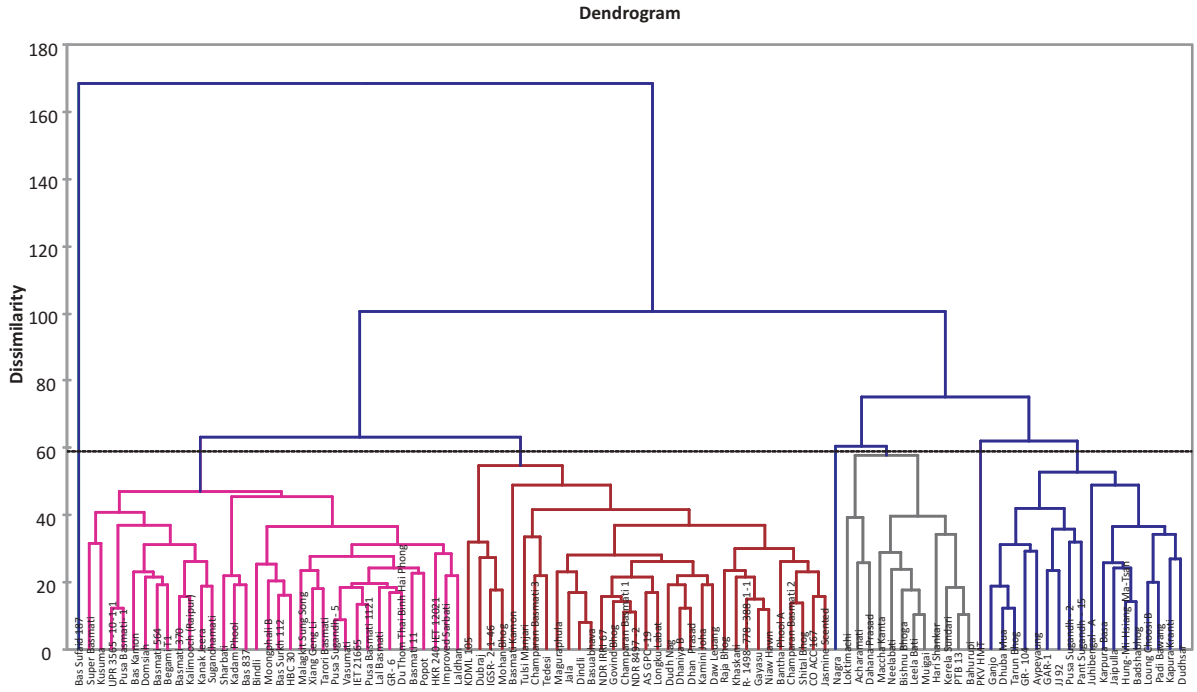

Fig. 1. Dendogram of 100 aromatic rice accessions derived by UPGMA based on Euclidean Distance from 20 agro-morphological and quality traits

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Genetic Analysis of Bacterial Wilt Resistant Genotypes of Tomato (*Solanum lycopersicum* L.) Under Organic and Inorganic Farming Conditions

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***Abstract*:** Nature of gene action for different traits of tomato were determined by analyzing one 8 × 8 half diallel under organic and inorganic farming conditions. Based on pooled over environments analysis, preponderance of non-additive gene action (^{2}D) was observed for the traits such as gross yield per plant, marketable yield per plant, pericarp thickness, total soluble solids, ascorbic acid and titrable acidity under organic conditions and gross yield per plant, marketable yield per plant, pericarp thickness, harvest duration, ascorbic acid and titrable acidity under inorganic conditions. Most of the traits,which had relatively higher estimates of additive genetic component (^{2}A) also revealed average degree of dominance values less than 1.00 (partial dominance) as per expectation. Remaining traits had higher values of non-additive (^{2}D) component of genetic variance which could be exploited through the development of hybrids.

***Key Words*:** Additive, Gene action, Inorganic, Organic, Non-additive Tomato (*Solanum lycopersicum* L.)

Tomato universally treated as “protective food” that contain adequate amounts of vitamins, minerals and which protect against development of a deficiency disease in human being. It is being extensively grown as annual plant all over the world. It is commonly consumed as fresh and as processed products such as juice, paste, puree, ketchup and sauce. It has high nutritional value; one medium fresh tomato (135g) provides 47% Recommended Dietary Allowance (RDA) of vitamin C, 22% RDA vitamin A and 25 calories (Chauhan *et al*., 2014). The pulp and juice are digestible, a promoter of gastric secretion and blood purifier (Chattopadhyay and Paul, 2012). Tomato plays an important role in the economy of the farmers of hill regions of our country. It is the most remunerative cash crop of mid hills of Himachal Pradesh. Production of tomato in the state has suffered a setback due to some biotic and abiotic stresses. Bacterial wilt of tomato incited by *Ralstonia solanacearum* is one of the most important and widespread diseases in tropical, sub-tropical and warm temperate regions of the world. In India, the pathogen can survive on 114 species of plants with or without symptoms. In Himachal Pradesh this disease is caused by race 1 biovar III of *R. solanacearum* and is restricted to mid-hill sub humid zone (Zone II) causing enormous losses (Kumar and Sood, 2002). It is difficult to control as commercial cultivars are highly susceptible to this disease and chemical control is not feasible. As such, genetic resistance in the cultivars is of practical significance and appears sustainable alternative for successful cultivation of tomato in wilt prone pockets. Therefore, an attempt has been made to use bacterial wilt resistance hybrids for the management of this disease. Hybrids are preferred over pure lines varieties in tomato on account of their superiority in marketable fruit yield, component traits and fruit quality (Kapur *et al*., 2013). The pace with which the F_1 hybrids of tomato are gaining popularity, it is demanding now to obtain such hybrids in public sector also, which have excellent quality and yield stability. Extensive pesticide use, especially in vegetable crops threatens the air, the water and the land on which human beings and animals depend for their food and habitat. Several studies showed that pesticides could cause health problem such as birth defects, nerve damage and cancer (Rekha *et al*., 2006). Organic, sustainable vegetable cultivation is a realistic and necessary alternative to these practices. Till date, no study has been taken up in Himachal Pradesh wherein the relative production potential of tomato hybrids has been quantified under organic and inorganic farming systems. Knowledge of genetic architecture of the characters under improvement is essential for adopting appropriate breeding procedure. Such knowledge leads the plant breeder to develop new commercial varieties of the crop. In a breeding programme, once the appropriate parents and potential crosses are identified, the next important step is to adopt a suitable breeding strategy for the purposeful management of generated variability which largely depends upon type of gene action in the population for the traits under genetic improvement. Diallel cross analysis provides the

estimates of genetic parameters regarding combining ability as well as a rapid overall picture of the dominance relationship of the parents studied using the first filial generations (F1) with or without reciprocals, Diallel analysis involving parents give the additional information as presence or absence of average degree of dominance, distribution of dominant and recessive genes in the parents (Renuka *et al*., 2015). The nature of gene action has been inferred from estimates of GCA and SCA variances. Application of diallel technique in a self-pollinated crop like tomato for this purpose may be appropriate. Hence, the present investigation was undertaken in 8 × 8 half cross set to gather genetic information on some of the important quantitative and qualitative traits and to suggest breeding approaches for developing specific genotypes suitable for cultivation under organic and inorganic conditions.

MATERIAL AND METHODS

The present investigation was carried out under organic (Department of Organic Agriculture) and inorganic (Department of Vegetable Science and Floriculture, CSKHPKV, Palampur) farming system during summer-rainy seasons of 2012 and 2013. Organic Farm and Vegetable Research Farm are located at 1.5 km away from each other. These farms are situated at 32°6' N latitude and 76°3' E longitude at an altitude of 1290.8 m above the mean sea level. The experimental material comprised 8 determinate and indeterminate genotypes *viz.,* CLN 2070, CLN 2123 A-1 red, Hawaii 7998, Palam Pride, 12-1, BWR-5, Arka Abha and Arka Meghali alongwith one standard check Avtar (7711) and their 28 F_1 hybrids developed by crossing them in a Diallel Matting Design Method 2 excluding reciprocals (Griffing, 1956). All the 37 genotypes (8 parental lines, their 28 F_1 hybrids and one standard check Avtar) were evaluated. The seedlings were transplanted in a randomized block design with three replications at the spacing of 75 cm between rows and 45 cm between plants. Thus, there were 7 plants in each entry per replication. Beginning with first row, either of the susceptible checks (Roma and Marglobe) were included at every 11th row alternatively to ensure the presence of uniform distribution of bacterial wilt disease inoculum in the experimental field. Recommended cultural practices and plant protection measures were followed (Anonymous, 2008). The data were recorded for the various traits on five randomly marked plants. The TSS values were expressed as per cent of juice (A.O.A.C., 1970). The ascorbic acid contents were estimated by 2, 6-Dichlorophenol Indophenol Visual Titration Method as described by Ranganna (1979).

RESULTS AND DISCUSSION

For bacterial wilt resistance, most of the cross combinations, their parents and the standard check were observed to be highly resistant (100% plant survival) on the basis of their mean performance under organic and inorganic conditions, therefore further investigation on gene action for plant survival or bacterial wilt resistance were not worked out. Under organic conditions, the estimates of $ó^2$SCA were higher than $ó^2$ GCA for the traits *viz*., gross yield per plant, marketable yield per plant, pericarp thickness, harvest duration, ascorbic acid and titrable acidity in all the environments, TSS in 2012 and pooled environment and marketable fruits per plant in 2012 and 2013 suggesting the

Table 1. Characteristics of the parents and checks involved in the study

Genotypes	Code No.	Sources	Growth habit	Bacterial wilt	Fruit shape, pedicel area and colour
CLN 2070	P_1	AVRDC/ CSK HPKV	Semi determinate	Resistant	Slightly flattened, medium, orange red colour
CLN 2123 A-1 (red)	P_2	AVRDC/CSK HPKV	Determinate	Resistant	Ovoid, shallow, deep red
Hawaii 7998	P_3	AVRDC/ CSKHPKV	Indeterminate	Resistant	Circular, shallow, red
Palam Pride	P_4	AVRDC/CSK HPKV	Indeterminate	Resistant	Heart shaped, shallow, red
12-1	P_5	CSKHPKV	Indeterminate	Resistant	Obovoid, shallow, red
BWR-5	P_6	IIHR/CSKHPKV	Determinate		Rectangular, deep, orange red
Arka Abha	P_7	IIHR	Semi-determinate	Moderate resistant	Flattened, medium, red
Arka Meghali	P_8	IIHR	Semi-determinate	Moderate susceptible	Flattened, medium, red
Standard check					
Avtar (7711)	SC	Nunhems	Indeterminate	Resistant	Obovoid, shallow, red
Susceptible check					
Roma		IARI/CSKHPKV	Determinate	Susceptible	Cylindrical, absent, red
Marglobe		IARI/CSKHPKV	Indeterminate	Susceptible	Round , medium, red

Table 2. Estimation of genetic components of variances and degree of dominance for different traits and pooled over environments under organic and inorganic conditions

Traits	Environments	Organic				Inorganic			
		$ó^2_{GCA}$	$ó^2_{SCA}= ó^2_D$	$ó^2_A=2\ ó^2_{GCA}$	Average degree of	$ó^2_{GCA}$	$ó^2_{SCA}= ó^2_D$	$ó^2_A=2\ ó^2_{GCA}$	Average degree of
Days to 50 per cent flowering	2012	3.36	2.66	6.71	0.63	2.68	2.44	5.36	0.67
	2013	2.43	1.26	4.86	0.51	1.45	0.76	2.91	0.51
	Pooled	6.07	1.91	12.14	0.40	3.23	1.70	6.46	0.51
Days to first harvest	2012	4.07	1.97	8.13	0.49	4.27	5.91	8.54	0.83
	2013	2.45	1.35	4.90	0.52	1.29	1.99	2.57	0.88
	Pooled	6.47	2.17	12.93	0.41	4.75	5.31	9.51	0.75
Gross yield/plant	2012	0.003	0.06	0.01	2.45	0.003	0.08	0.01	2.83
	2013	0.03	0.16	0.06	1.63	0.05	0.08	0.10	0.89
	Pooled	0.03	0.18	0.06	1.73	0.04	0.15	0.08	1.37
Marketable yield/plant	2012	0.01	0.06	0.01	2.45	0.01	0.11	0.02	2.35
	2013	0.002	0.03	0.004	2.74	0.01	0.05	0.01	2.24
	Pooled	0.01	0.07	0.02	1.87	0.02	0.13	0.03	2.08
Total number of fruits/plant	2012	28.61	25.46	57.22	0.67	33.57	14.98	67.15	0.47
	2013	21.80	14.86	43.60	0.58	18.38	25.41	36.76	0.83
	Pooled	50.01	25.92	100.02	0.51	51.35	32.85	102.70	0.57
Marketable fruits/plant	2012	12.71	16.87	25.42	0.81	27.41	34.47	54.82	0.79
	2013	3.91	7.86	7.81	1.00	5.18	6.03	10.36	0.76
	Pooled	15.05	12.98	30.11	0.66	28.94	24.33	57.87	0.65
Fruit weight	2012	21.09	20.43	42.17	0.70	29.42	14.81	58.85	0.50
	2013	16.37	16.02	32.73	0.70	20.37	30.74	40.75	0.87
	Pooled	36.80	36.40	73.61	0.70	48.19	44.37	96.38	0.68
Fruit shape index	2012	0.003	0.001	0.01	0.32	0.003	0.002	0.01	0.45
	2013	0.002	0.001	0.004	0.50	0.001	0.0006	0.003	0.45
	Pooled	0.005	0.002	0.01	0.45	0.004	0.002	0.01	0.45
Pericarp thickness	2012	0.03	0.15	0.05	1.73	0.03	0.06	0.06	1.00
	2013	0.03	0.15	0.06	1.58	0.01	0.05	0.03	1.29
	Pooled	0.05	0.33	0.11	1.73	0.03	0.14	0.07	1.41
Locules per fruit	2012	0.18	0.10	0.36	0.53	0.20	0.13	0.39	0.58
	2013	0.21	0.15	0.42	0.60	0.24	0.11	0.49	0.47
	Pooled	0.39	0.25	0.77	0.57	0.43	0.25	0.87	0.54

Cont...

Plant height	2012	72.99	13.73	145.97	0.31	102.27	90.58	204.54	0.67	
	2013	238.58	212.66	477.16	0.67	159.59	106.18	319.17	0.58	
	Pooled	283.04	176.43	566.08	0.56	262.02	136.84	524.05	0.51	
Harvest duration	2012	15.41	36.23	30.82	1.08	5.33	10.02	10.66	0.97	
	2013	-1.59	18.53	-3.18	2.41	1.73	5.32	3.45	1.24	
	Pooled	8.61	15.69	17.21	0.95	5.72	12.77	11.44	1.06	
TSS	2012	0.03	0.07	0.05	1.18	0.07	0.01	0.14	0.27	
	2013	0.02	0.01	0.04	0.50	0.03	0.05	0.07	0.85	
	Pooled	0.04	0.10	0.09	1.05	0.07	0.05	0.14	0.60	
Ascorbic acid	2012	-0.95	11.63	-1.89	2.48	-0.69	11.67	-1.38	2.91	
	2013	0.64	9.32	1.28	2.70	-0.57	9.89	-1.15	2.93	
	Pooled	-0.28	12.79	-0.57	2.18	-0.99	13.74	-1.98	2.63	
Titrable acidity	2012	0.002	0.01	0.003	1.38	0.001	0.01	0.002	1.73	
	2013	0.0003	0.01	0.001	3.26	0.001	0.01	0.001	2.42	
	Pooled	0.002	0.01	0.004	1.64	0.001	0.01	0.003	1.90	

role of non-additive gene action for these traits. **The** estimates of $ó^2$GCA were higher than $ó^2$SCA for the traits *viz*., days to 50 per cent flowering, days to first harvest, total number of fruits per plant, fruit weight, fruit shape index, locules per fruit and plant height in all the environments, marketable fruits per plant in pooled environment, TSS in 2013. The preponderance of $ó^2$GCA revealed the predominant role of additive gene action governing these traits. Under inorganic conditions, the estimates of $ó^2$SCA were higher than $ó^2$GCA for the traits *viz*., days to first harvest, gross yield per plant, marketable yield per plant, pericarp thickness, harvest duration, ascorbic acid and titrable acidity in all the environments, total number of fruits per plant, fruit weight and TSS in 2013 and marketable fruits per plant in 2012 and 2013. The preponderance of $ó^2$SCA revealed the predominant role of non-additive gene action governing these traits. The estimates of $ó^2$ GCA were higher than $ó^2$SCA for the traits *viz*., days to 50 per cent flowering, fruit shape index, locules per fruit and plant height in all the environments, marketable fruits per plant in pooled environment, total number of fruits per plant, fruit weight and TSS in 2012 and pooled environment indicating predominant role of additive gene action governing these traits.

The results of analysis of variance were also confirmed from the study of additive ($ó^2$A) and dominant ($ó^2$D) component of variances and average degree of dominance. Under organic conditions, the dominant component of variation ($ó^2$D) were greater than the additive component of variation ($ó^2$A) for the traits gross yield per plant, marketable yield per plant, pericarp thickness, ascorbic acid and titrable acidity in all the environments and marketable fruits per plant in 2013, harvest duration in 2012 and 2013 and TSS in 2012 and pooled environment, indicating predominant role of non-additive gene action governing these traits. The additive component of variances ($ó^2$A) were greater than the dominant variances ($ó^2$D) for days to 50 per cent flowering, days to first harvest, total number of fruits per plant, fruit weight, fruit shape index, locules per fruit and plant height in all the environments, marketable fruits per plant in 2012 and pooled environment, harvest duration in pooled environment and TSS in 2013, suggesting the role of additive gene action for these traits.

Under inorganic conditions, the values of the dominant component of variances ($ó^2$D) were greater than the additive component of variances ($ó^2$A) for marketable yield per plant, ascorbic acid and titrable acidity in all the environments, gross yield per plant in 2012 and pooled environment, pericarp thickness and harvest duration in 2013 and pooled environment, indicating predominant role of non-additive gene action governing these traits. The additive component of

variances ($ó^2A$) were greater than the dominant ($ó^2D$) for days to 50 per cent flowering, days to first harvest, total number of fruits per plant, marketable fruits per plant, fruit weight, fruit shape index, locules per fruit, plant height and TSS in all the environments, gross yield per plant in 2013 and harvest duration in 2012, which indicated the involvement of additive gene action. For pericarp thickness in 2012, the $ó^2A$ and $ó^2D$ were equal. This suggested the role of both additive and non-additive gene action for the inheritance of these traits.

Under organic conditions, the traits in which ^{2}SCA were higher than ^{2}GCA, ^{2}D were also higher than ^{2}A except for the traits marketable fruits per plant in 2012 and harvest duration in pooled environment under organic conditions. Under inorganic conditions similar findings were observed for the traits harvest duration in 2012, gross yield per plant, total number of fruits per plant, fruit weight and TSS in 2013, marketable fruits per plant in 2012 and 2013 and days to first harvest in all the environments.

The, significant advancement could be achieved in the segregating generations using simple selection procedures or conventional breeding methods such as pedigree and bulk selection, which are useful for accumulation of desirable genes for these traits. In accordance with present studies, predominance of additive gene action have also been reported earliar for days to 50 per cent flowering (Shankar *et al*., 2013), days to first harvest (Garg *et al*., 2008), total number of fruits per plant (Dordevic *et al*., 2010), marketable fruits per plant (Garg *et al*., 2008), fruit weight (Dhaliwal and Cheema, 2011; Shankar *et al*., 2013), fruit shape index (Garg *et al*., 2008), locules per fruit (Garg *et al*., 2008), plant height (Shankar *et al*., 2013; Sharma and Sharma, 2010) and TSS (Rai *et al*., 2005). However, contradictory reports are also available in literature with respect to gene action studies. Non-additive gene action have been reported by Dod *et al*. (1992) for days to 50 per cent flowering, Saleem *et al*. (2013) for days to first harvest, Dod *et al*. (1992) for total number of fruits per plant, for marketable fruits per plant, Yadav *et al*. (2013) for fruit weight, Joshi and Kohli (2006) for locules per fruit, Farzane *et al*. (2013) for plant height and Yadav *et al*. (2013) for TSS. However, additive as well as non-additive gene action have also been reported by Mondal *et al*. (2009) for days to 50 per cent flowering, Virdelwala *et al*. (1981) for days to first harvest, Mondal *et al*. (2009) for total number of fruits per plant, Rai *et al*. (2005), Agarwal *et al*. (2014) for fruit weight, Mondal *et al*. (2009) for locules per fruit, Ahmad *et al*. (2009) for plant height and Agarwal *et al*. (2014) for TSS.

Based on pooled over environments analysis, preponderance of non-additive gene action (^{2}D) was observed for the traits such as gross yield per plant, marketable yield per plant, pericarp thickness, total soluble solids, ascorbic acid and titrable acidity under organic conditions and gross yield per plant, marketable yield per plant, pericarp thickness, harvest duration, ascorbic acid and titrable acidity under inorganic conditions. Similar gene action have also been reported for gross yield per plant (Dhaliwal and Cheema, 2011), marketable yield per plant (Sharma and Sharma, 2010, Saleem *et al*., 2013 and Yadav *et al*., 2013), pericarp thickness (Garg *et al*., 2008 and Sharma and Sharma, 2010), ascorbic acid (Garg *et al*., 2008) and titrable acidity (Garg *et al*., 2008). Additive gene action have also been reported earlier by Kaul and Nandpuri for gross yield per plant, Garg *et al*. (2008) for marketable yield per plant. Additive as well non-additive gene action have also been reported by Cheema *et al*. (2003) for gross yield per plant, Agarwal *et al*. (2014) for marketable yield per plant, Dod *et al*. (1992) for pericarp thickness. Variation may be attributed to the differences in the genetic constitution of the parental lines used and environment under which these studies were carried out.

Most of the traits, which had relatively higher estimates of additive genetic component (^{2}A) also revealed average degree of dominance values less than 1.00 (partial dominance) as per expectation. These conclusions were also confirmed from high values of the broad and narrow-sense heritability. Remaining traits had higher values of non-additive (^{2}D) component of genetic variance, which could be exploited through the development of hybrids.

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Diversity of Cowpea (*Vigna unguiculata* L. Walp) in Terms of Some Germination Components under Drought Stress

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***Abstract*:** Comparative study was carried out the effect of different PEG-4000 concentration on germination components of five cowpea verities (BL-1, BL-2, EC-4216, Kohinoor and Local). Seeds of all verities were tested for drought tolerance using different concentration of PEG-4000 (control, -0.075, -0.1 and -0.2 MPa). PEG-induced drought stress decreased germination speed, coefficient velocity of germination, germination rate index, seedling length, relative growth rate and led to reduction in water content in all varieties and mean germination time increased with increasing drought stress concentrations. Germination speed was highly inhibited in all five varieties at -0.2 MPa PEG concentrations. BL-2 variety showed greater drought tolerance during germination parameters. BL-2 might be used for further study of drought stress on growth processes and its physiological consequences at an advanced stage of growth.

***Key Words*:** Cowpea, Diversity, Drought, Germination, PEG, Stress

Recent year water resources for successful crop production have been decreasing. Furthermore, in view of various "climate changes" has a negative impact on agriculture production. A modest evolution suggested that nearly 90% of global rural area is affected by Abiotic stress (Cramer *et al*., 2011). Abiotic factors such as drought, cold, chill, flood, frost, elevated CO_2 level, heat and light that severely affected the plant growth (Basha *et al*., 2015). Drought stress highly affected numerous plant responses, varying from; maintaining higher plant productivity, altered gene expression for metabolic process under environmental stresses is the main challenge facing modern agriculture (Gill and Tuteja, 2010). Noteworthy developments were made in understanding the physiological, biochemical, and molecular agronomic scale especially the potential target and response mechanism for improving crop response to drought (Chen *et al*., 2013).

Cowpea (*Vigna unguiculata* L. Walp.) is grown in the tropical and sub-tropical areas that includes parts of Asia, Africa, Southern Europe, Southern United States and Central and South America which is adapt to various climatic and ecological conditions. Leguminous plants, they can improve fertility of agriculture soils and thus reduced amount of mineral fertilizer used. Cowpea contributes in human food, particularly their seeds very rich in good quality protein and essential amino acids. For this region seeds are used in complementing diet on cereals which are protein nitrogen compound (Tsoata *et al*., 2015).

Poly ethylene glycol (PEG) is one of the dependable approaches for the selection of desirable verity. Several reports have shown that invitro screening techniques using PEG (Sakthivelu *et al*., 2008). Identification of cowpea verity under water stress condition is vital to increase production. This can be accomplished by explaining the drought tolerance verity of cowpea. Current study was planned for simple and quick screening of higher tolerant cowpea verity to drought and understands the effect of different PEG-4000 concentration on germination and early growth parameters.

MATERIAL AND METHODS

Seeds of five different cowpea varieties used in the study were collected from Indian Grassland and Forage Research Institute (IGFRI), Jhansi, India. The names of the varieties are BL-1, Bl-2, EC-4216, Kohinoor and Local (available in local area), uniform seeds of all varieties were surface sterilized 0.1% $HgCl_2$ for 3-5 minutes and then washed thoroughly with autoclaved double distilled water and surface dried. Ten seeds of each verity in each treatment were allowed to germinate on a filter paper in 9 cm diameter petri dishes. Each filter paper was moistened with solutions of 0 MPa (distilled water) as a control, or final osmotic potentials of -0.075, -0.1 and -0.2 MPa of PEG (MW 4000).

20 ml of appropriate solution was applied to each petri dish pletely randomized design (CRD) with three replicates for each treatment. Germination room temperature was maintained at 25 ± 1°C in the dark with 8 h photoperiod. Petri plates were periodically checked and respective solutions were applied to compensate evaporation. Seedling lengths were measured (1 to 10 days after treatment application) by using a scale. GS, MGT, GRI, CVG, RGR and WC were calculated by the following formulae

$GS = \sum Si / D$ (Rajabi and Poustini, 2005)

Where, Si= no. of germinated seed i^{th} day, Di= day no. of n^{th} counting

MGT= $\sum$NiTi / $\sum$Ni (Andalibi *et al*., 2005)

CVG= $\sum$Ni / NiTi

Where, Ni= no. of germinated seed for each day, Ti= no. of days as of the start of experiment

GRI= G1/ 1+G2 /2----------+Gn /n (Fakhr, 2014)

Where, G1= germination percentage at 1^{th} day, G2= germination percentage at 2^{th} day

RGR= Dry weight after treatment – Dry weight before treatment / Treatment duration (Guo *et al*., 2013)

WC= 100 x (fresh weight-dry weight / fresh weight)

Statistical analysis was carried out to identify significant difference among the cowpea varieties at different treatments. ANOVA was carried out to test the variation at p<0.01 significance and Turkey's multiple.

RESULTS AND DISCUSSION

There was a significant two-way interaction (drought level and cultivars) (P 0.01) for all germination parameters (Table 2). Water deficiencies stress caused increasing of mean germination time from 1.30 to 2 days. (Table 1) showed that under control and water deficiency stress conditions, Kohinoor cultivar (2 day) had the most and BL-1 (1.62 day) had the least mean germination time (Fig 1), Similar result was observed Abdoli and Saidi, 2012. Sadat noori *et al*. (2007) reported that canola seeds under stress, more time needed for germination.

The maximum germination speed (GS) 5 was recorded in all verities under control. Stress level increased -0.075 to -0.2 MPa (Table 1). There was decrease in GS observed. The lowest negative impact on GS (2.66) was recorded in BL-2 at maximum stress level (-0.2 MPa). Further, Kohinoor and Local suffered maximum decreased in

Table 1. Effect of different levels on germination component of five cowpea cultivars

Parameters	PEG (MPa)	Cultivars name					Mean	LSD 0.05
		BL-1	BL-2	EC-4216	Kohinoor	Local		
Germination speed (GS)	Control	5	5	5	5	5	5	3.66
	-0.075	2.66	5	2.66	2.66	5	3.58	
	-0.1	2.66	2.66	2	1.33	2	2.11	
	-0.2	2	2.66	2	1.33	1.33	1.82	
Mean germination time (MGT)	Control	1.3	1.2	1.3	1.3	1.3	1.28	1.18
	-0.075	1.5	1.4	1.62	1.62	1.5	1.52	
	-0.1	1.62	1.5	1.66	1.75	1.66	1.63	
	-0.2	1.66	1.62	1.83	2	1.75	1.77	
Germination rate index (GRI)	Control	85	90	85	85	85	86	245.4
	-0.075	63.33	83.33	58.33	61.66	78.33	68.99	
	-0.1	58.33	63.33	43.33	28.33	43.33	47.33	
	-0.2	43.33	58.33	38.33	23.33	28.33	38.33	
Coefficient velocity germination (CVG)	Control	76.92	83.33	76.92	76.92	76.92	78.20	287.1
	-0.075	66.66	71.42	61.53	61.53	66.66	65.56	
	-0.1	61.53	66.66	60	57.14	60	62.39	
	-0.2	60	61.53	54.54	50	57.14	56.64	
	Control	12.82	11.74	11.42	10.15	10.6	11.34	40.8
	-0.075	10.89	11.82	8.27	8.01	10.09	11.17	
	-0.1	7.70	8.88	5.04	3	496	8.98	
	-0.2	4.66	8.08	3.84	1.6	2.52	6.91	
Relative growth rate (RGR)	Control	0.048	0.045	0.049	0.048	0.042	0.046	267.6
	-0.075	0.036	0.035	0.043	0.032	0.037	0.036	
	-0.1	0.028	0.033	0.034	0.026	0.034	0.031	
	-0.2	0.025	0.030	0.025	0.020	0.028	0.025	
Water content (WC)	Control	91.98	86.92	90.55	89.89	85.45	88.95	122.5
	-0.075	89.06	86.71	89.81	89.69	84.92	88.03	
	-0.1	88.89	86.67	88.77	89.21	84.58	87.62	
	-0.2	88.07	86.34	88.65	87.00	84.27	87.06	

GS (1.33) at this level (Fig. 1).

All the verities subjected to stress under gone consistent decreased in germination rate index (GRI) as level of osmotic stress progressed. GRI ranged from 90 to 85 under control (Table 1). Reduction in GRI 72.55 percent was observed in Kohinoor and least reduction in BL-2 (35.15 percent) at highest osmotic level (Fig. 1). Soltani *et al*. (2006) expressed that probably reduced seed germination rate index under low osmotic potential due to endosperm material decompose or slower transfer of this material to the seedling.

Coefficient velocity germination in different verities of cowpea seedlings were negatively affected across the different levels of increasing osmotic stress. The comparatively less inhibitory effect of increasing osmotic stress on the CVG was observed in BL-2 from control (83.33) to 61.53 at -0.2 MPa stress level. CVG of Kohinoor it maximum affected from control 76.92 to 57.14 at highest stress level (Fig 1). Rest of the verities had shown moderate effect on MGT, GS, GRI and CVG under stress.

Seedling length decreased significantly with increasing osmotic stress the highest seedling length under PEG (-0.2 MPa) was related to cultivars BL-2 with 8.08 cm, and lowest value was related to Kohinoor with 1.6 cm. (Fig 1). It is important that drought resistance is characterized by small reduction of seedling growth under drought stressed condition (Omar, 2014).

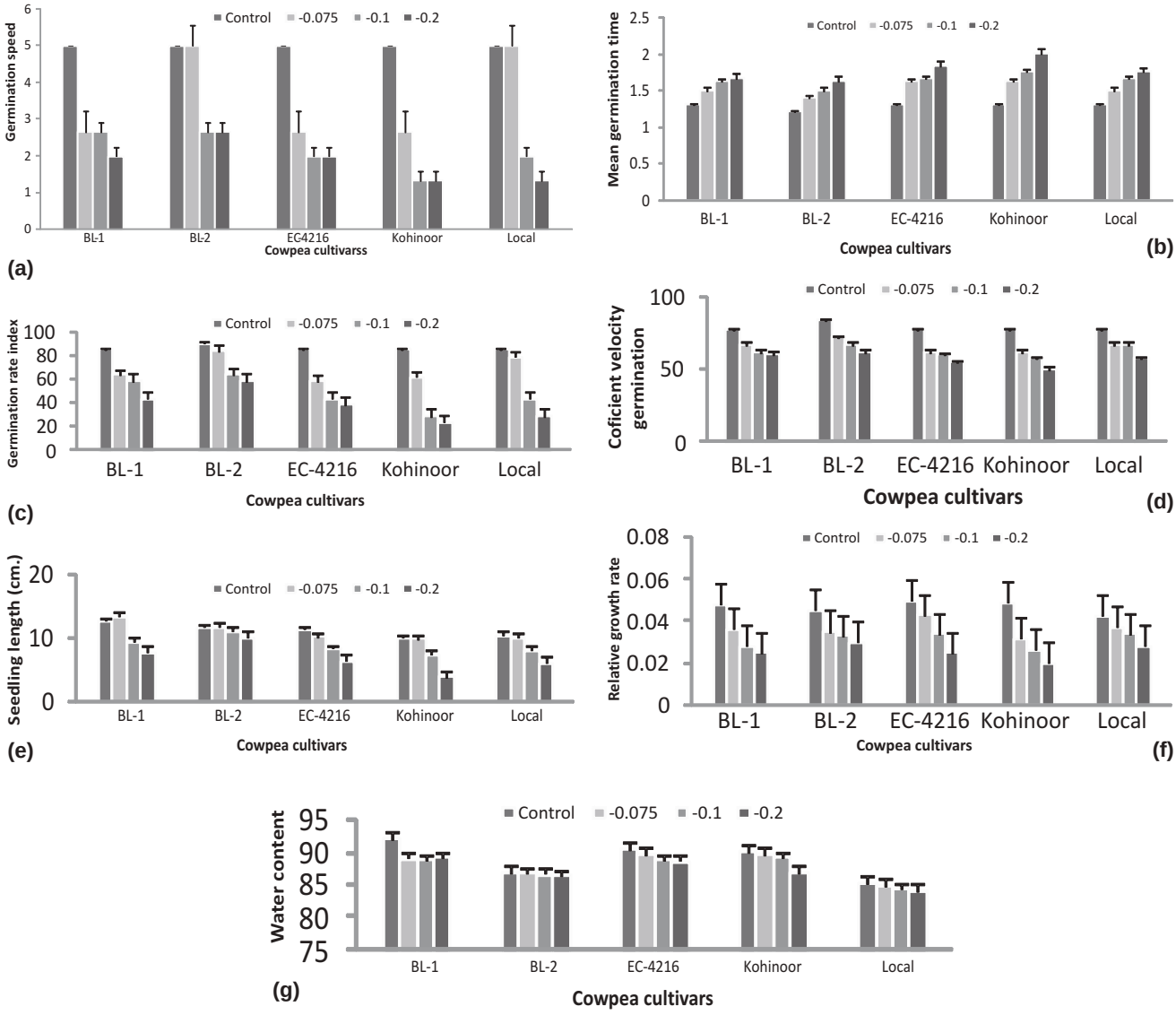

Fig. 1. Interaction cultivars x drought levels (Control, -0.075, -0.1 and -0.2 MPa) PEG4000 for germination components. Bars represent standard error (±S.E) of means

Table 2. Analysis of variance for effect of different drought levels on germination components of cowpea cultivars

SOV	df	Mean square (MS)						
		Germination speed	Mean germination	Germination rate index	Coefficient velocity	Seedling length	Relative growth	Water content
Cultivers	4	0.88**	0.032**	319.32**	51.5**	8.05**	0.0016**	18.0**
Drought levels	3	10.52**	0.22**	2311**	415**	21.0**	0.0004**	3.13**
CultiversxDrought levels	12	6.56**	1.97**	2642**	3534**	72.4**	0.0009**	643**
Error	20	3.66	1.18	1547	2118	45.9	0.0008	386
Total	39							
CV %		40.38	11.61	30.95	12	18.85	20	1.17

SOV: Source of variance, MS: Mean Square, df: degree of freedom * and ** significant at 0.05 and 0.01 P value respectively

The RGR and WC of all verities were decreased with increasing PEG concentration, with the greatest reductions occurring under the highest water stresses (Fig 1). The RGR and WC was observed minimum decreased 34.06 and 0.66 percent in BL-2 and the maximum reduction of RGR and WC was recorded in Kohinoor i.e., 58.84 and 3.21 percent respect to control respectively increase in PEG-6000 concentration (Table 1).

Results from analysis of variance (Table 2) showed that mean squares of the genotypes were significant for all the traits, which represent a significant difference between the genotypes in terms of all the traits. The most important and critical stage in the life cycle of plants is germination (Ahmad *et al*., 2009) Reduction in germination components can result from PEG treatments that decrease the water potential gradient of between seeds and their surrounding medium, which benefit to reduce membrane system injury in process of seed imbibitions and repair impaired membrane system (Jiao *et al*., 2009). Water stress not only affects seed germination but also increases mean germination time in crop plants (Warwich *et al*., 2015). An osmotic stress treatment suggests a great deal of genetic variation among cultivars that could be utilized to develop new cultivars adapted to arid and semiarid regions (Dodd and Donovan., 1999). Results presented here are consistent with previous finding that certain germination criteria can be used for selecting drought resistant cultivars.

CONCLUSION

The results showed that various cowpea verities (BL-1, BL-2, EC-4216, Kohinoor and Local) differently responded to water stress at germination stage and seedling growth. The best tolerant verity to drought condition taking all traits into account in this study. The BL-2 verity, possess the best germination characteristics and less affected by PEG-4000 water stress than other verities during growth.

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Genetic Variability and Association Analysis for Morpho-Physiological Traits and Seed Yield in Mungbean (*Vigna radiata* (L.) Wilczek) Under Water Stress Condition

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***Abstract*:** A study comprising of 60 mungbean genotypes was conducted under irrigated and limited irrigated conditions. There was no significant difference for photochemical efficiency under the two moisture regimes. High estimates of heritability were observed for most of the characters except necrosis and number of pods. High genetic advance was recorded for canopy temperature difference, seed yield, membrane stability index, biomass, necrosis, plant height, harvest index, pod weight and number of branches under limited irrigation. Seed yield was significantly and positively correlated with flower retention, number of pods, number of seeds, biomass, pod weight, harvest index, canopy temperature difference, photochemical efficiency, membrane stability index and total chlorophyll content.

Key Words: Correlations, GCV and PCV, Genetic advance, Heritability, Mungbean

Mungbean [*Vigna radiata* (L.) Wilczek] is an important pulse crop which provides an excellent complement for cereal-based diets and is well suited to both rainfed and irrigated conditions. It is the fourth most important pulse crop of India after chickpea, pigeon pea and urdbean. It is grown throughout the year in all the three crop seasons. In Northern India, it is cultivated in spring/summer and rainy season, however, in Southern India, it is also grown in *rabi* season after rice on residual moisture. Being a short duration pulse crop, it fits well into many cropping systems. Mungbean suffers from various biotic and abiotic stresses particularly heat and water stress resulting in low production and productivity per unit area. The regions that are growing mungbean traditionally are most often facing water scarcity at one or the other crop growth stage. Water deficit is frequently the primary limiting factor for mungbean production under arid and semi-arid conditions. It affects nearly all the plant growth processes. Drought at vegetative stage reduces biomass and at reproductive stage, it can delay or prevent flowering. Substantial yield improvements have been made in mungbean through conventional breeding approaches for development of early maturing, high yielding stable varieties imparting resistance to diseases and insect pests. However, little efforts have been made towards developing genotypes which can withstand the environmental stresses especially heat and drought that causes huge losses to the crop particularly at reproduction and seed development stages. Considering these facts, the present study was planned with the objective to study the genetic parameters like heritability, genetic advance and correlations between various seed yield and other morpho-physiological traits related to water stress and high temperature tolerance strategies for future mungbean breeding programmes.

MATERIAL AND METHODS

In the present investigation 60 mungbean genotypes were sown in randomized block design (RBD) with three replications having a plot size of 2 rows x 2m at CCS Haryana Agricultural University, Hisar and the crop was sown in April, 2013. Only pre-sown irrigation was applied. Rainfall was only 2.3 mm during the crop season. Observations were recorded on five randomly selected plants from each genotype in each replication for characters *viz.* flower retention, plant height, number of pods per plant, number of branches per plant, number of seeds per pod, pod weight per plant, 100-seed weight, photochemical efficiency, relative stress injury and total chlorophyll content. Days to first flowering, days to first pod initiation, days to maturity, total biomass, seed yield, harvest index, incidence of Mungbean Yellow Mosaic Virus (MYMV), canopy temperature and necrosis were recorded on plot basis.

For recording incidence of MYMV, 1 to 9 ratings scale was used. Total chlorophyll content was measured by SPAD chlorophyll meter and necrosis was recorded on visual basis on 0-4 scale where, 0-no necrosis, 1-1 to 25% necrosis, 2-26 to 50% necrosis, 3-51 to 75% necrosis and 4-76 to 100% necrosis. Canopy temperature (°C) was recorded with a hand held infrared thermometer (IRT), model AG-42, Tele temp crop, Fullerton (CA), for instantaneous measurement of

canopy temperature depression. Data were recorded between 1200 hrs to 1400 hrs. Photochemical efficiency was measured by chlorophyll a florescence meter in terms of $F_{v/m}$ which was calculated as $(F_m-F_o)/Fm$, where, F_o-minimal florescence, F_m-maximal florescence and F_v-variable florescence. Relative stress injury (RSI) was calculated as a ratio of electrical conductivity before boiling (EC_1) to the ratio of electrical conductivity after boiling (EC_2) and expressed in percentage.

$$RSI(\%) = \frac{EC_1}{EC_2} x100$$

To measure membrane thermo stability, method of Ibrahim and Quick (2001a & b) was followed. A random sample of leaves from five plants from each replication was collected. Membrane Stability Index was expressed in percentage and calculated by the following formula:

$$MSI = 1- \frac{T_1}{T_2} x100$$

where;

T_1=conductivity reading after heat treatment

T_2=conductivity reading after autoclaving

The data for different characters were statistically analyzed to work out genotypic and phenotypic coefficients of variation (Burton and Devane, 1953) based on the estimate of genotypic and phenotypic variance. Heritability in broad sense was calculated as per the formula suggested by Hanson *et al*. (1956) and expected genetic gain as suggested by Johnson *et al*. (1955). Correlation coefficients at phenotypic and genotypic level were calculated as per procedure given by Al-Jibouri *et al*. (1958).

RESULTS AND DISCUSSION

Under water stress conditions significant variation among 60 genotypes of mungbean was revealed for all the morphological and physiological characters studied except for incidence MYMV. This indicated that there was considerable variability among the genotypes of mungbean for all the characters except incidence of MYMV. Rao *et al*. (2006), Bharti *et al.* (2011) and Mehndi *et al*. (2013) also observed a wide spectrum of variation for yield and yield components in mungbean. Contrarily, Dhananjay *et al.* (2009) reported less genetic variability for pods per cluster, seeds per pod, days to 50 % flowering, pods per plant. Similarly Aziz *et al.* (2010) observed that primary and secondary branches, pods per cluster and pod length showed lesser variability while 100-seed weight and harvest index exhibited intermediate range of variability and sufficient genetic variability was observed for plant height, pods per plant, total plant weight and seed yield. The phenotypic coefficients of variation were higher than the respective genotypic coefficients of variation under limited moisture condition indicating the effects of environment in expression of these traits (Table 1). The range of PCV for different traits was observed from 4.35 (days to maturity) to 71.25% (necrosis) whereas the range of GCV was 4.12 (days to maturity) to 57.12% (canopy temperature difference). The presence of wide range of PCV and GCV under water stress regime revealed the larger extent of phenotypic and genetic variability. High PCV was observed for necrosis, canopy temperature difference, MYMV, number of pods per plant and moderate for number of branches per plant, biomass, harvest index, membrane stability index, seed yield per plot, plant height, total pod weight per plant, total chlorophyll content, number of seeds per pod and 100-seed weight .The high to moderate GCV were observed for canopy temperature difference, necrosis , biomass, seed yield per plot, membrane stability index, harvest index, plant height, number of branches per plant, total pod weight per plant, number of pods per plant, total chlorophyll content, 100-seed weight and number of seeds per pod .Similar findings were also reported by Marappa *et al.* (2008) and Narasimhulu *et al.* (2012) in mungbean for many of these traits. Low values of PCV and GCV for days to maturity, days to 50 per cent flowering, seeds per pod were observed by Khedar *et al.* (2006).

High broad sense heritability was recorded for photochemical efficiency followed by grain yield per plot, membrane stability index, seed dry weight per plant, days to maturity, plant height, canopy temperature difference, 100-seed weight, biomass, total chlorophyll content, total pod weight per plant, harvest index, flower retention, days to first flowering, number of seeds per pod, days to first pod, number of branches per plant and number of pods per plant. This indicated the preponderance of additive gene action in the expression of all these traits. Similar results have also obtained by Rao *et al.* (2006) and Biradar *et al.* (2007) substantiating the results obtained in this study. The magnitude of genetic advance as per cent of mean ranged from 4.26 to 108.42%. Highest genetic advance as per cent mean was recorded for canopy temperature difference, seed dry weight per plant, grain yield per plot, membrane stability index, biomass, necrosis, plant height, harvest index, total pod weight per plant, number of branches per plant which were in confirmation of the results obtained Rao *et al.* (2006) and Reni *et al.* (2013). Moderate genetic advance as per cent of mean for total chlorophyll content, 100 seed weight, number of seeds per pod, photochemical efficiency, number of pods per plant, flower retention and low for days to first flowering, days to maturity, days to first pod, MYMV were observed. The traits exhibiting high heritability coupled with

Table 1. Mean, PCV, GCV, heritability, genetic advance and genetic advance as per cent of mean for various characters in mungbean under limited irrigation

Characters	Mean	PCV (%)	GCV (%)	Heritability (%)	Genetic advance	Genetic advance as % of mean
Days to first flowering	43.211	6.255	5.219	69.617	3.877	8.971
Days to first pod	46.756	5.202	4.137	63.245	3.169	6.778
Flower retention (%)	83.448	8.710	7.308	70.404	10.541	12.632
Plant height (cm)	44.776	15.680	14.821	89.343	12.921	28.858
No. of pods/plant	18.182	20.435	11.957	34.239	2.261	14.413
No. of branches/plant	3.222	17.790	13.825	60.392	0.713	22.132
No. of seeds/pod	9.617	12.298	10.211	68.942	1.680	17.466
Days to maturity	64.156	4.351	4.122	89.783	5.162	8.046
Biomass (g)	535.859	17.617	15.939	81.860	159.189	29.707
Total pod weight/plant (g)	10.499	14.864	12.781	73.942	2.377	22.641
Seed yield/plot (g)	126.520	16.206	15.802	95.080	40.159	31.742
Harvest index (%)	24.06	17.577	15.108	73.877	0.064	26.750
100 seed weight (g)	5.126	11.221	10.274	83.844	0.993	19.380
Canopy temp. diff. (°C)	-1.163	61.984	57.116	84.910	1.261	108.419
Photochemical efficiency	0.567	7.677	7.494	95.535	0.086	15.088
Mem. stability index (%)	49.881	16.586	15.763	90.325	15.394	30.861
Total chlorophyll content	52.428	13.199	11.454	75.312	10.736	20.477
Necrosis	2.0333	71.250	32.003	20.175	0.602	29.612
Mungbean Yellow Mosaic Virus	1.239	40.962	9.201	5.046	0.053	4.258

high genetic advance can be improved by direct selection. Low heritability coupled with low genetic advance and low GCV suggested presence of non-additive gene action and high GXE interaction. Mehandi *et al.* (2013) also indicated that plant height, number of clusters per plant and number of pods per plant exhibited high heritability coupled with high to moderate genetic advance and days to 50% flowering, number of branches per plant, days to maturity, seed yield per plant showed high to moderate heritability coupled with moderate to low genetic advance.

The genotypic correlation coefficients, in general, were higher than the phenotypic correlation coefficients which indicated masking of modifying effects of environment and also the presence of strong association between the two corresponding characters (Table 2). This also indicated that the selection for these characters might be rewarding. Further, the seed yield was positively associated with all characters except days to flowering, pod initiation, days to maturity. Thus, it may be inferred that the selection based on these traits either in combination or alone would be beneficial to identify the genotypes having better yield potential under water stress conditions. Similar views have been reported by Srivastava *et al* . (2008), Dhananjay *et al.*(2009), Narasimhulu *et al*. (2012), Reni *et al*. (2013).

Days to maturity showed positive association with days to first flowering, days to first pod, biomass and total chlorophyll content but number of pods per plant, seed weight per plant, seed yield per plot, harvest index and 100 seed weigh were negatively correlated which was in conformity with the findings of Bharti *et al*. (2011). Flower retention showed positive correlation with number of pods per plant, biomass, seed weight per plant, seed yield per plot and harvest index but negative with canopy temperature difference. Number of pods per plant showed positive association with flower retention, number of branches per plant, biomass, pod weight per pant, seed weight per plant, seed yield per plot and harvest index but negative association with pod initiation, number of seeds per pod, days to maturity and 100-seed weight. Srivastava *et al*. (2008) reported that number of pods per plant had negative correlation with days to 50 % flowering and days to maturity. Kumar *et al*. (2010) observed high correlation for pods per plant and harvest index. Canopy temperature difference was positively correlated with biomass, pod weight per plant, seed yield per plot, seed weight per plant and harvest index whereas, days to first flowering ,plant height, flower retention days to first pod, and days to maturity showed negative correlation. Membrane stability index was positively correlated with seed yield per plot, seed weight per plant, photochemical efficiency and total chlorophyll content.

Table 2. Genotypic and phenotypic correlation coefficients for different characters in mungbean water stress condition

	Days to first flowering	Days to first pod	Flower retention	Plant height	No. of branches plant	No. of branches/ plant	No. of seeds/ pod	Days to maturity	Biomass	Pod weight/ plant	Seed yield/plot	Harvest index	100- seed weight	Canopy Temp. Difference	Photochemical Efficiency	Membrane Stability Index	Total Chlorophyll Content	Necrosis	MYMV
Days to first flowering	1	1.000	0.128	0.139	-0.105	0.116	-0.069	0.584	0.215	-0.119	-0.429	-0.478	-0.127	-0.312	0.125	0.129	0.128	0.139	0.132
Days to first pod	0.906**	1	0.128	0.126	-0.093	0.298	-0.025	0.578	0.196	-0.117	-0.365	-0.470	-0.142	0.120	0.140	0.121	0.257	0.129	0.137
Flower retention	0.119	0.109	1	0.108	0.266	0.138	0.054	0.052	0.276	0.121	0.298	0.272	-0.114	0.236	-0.117	0.008	0.172	0.048	0.004
Plant height	0.132	0.117	0.118	1	-0.141	-0.072	0.095	0.127	0.392	-0.003	-0.109	-0.610	0.135	-0.239	-0.118	0.055	0.409	0.129	-0.136
No. of branches/plant	-0.141	-0.061	0.219**	-0.139	1	0.251	-0.212	-0.414	0.194	0.654	0.703	0.596	-0.417	-0.006	0.137	0.146	0.040	0.097	0.119
No. of branches/plant	0.105	0.248**	0.105	-0.051	0.202**	1	-0.119	-0.017	0.312	0.326	0.077	0.070	0.003	0.116	0.121	-0.114	-0.089	-0.125	0.077
No. of seeds/pod	-0.027	-0.029	0.011^{NS}	0.071	-0.159*	-0.088	1	-0.072	0.216	0.214	0.276	0.014	-0.335	-0.097	-0.125	0.218	0.102	0.114	0.104
Days to maturity	0.482**	0.465**	0.043^{NS}	0.115	-0.206**	0.009	-0.076	1	0.256	-0.131	-0.314	-0.589	0.118	-0.218	-0.130	0.009	0.391	-0.113	0.125
Biomass	0.192	0.152*	0.208**	0.344**	0.178*	0.257**	0.153*	0.222**	1	0.388	0.558	-0.506	-0.235	0.557	0.316	0.307	0.172	-0.123	0.128
Pod weight/plant	-0.109**	-0.108	0.084	-0.011	0.313**	0.248**	0.143	-0.102	0.303**	1	0.799	0.410	0.141	0.232	0.334	0.422	0.273	-0.110	0.122
Seed yield/plot	-0.350**	-0.281**	0.287**	-0.103	0.384**	0.049	0.221**	-0.293**	0.497**	0.661**	1	0.424	0.114	0.425	0.377	0.367	0.197	-0.056	-0.025
Harvest index	-0.345**	-0.294**	0.268**	-0.518**	0.327**	0.071	0.014	-0.475**	-0.579**	0.305**	0.398**	1	-0.103	0.275	0.127	0.041	-0.042	0.108	0.059
100- seed weight	-0.116	-0.139	-0.105	0.126	-0.228**	0.008	-0.299**	-0.195**	-0.196**	0.140	0.090	-0.100	1	-0.138	0.201	0.137	0.274	0.132	0.115
Canopy Temp.	-0.291**	-0.107	-0.207**	-0.227**	-0.030	0.073	-0.087	-0.198**	0.470**	0.185*	0.391**	0.226	-0.112**	1	-0.065	-0.345	-0.407	-0.113	0.122
Photochemical Efficiency	0.117**	-0.123	-0.098	-0.098	0.121	0.098	-0.111	-0.120	0.263**	0.268**	0.350**	0.118	0.187*	-0.329**	1	0.215	0.344	0.253	0.031
Membrane Stability Index	0.072^{NS}	0.066	-0.004	0.025**	0.089	-0.069	0.113	0.001	0.112	0.340**	0.341**	0.046	0.135**	0.301**	0.191*	1	0.362	-0.535	0.114
Total Chlorophyll Content	0.121	0.183*	0.152	0.326**	0.019	-0.064	0.039	0.321**	0.272**	0.241**	0.162*	-0.034	0.193**	0.311**	0.332**	0.292**	1	-0.322	-0.104
Necrosis	-0.120	-0.119	0.041	-0.117	0.119	-0.105	0.078	-0.102	-0.115	-0.099	-0.014	0.112	-0.127	-0.144	-0.198**	0.259**	-0.215**	1	0.053
MYMV	-0.123	-0.117	-0.003	-0.127	0.098^{NS}	0.001	0.138	-0.109	0.055	0.110	0.082	0.013	-0.093	-0.110	-0.003	0.077	-0.085	0.051	1

* Significant at p= 0.05, ** Significant at p= 0.01

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Effects of Waterlogging, Salinity And Combination at Different Stages of Development on Survival and Root Anatomy of Pigeonpea (*Cajanus cajan* (*L.*) *Millsp.*) Genotypes

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***Abstract*:** Waterlogging and salinity are serious problems, which affect crop growth and yield. Waterlogged plants are affected by various stresses, such as limitations to gas, mineral nutrient deficiencies and microelement toxicities. The main cause of damage under waterlogging is oxygen deprivation, which affect nutrient and water uptake, so the plants show wilting even when surrounded by excess of water. Most of the waterlogged area is saline also which further exacerbates the effect of waterlogging. In the present investigations the effects of waterlogging and salinity on percent survival and aerenchyma formation were studied individually and in combination. Four genotypes (ICPH 2431, UPAS 120, H09 33 and Paras) were raised in polythene bags filled with half kg soil + FYM manure mixture (3 soil: 1manure v/v), NPK (@20:60:20 kg per ha) and irrigated with hoagland nutrient solution. Waterlogging, salinity (30 mM NaCl) and waterlogging + salinity (30 mM NaCl) treatments were given for 8 and 12 days to the 20 and 40 day old plants and observations were taken 1 and 8 days after removal from treatments. Waterlogging and combined stress resulted in decline in percent survival and increased aerenchyma formation in roots. No significant effect was observed under alone salinity.

Key Words: Aerenchyma, Combined stress, Pigeonpea, Salinity, Waterlogging

Pigeonpea (*Cajanus cajan* (*L.*) *Millsp.*) is the sixth most important grain legume of tropics and subtropics. Because of its multiple uses, it plays an important role in subsistence agriculture. It is an important pulse crop that performs well in poor soils and regions where moisture availability is unreliable or inadequate (Kimani, 2001). In India, pigeonpea is mainly grown in the regions lying between 14^0N and 29^0N latitudes with mean annual rainfall ranging between 600 and 1500 mm. Waterlogging is a serious problem, which affects crop growth and yield in low lying rain-fed areas. Waterlogged plants are affected by various stresses, such as limitations to gas, mineral nutrient deficiencies and microelement toxicities (Setter and Waters, 2003; Setter *et al.*, 2009). The main cause of damage under waterlogging is oxygen deprivation, which affect nutrient and water uptake, so the plants show wilting even when surrounded by excess of water. As soon as the free O_2 surrounding the roots are depleted, hypoxia stress occurs, causing a transfer from aerobic to anaerobic metabolism in roots, with dramatic restrictions to ATP synthesis and plant growth (Barrett-Lennard, 2003; Teakle *et al.,* 2006). Excessive soil salinization is also a major ecological and agronomic problem throughout the world. According to the FAO Land and Plant Nutrition Management Service (2008), more than 800 Mha of land throughout the world is affected by salinity, which accounts for over 6% of the world's total land area. Apart from natural salinity, secondary (human-induced) salinization of arable land has become a serious threat to agricultural production owing to improper cultivation practices and irrigation (Pannell and Ewing, 2004). Most of the waterlogged area is saline also which further exacerbates the effect of waterlogging. A common adaptation of plants to waterlogging is the survival and growth of seminal roots and production of numerous adventitious roots with aerenchyma (Hossain and Uddin, 2011). The root growth in waterlogging intolerant genotypes is drastically suppressed by waterlogging stress. However, the tolerant genotypes have the ability to continue their root growth under the stress to some extent.

Aerenchyma is a special tissue which consists of continuous gas filled channels or much enlarged gas spaces. Aerenchyma provides a low resistance internal pathway for the movement of O_2 from the shoots to the roots (Hossain and Uddin, 2011). Aerenchyma tissue in roots allows the roots to respire aerobically and to maintain growth under hypoxic conditions. Moreover, a part of oxygen transported to plant root tips through the aerenchyma leaks out into the surrounding soil and results in a small zone of oxygenated soil around the roots providing an aerobic environment for microorganisms that can prevent the influx of potentially toxic soil components (Visser *et al.*, 1997) such as nitrites and sulphides of Fe, Cu and Mn. Therefore, aerenchyma formation is thought to be one of the most important morphological adaptations for the tolerance to hypoxic or

anoxic stress. Most species appear to form aerenchyma as a response to hypoxia (Drew, 1983). Only a few plants have constitutive aerenchyma (John, 1977; Moezel *et al.,* 1989), and even these species have an increase in aerenchyma formation as a response to hypoxia (Armstrong, 1971; Moezel *et al.*, 1989; Armstrong and Drew, 2002). Formation of aerenchyma has been observed in the roots of wheat when grown under low O_2 concentrations (Hossain and Uddin, 2011). However a very little work was done on effect of salinity and combination of waterlogging and salinity on aerenchyma formation. So, present investigation was conducted with following objective:

- To study the independent and interactive effect of waterlogging and salinity on percent survival and aerenchyma formation in pigeonpea genotypes

MATERIAL AND METHODS

Four genotypes (two relatively tolerant and two relatively sensitive) were raised in polythene bags filled with half kg soil + FYM manure mixture (3 soil: 1manure v/v), NPK (@20:60:20 kg per ha). Twenty and forty days after sowing the pots were placed in cemented tanks (length 160 cm, breadth 125 cm and depth 65 cm). T_2 and T_3 tanks were filled with water and the water level in T_2 were maintained for eight days. The water level in T_3 were maintained for twelve days. In T_4 and T_5 treatment, the plants were treated with 30 mM NaCl solutions twenty and forty days after sowing for 8 days and 12 days respectively. T_6 and T_7 tanks were filled with 30 mM NaCl solution for eight days and twelve days respectively. After eight and twelve days water and NaCl solution were drained out of tanks. T_1 served as control and was watered with water at appropriate intervals.

Genotypes: Four (ICPH 2431, PARAS, UPAS 120, H09-33)

Treatment stages: Twenty and forty days after sowing:

Treatments: Seven (T_1– Control, T_2 - Waterlogging (8 days), T_3 - Waterlogging (12 days), T_4 - NaCl 30 mM (8 days), T_5 - NaCl 30 mM (12 days), T_6 - Waterlogging (8 days) + 30 mM NaCl, T_7 - Waterlogging (12 days) + 30 mM NaCl)

Sampling stages: One and 8 days after draining out the wáter and NaCl solutions.

Survival percentage: After removal from the treatments the living plants were counted and expressed in the term of percent survival

Aerenchyma formation in roots: For studying the general anatomy and effects of different levels of salinity and waterlogging on aerenchyma formation in roots, the materials were fixed in formalin-acetic acid- alcohol solution [FAA (Sass, 1964)] at vegetative stage eight days after removal of treatment.

Composition of FAA solution

Ethanol	-	50ml
Acetic acid glacial	-	5ml
Formalin	-	10ml
Water	-	35ml

After fixing the materials for 24-48 hrs, the materials were washed and preserved in 70 percent alcohol till further use. For anatomical studies root was sampled below the root-shoot transition region at vegetative stage (8 days after removal of treatments).The preserved materials when used were dehydrated through ethanol xylene series and then infiltrated and embedded in paraffin wax (congealing point 58-60^0 C). Serial transverse sections of roots were cut at 8-10 µm on rotary microtome (Spencer 820 microtome, USA). Affixing of the paraffin ribbons to the slides was made by using synthetic gum.

Conventional combination like safranin and light green stain (Johansen, 1940) were used for studying the aerenchyma formation in roots. The observations were recorded from 10-15 samples from each treatment.

RESULTS AND DISCUSSION

Percent survival: A 40 to 50 % decline was observed in percent survival 1 DAR (day after removal) which further increased to 65 to 90% 8 DAR from waterlogging (W) (8 days) treatment (Table 1) in 20 day old plants. Twelve days W treatment was more deleterious and resulted in 50 to 75% decrease in percent survival 1 DAR which further increased to 100% 8 DAR. Salinity (S) treatment alone had no deleterious effect and no decline in percent survival was observed. Waterlogging and salinity (W+S) treatment in combination was more deleterious resulting in 70 to 80% decrease in percent survival 1 DAR and 100% 8 DAR from 8 days treatment. No survival was observed with 12 days W + S treatment 1 and 8 DAR. Forty day old plants recorded 40 to 80% decrease 1 DAR was which further reached to 100% 8 DAR from 8 days W (Table 1 B). No survival was observed with 12 days W and W + S treatment 1 and 8 DAR. No decline in percent survival was observed under S treatment also in 40 day old plants. ICPH 2431 performed best under W and W + S treatments (8 days and 12 days) followed by PARAS, HO9-33 and UPAS-120 in 20 day as well as 40 day old plants. Kumutha *et al.,* (2008) have reported in green gram that tolerant genotype MH96-1 did not show any mortality even after 8 days of waterlogging and recovery while susceptible genotype MH 1K- 24 showed more than 60% mortality during recovery after 8 days of waterlogging.

Aerenchyma formation: Aerenchyma is a special tissue which consists of continuous gas filled channels or much enlarged gas spaces. Aerenchyma formation was observed

Table 1. Effect of waterlogging, salinity and their combination (8 and 12 days) on survival percent (%) of pigeonpea

Genotype	8day* (1 day)**				12day* (1 day)**			8day* (8 day)**				12day* (8 day)**		
	C	W	S	W+S	W	S	W+S#	C	W	S	W+S#	W#	S	W+S#
							20 days after sowing							
ICPH 2431	100	58	100	35	50	100	0	100	38	100	0	0	100	0
UPAS 120	100	46	100	19	24	100	0	100	15	100	0	0	100	0
HO9 33	100	47	100	26	41	100	0	100	21	100	0	0	100	0
PARAS	100	47	100	33	43	100	0	100	26	100	0	0	100	0
							40 days after sowing							
Genotype	C	W	S	W+S	W#	S	W+S#	C	W#	S	W+S#	W#	S	W+S#
ICPH 2431	100	40	100	20	0	100	0	100	0	100	0	0	100	0
UPAS 120	100	20	100	10	0	100	0	100	0	100	0	0	100	0
HO9 33	100	20	100	10	0	100	0	100	0	100	0	0	100	0
PARAS	100	30	100	20	0	100	0	100	0	100	0	0	100	0

* Duration of treatment ** Stage of sampling # No survival was observed

under W and W+S treatments (Fig. 1, 2, 3, 4). The control plant there was no aerenchyma formation. Waterlogging treatment (8 days) resulted in increased aerenchyma formation in all the genotypes. Aerenchyma formation was more in ICPH 2431 and Paras which represent the tolerant nature of these genotypes. More aerenchyma formation in ICPH 2431 and Paras was observed when treatments were given to 40 day old plants as compared to 20 day old plants. Eight days and twelve days waterlogging treatment also resulted in increased aerenchyma formation in ICPH 2431 and Paras 8 and 1 Day after removal (DAR) respectively as compared to 1 DAR from 8 days treatment. However not so much increase was observed in UPAS 120 and H09 33. An intensive production of aerenchyma was also observed due to waterlogging in maize cultivars such as cv. *Seneca Horizon* and cv. *Single cross704* Hossain and Uddin, (2011) in wheat and De-Souza *et al.,* (2009) in maize also noticed formation of aerenchyma in root tissue of tolerant variety of wheat in response to anoxia.

No aerenchyma formation was observed with salinity alone. Akhtar *et al*. (1998) however reported that salinity under hypoxic conditions significantly reduced aerenchyma development near the root tip and root shoot interface compared to hypoxia alone

The aerenchyma formation was more in roots of W plus S (30mM NaCl) treated plants as compared to W alone 1 DAR from 8 day treatment in 20 and 40 day old plants. No survival was observed at other stages. Effect of combined waterlogging and salinity was also more when given to 40 day old plants of ICPH 2431 and Paras as compared to 20 day old plants. Naidoo and Mundree, (1993) have also reported decreased central air spaces under waterlogging +

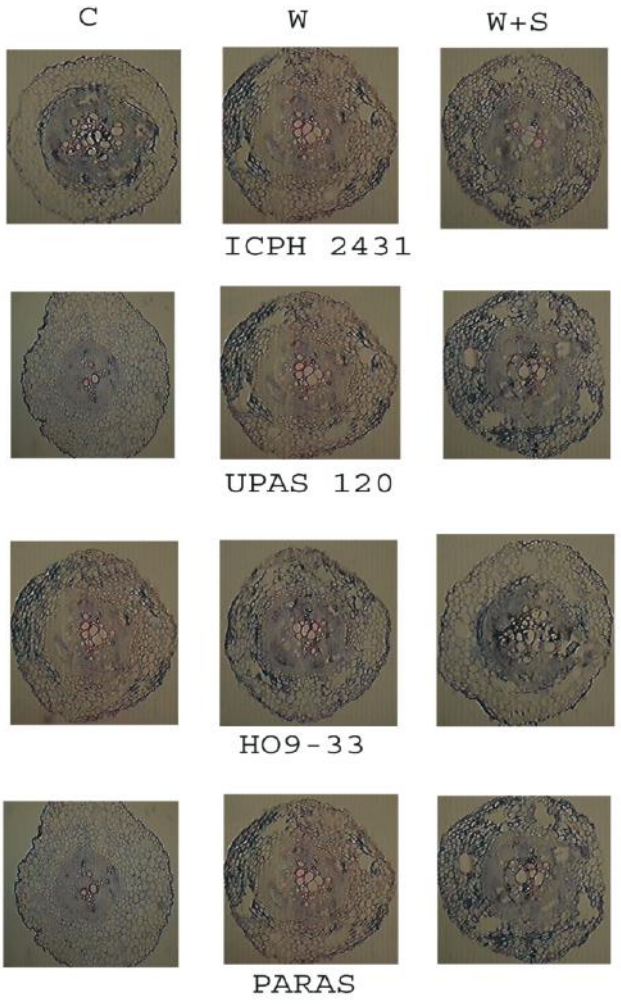

Fig. 1. Aerenchyma formation in roots of 20 day old pigeonpea genotypes 1 DAR from 8 days W and W+S treatments

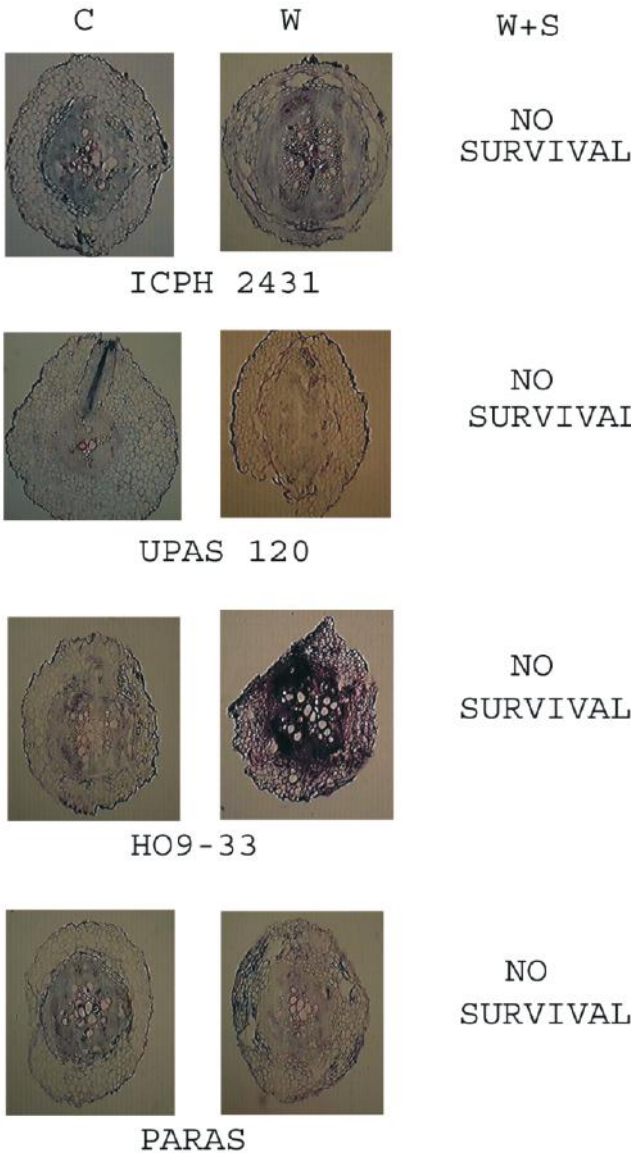

Fig. 2. Aerenchyma formation in roots of 20 day old pigeonpea genotypes 8 DAR from 8 days W and W+S treatments

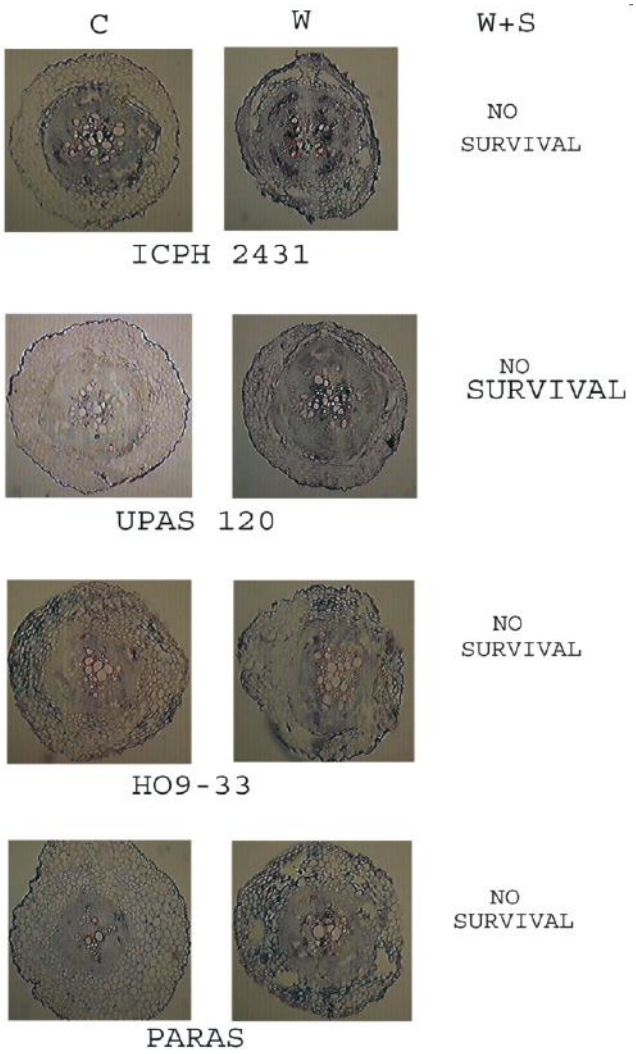

Fig. 3. Aerenchyma formation in roots of 20 day old pigeonpea genotypes 1 DAR from 12 days W and W+S treatments

salinity greater than 100 mM NaCl and suggested that the capacity for aerenchyma induction was reduced by high salinity. In present investigation, the NaCl concentration used with waterlogging was much lower and this may be the reason an increased aerenchyma formation was observed. Haddadi et al., 2016 also observed formation of aerenchyma under combined waterlogging and salinity stress in *Mentha aquatica* . It may concluded from this study that combined stress of waterlogging and salinity is more deleterious compared to these stresses alone and aerenchyma formation is one of the strategy which plants opt to cope up with waterlogging and combined stress. More aerenchyma formation in ICPH 2431 and Paras represent tolerant behavior of these genotypes towards waterlogging and combined stress. It is also concluded from the study that stress become more deleterious when given for long time and at latter vegetative stages.

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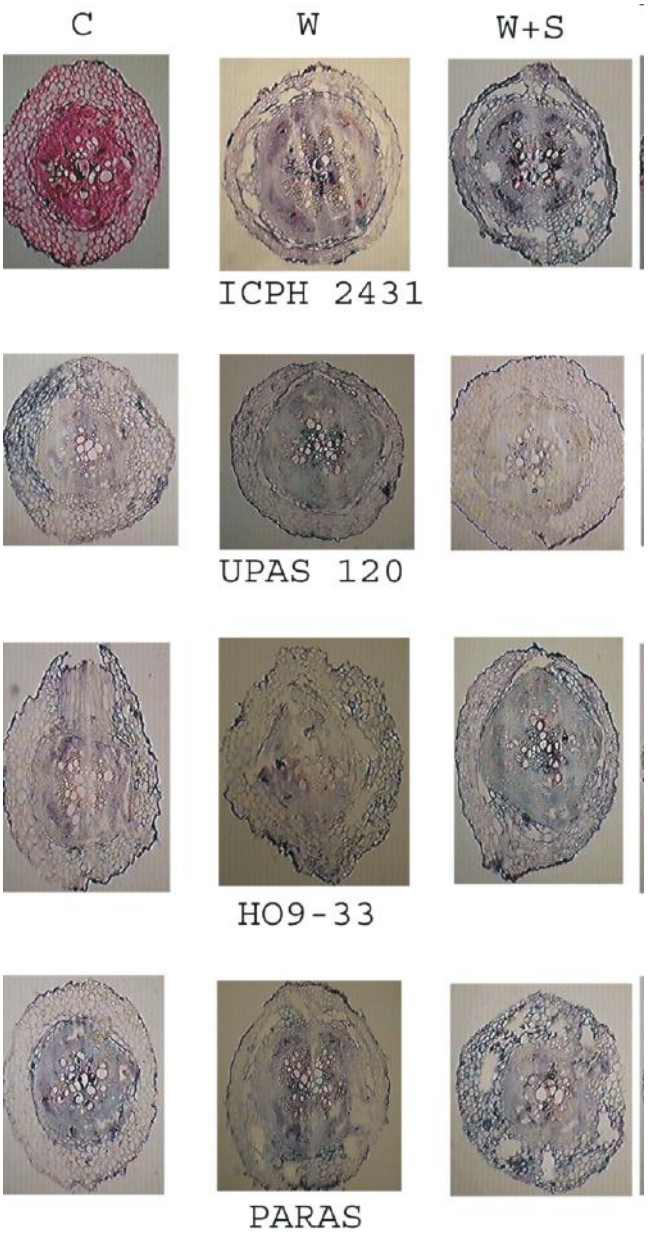

Fig. 4. Aerenchyma formation in roots of 40 day old pigeonpea genotypes 1 DAR from 8 days W and W+S treatments

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A non-Destructive Approach for Identification of Newly Released Rice Hybrid (KRH-4) and its Parental Lines

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***Abstract*:** An experiment was conducted to identify the parental lines and newly released rice hybrid (KRH-4) based on morphological characters and using rapid chemical tests. Most of the morphological characters of female parent and hybrid were similar, whereas male parent can be distinguished from them based on test weight, L/T ratio, dehusked L/W ratio and seed thicknesss. At 50 and 100 ppm, GA_3 and kinetin gave more variation in shoot length between the parental lines and hybrid. Parental lines and hybrid can be distinguished from each other based on seedling growth response to 2, 4-D at 5 and 10ppm. Among the chemical tests, female parent and hybrid reacted positively, whereas male parent reacted negatively to phenol test. Thus it can be effectively used for detecting the admixtures of male parent (no colour change) in hybrid (dark brown) and female parent (light brown) seed lots. Based on the colour reaction to NaOH and KOH test, parental lines and hybrid can be grouped into two categories *viz*., light yellow (MSN36) and dark yellow (CRMS32A and KRH-4). The study revealed that phenol test showed distinct response, which can be effectively used for purity assessment of female parent and hybrid seed lots.

***Key Words*:** KOH, KRH-4, NaoH, Non-destructive approach, Phenol, Parental lines, Rice

Rice is the most important cereal grain of the world. India has the largest acreage under rice growing countries of world but ranks second in production, owing to its lower productivity. Total rice production in India is about 106.65mt with 1,100 rice varieties and 75 hybrids (Anonymous, 2015). A large number of high yielding varieties and hybrids have been developed and notified in the recent past. Hence the need for initial identification of varieties and hybrid identity arises throughout the sequence of events from breeding to release. Beside the plant breeder's rights has brought even more exacting requirements for genotype identification and distinctness testing in seed certification. Many researchers have used seed, seedling morphological characters and different chemical tests for varietal identification (Mor*et al*., 2006 and Mallick *et al*., 2013). Even though many studies have revealed that wide variability existed among rice genotypes in seed morphology. Due to narrow genetic base and reduced range of variation among varieties, it is very difficult to distinguish them based on morphological characters alone. Thus many chemical tests have been used to distinguish rice varieties in addition to seed morphological characters. The chemical tests reveal chemical differences among seeds, which does not require any technical expertise, results can be easily interpreted and completed in a relatively short period of time. Phenol colour reaction was used for determining the varietal identification in rice based on colour positive and negative reaction (Chakrabarty *et al*., 2007). Rapid chemical test, NaoH test have been used for identification of eleven popular rice varieties of Assam (Bora *et al*., 2008).Thus in view of these, in the present study various seed morphological characters and biochemical tests are being used simultaneously to reveal differences among the seeds or seedlings of parental lines and hybrid. Karnataka Rice Hybrid-4 is a newly released hybrid which is non-scented, non-shattering with a less dormancy period (10-15 days) and grain yield of 8 to 8.5t/h. It contains high amount of protein (8.52%), fat (1.38%) and carbohydrate (76.88%) compared to earlier popular hybrid KRH-2.

MATERIAL AND METHODS

Pure seeds of parental lines (CRMS32A and MSN36) and rice hybrid (KRH-4) were collected from Zonal Agricultural Research Station, VC Farm, Mandya. Seeds of the parental lines and hybrid were studied for morphometric characters *viz*., seed length (mm), seed width (mm), seed thickness (mm), dehusked seed thickness (mm), dehusked seed length and width (mm) with the help of grain micrometer, seed size (mm^3) was calculated by using the formula $(l \times w \times t)^{1/3}$. Length to width ratio (mm), dehusked length to width ratio (mm), length to thickness ratio (mm) and presence of pearl spot were also recorded. Seed colour was recorded by using Munsell soil colour chart (Anonymous, 1954) and seed pubescence was observed by using Steriobinocular microscope. In each parental lines and hybrid, 25 seeds of eight replicates were used for recording these measurements. Eight replications of 1000 seed each were used to calculate test weight.

Chemical tests *viz*., phenol, modified phenol test

with copper sulphate, NAOH and KOH test were performed. The observations on 100 seeds of four replications were also made for seedling growth response to different chemicals like Gibberellic acid, Kinetin and 2, 4-D. The data were statistically analyzed using completely randomized design with two factorial ANOVA.

Phenol test: The standard phenol test as suggested by Jaiswal and Agarwal (1995) was followed. Four replications of 100 seeds each were soaked in distilled water for 24 hours. The seeds were then placed in petri dishes containing filter paper moistened with 5 ml of 1% phenol solution and kept at room temperature (28°C) for 24 hours. After that, the seeds were examined and grouped into different colour classes as no colour change, light brown, brown and dark brown.

The reliability of phenol test was also checked with known admixture seed lots of desired level of impurities (95, 98, 99 and 100%) by mixing hybrid (KRH-4) with its male parental line (MSN36) and female parent (CRMS32A) with male parental line (MSN36). Seeds of different admixture seed lots were soaked in distilled water for 24 hours. The seeds were then placed in petri dishes containing filter paper moistened with 5 ml of 1% phenol solution and kept at room temperature (28°C) for 24 hours. After that, the seeds were examined and grouped into different colour classes as no colour change, light brown, brown and dark brown.

Modified Phenol test: The procedure of modified phenol test was similar to the standard phenol test as suggested by Jaiswal and Agarwal (1995) except that the seeds were soaked in a solution of 0.5% $CuSo_4$ instead of soaking in distilled water. The seeds were examined and grouped into five distinct groups namely no colour change, light brown, brown, dark brown and black.

NaOH test: Four replications of fifty seeds each were soaked in 3% NaOH solution for 3 hours and thereafter the change in colour of the solution was observed. Based on intensity of colour reaction, the parental lines and hybrid were classified into three groups *viz.,* no change in colour, yellow and light yellow.

KOH test: Four replications of fifty seeds each were soaked in 4% KOH solution for 3 hours and thereafter the change in colour of the solution was observed. Based on intensity of colour reaction, the parental lines and hybrid were classified into two groups *viz*., no change in colour and reddish brown.

Giberellic acid test: Four hundred seeds were soaked in 25, 50 and 100 ppm GA_3 for 24 hours and germinated as per ISTA (2010). The shoot and root length were measured on 14th day and the percentage increase in root and shoot length over control was computed according to Agarwal and Pawar (1990).

Kinetin test: Four hundred seeds were soaked in 25, 50 and 100 ppm kinetin solution for 24 hours and germinated as per ISTA (2010). The shoot and root length were measured on 14th day and the percentage increase in root and shoot length over control was computed according to Agarwal and Pawar (1990).

2, 4-D test: Four hundred seeds were soaked in 5 and 10 ppm 2, 4-D solution for 24 hours and germinated as per ISTA (2010). Observations were recorded on 7th day interms of decrease in shoot and root length over control according to Agarwal and Pawar (1990).

RESULTS AND DISCUSSION

The data of seed morphological characters of parental lines and hybrid (KRH-4) are presented in the table 1. Dehusked seed length, length to thickness ratio, length to width ratio, dehusked length to width ratio, seed size and test weight were statistically significant at 1% probability level. Seed length varied from 7.73 (MSN36) to 8.00 mm (CRMS32A and KRH-4). Similarly the dehusked seed length varied from 5.31 (MSN36) to 5.91 mm (CRMS32A and KRH-4).

Seed width ranged from 2.00 (CRMS32A and KRH-4) to 2.10 mm (MSN36) while dehusked seed width ranged from 1.88 (CRMS32A) to 2.01 mm (MSN36). Based on

Table 1. Seed morphological characters of parental lines and rice hybrid (KRH-4)

Parental lines and hybrid	Seed length (mm)	Dehusked seed length (mm)	Seed width (mm)	Dehusked seed width (mm)	Seed thickness (mm)	Dehusked seed thickness (mm)	Seed size (mm^3)	L/W Ratio	Dehusked L/W Ratio	L/T Ratio	Test weight (g)
CRMS32A	8.00 (M)	5.91 (S)	2.00 (N)	1.88 (M)	2.00 (M)	1.93 (H)	3.16 (M)	3.98 (E)	3.20	3.98 (B)	15.33 (VL)
KRH-4	8.00 (M)	5.91 (S)	2.00 (N)	1.93 (M)	2.10 (B)	2.01 (H)	3.11 (M)	4.05 (E)	3.08	3.78 (B)	15.21 (VL)
MSN36	7.73 (M)	5.31 (S)	2.10 (N)	2.01 (M)	2.80 (B)	2.05 (H)	3.51 (L*)	3.71 (E)	2.64	2.83 (B)	17.61 (L)
Mean	7.92	5.71	2.03	1.94	2.30	2.00	3.26	3.91	2.99	2.99	16.05
SEm±	0.04	0.03	0.02	0.03	0.02	0.04	0.03	0.04	0.03	0.03	0.05
CD (p=0.01)	0.16	0.12	0.11	0.10	0.11	0.15	0.09	0.16	0.10	0.13	0.19
CV (%)	1.52	1.46	4.09	3.82	3.60	5.17	2.09	2.99	2.41	2.58	0.87

M-Medium, S-Short, N-Narrow, B-Bold, H-High, L*-Large, E-Elongated, L-Light, VL-Very light

dehusked seed length and width both parental lines and hybrid were grouped into short and medium. Similarly Mallick *et al*. (2013) reported that grain length and width of newly released rice variety BNKR-1 is short and medium type. The seed thickness varied from 2.00 (CRMS32A) to 2.80 mm (MSN36) where as dehusked seed thickness values varied from 1.93 to 2.05. The length to width ratio was ranged from 3.71 (MSN36) to 4.05 mm (CRMS32A and KRH-4). Besides, the length to thickness ratio was ranged from 2.83 (MSN36) to 3.98 mm (CRMS32A). Thus, the parental lines and hybrid rice (KRH-4) are of elongated and bold type. Significant differences were not observed between the parental lines and hybrid for test weight. Based on seed index, the parental lines and hybrid rice were grouped into light (MSN36) and very light type (CRMS32A and KRH-4). The values ranged from 15.21 g (CRMS32A) to 17.61 g (MSN36). Based on dehusked grain shape, the parental lines and hybrid were grouped into semi long (MSN36) and elongated type (CRMS32A and KRH-4). The parental lines and hybrid showed significant difference for seed size, it ranged from 3.11 (KRH-4) to 3.51 mm^3 (MSN36). Based on seed size the parental lines and hybrid were grouped into large (MSN36) and medium type (CRMS32A and KRH-4). Pearl spot was observed both in parent lines and rice hybrid.

An attempt was also made to identify the parental lines and hybrid based on seedling growth response to GA_3, Kinetin and 2, 4-D. There was no significant difference in seedling growth response (shoot length) between male and female parent for GA_3 application at 25ppm (Table 2). The values ranged from 124.9% to 145.2%. Similarly at 100ppm GA_3 female parent and hybrid (168.1%) showed similar performance, male parent (143.4%) can be differentiated them. But at 50ppm GA_3 parental lines (CRMS32A-152.3% & MSN36-135.9%) and hybrid (142.8%) can be differentiated from each other. Significant variations were observed between parental lines and rice hybrid at all concentrations of GA_3 application in terms of root length. Similarly GA_3 at three different concentrations (25, 50 & 100ppm) was used for identification of three rice hybrid and their parental lines by Nethra *et al.* (2007). At 25ppm kinetin, female parent and hybrid (101.2%) exhibited similar seedling growth performance in terms of shoot length where as MSN36 (84.4%) can be differentiated them.

Parental lines and hybrid can be differentiated from each other in terms of shoot length at 50 (97.8 to 110.1%) and 100ppm (95.5 to 112.7%) kinetin application. There was no significant difference in seedling growth response in terms of root length between parental lines and rice hybrid for kinetin application at all the concentrations. But there was a significant difference in seedling growth response between control and kinetin in terms of root length. The values are low in control compared to treated as cytokinin inhibit root initiation, elongation and development but the number of studies on this aspect is limited (Zaochang Liu. 2000). Cytokinin can inhibit root elongation (Scott. 1984) especially when applied to the roots growing in the dark. There was significant difference in seedling growth response (root and shoot length) between parental lines and rice hybrid to 2, 4-D at different concentrations. At 5ppm 2, 4-D, parental lines (CRMS32A-117.2% & MSN36-103.1%) and hybrid (58.3%) can be differentiated from each other. Similarly Anitalakshmi *et al*. (2014) grouped the eightenn rice genotypes based on seedling growth response to 2,4-D. Significant decrease in shoot length to 2, 4-D at different concentrations was observed in KRH-4 compared to parental lines. The differences in seedling growth response of genotypes might be due to differential ethylene production upon application of 2,4-D (Sundaru *et al.,*1983).The values at 10ppm 2, 4-D ranged from 60.0% (KRH-4) to 100.0% (MSN36) in terms of shoot length. There was significant difference in seedling growth response between 2, 4-D and control at 5ppm both in terms of shoot and root length. It might be due to fact that, 2, 4-D at some concentrations exhibits auxin like effect (Anonymous, 2013) to promote cell division and elongation even though it's a growth inhibitor. Hence, the values are more in treated compared to untreated.

In the present study, CRMS32A (light brown) and KRH4 (dark brown) reacted positively as where MSN36 (no change in colour) reacted negatively to standard phenol test. Based on modified phenol test with copper sulphate, the parental lines and hybrid were further sub grouped in to three groups as no change in colour (MSN36), dark brown (CRMS32A) and black (KRH-4). Similarly Janaiah *et al.* (2003) used phenol colour test and its modifications to identify rice varieties with uniform negative colour reaction Beside the reliability of the phenol test was also checked with known admixture seed lots of desired level of impurities (95, 98, 99 and 100%) created by mixing F_1 hybrid (KRH-4) with male parental line (MSN36) (Fig 1) and female parent (CRMS32A) with male parental line (MSN36). The validation of phenol test was also confirmed that the percentage admixture detected is at par with deliberate mixing. Based on the colour reaction to NaOH and KOH test, parental lines and hybrid can be grouped into two categories *viz*., light yellow (MSN36) and dark yellow (CRMS32A and KRH-4). Similar observations were made by Vijayalakshmi and Vijay (2009) in twenty three rice genotypes.

In conclusion, the present study reveals that most of the morphological characters of female parent and hybrid were similar. Further seedling growth response of parental lines and

Table 2. Seedling growth (shoot length and root length in cm) response of parental lines and rice hybrid (KRH-4) to different chemicals

		Shoot length (cm)				Root length (cm)			
Seedling growth response to GA_3 in parental lines and rice hybrid (KRH-4)	Genotypes	Control	25ppm	50ppm	100ppm	Control	25ppm	50ppm	100ppm
	CRMS32A	8.03	10.03 (124.9)	12.23 (152.3)	13.50 (168.1)	13.13	15.00 (114.2)	15.00 (114.2)	16.26 (123.8)
	KRH-4	8.26	12.00 (145.2)	11.80 (142.8)	13.90 (168.2)	14.10	15.13 (108.5)	15.13 (107.3)	16.36 (116.0)
	MSN36	9.90	12.46 (125.8)	13.46 (135.9)	14.20 (143.4)	15.96	16.13 (101.0)	15.30 (95.8)	16.76 (105.0)
	Mean	8.73	11.49 (131.9)	12.49 (140.3)	13.86 (159.9)	14.40	15.42 (107.9)	15.14 (105.7)	16.46 (114.9)
			Genotypes(G)	Concentration(C)	G×C		Genotypes(G)	Concentration(C)	G×C
		SEm±	0.05	0.06	0.10	SEm±	0.06	0.07	0.12
		CD (p=0.01)	0.20	0.23	0.34	CD (p=0.01)	0.23	0.26	0.46
			CV(%) 1.49				CV(%)1.30		
Seedling growth response to Kinetin in parental lines and rice hybrid (KRH-4)	Genotypes	Control	25ppm	50ppm	100ppm	Control	25ppm	50ppm	100ppm
	CRMS32A	8.03	8.23 (102.4)	7.86 (97.8)	8.68 (108.0)	13.10	10.06 (76.6)	8.63 (65.7)	8.06 (61.3)
	KRH4	8.26	8.36 (101.2)	9.10 (110.1)	9.31 (112.7)	14.10	10.16 (72.0)	9.26 (65.6)	8.71 (61.7)
	MSN36	9.90	8.36 (84.4)	10.10 (102.0)	9.46 (95.5)	15.90	12.00 (75.1)	10.06 (63.0)	10.03 (62.8)
	Mean	8.73	8.20 (96.0)	9.00 (103.3)	9.10 (105.4)	14.30	10.74 (74.6)	9.31 (64.7)	8.93 (61.0)
			Genotypes(G)	Concentration(C)	G×C		Genotypes(G)	Concentration(C)	G×C
		SEm±	0.05	0.05	0.09		0.07	0.08	0.14
		CD (p=0.01)	0.18	0.20	0.35		0.28	0.32	0.56
			CV(%) 1.78				CV(%)2.29		
Seedling growth response to 2,4-D in parental lines and rice hybrid KRH-4)	Genotypes	Control	5ppm	10ppm		Control	5ppm	10ppm	
	CRMS32A	2.90	3.40 (117.2)	2.10 (72.4)		6.10	7.90 (130.0)	3.10 (50.8)	
	KRH4	3.60	2.10(58.3)	2.10 (60.0)		8.10	6.10 (75.3)	5.30(65.4)	
	MSN36	3.20	3.30(103.1)	3.20 (100.0)		8.20	8.30(101.2)	6.2 (75.6)	
	Mean	3.20	2.90 (92.8)	2.40 (77.4)		7.40	7.40 (102.1)	4.8 (63.9)	
		Genotypes (G)	Concentration	G×C			Genotypes (G)	Concentration (C)	G×C
	SEm±	0.03	0.03	0.05			0.03	0.03	0.05
	CD (p=0.01)	0.12	0.12	0.21			0.12	0.12	0.21
			CV(%) 3.33				CV(%) 1.40		

Values in Paranthesis indicate per cent increase over control (GA_3, Kinetin and 2, 4D)

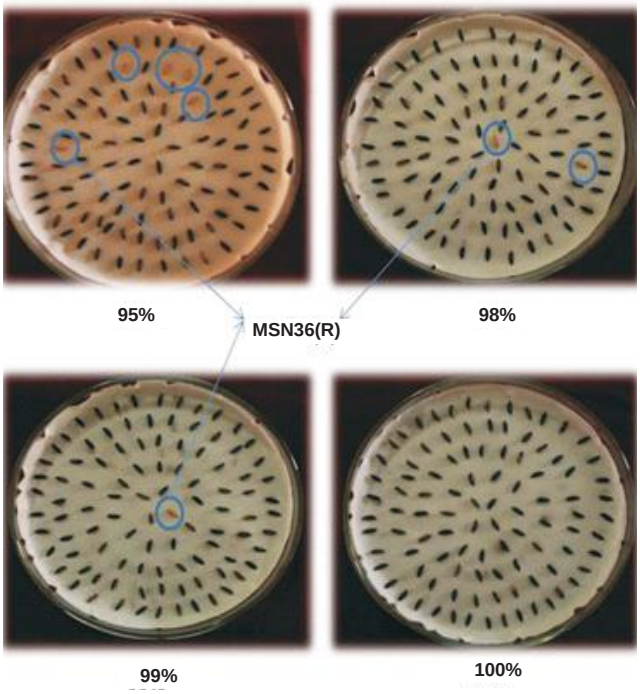

Fig. 1. Validation of phenol test for detecting admixtures of MSN36 with KRH-4 seeds

hybrid to different chemicals GA_3 & Kinetin at some concentrations was almost similar whereas 2, 4-D at 5 and 10 ppm can be used for distinguishing rice hybrid and its parental lines. Phenol test gave the stable results which can be effectively used for detecting the admixtures of male parent in hybrid and female parent seed lots. Even though based on colour reaction to KOH and NaOH test male parent can be distinguished from female parent and hybrid, still the protocol as to be refined. Based on few morphological characters male parent can be distinguished from hybrid and female parent. However the individual morphological characters of seed and single chemical test may not be quite effective in identifying the parental lines and hybrid, it as to be used in conjunction with each other.

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Assessment of Groundwater Quality for Irrigation Purposes using Chemical Indices

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Abstract: Eighty one groundwater samples were collected and analyzed for various hydrochemical parameters like EC, pH, Na^+, K^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, Cl^-, HCO_3^-, CO_3^{2-}, NO_3^- and F^-, Irrigation indices such as Sodium adsorption ratio (SAR), Sodium percentage (Na%), Residual sodium carbonate (RSC), Permeability Index (PI), Kelly's Ratio (KR), Magnesium Hazard (MH) and Hardness were also calculated. The SAR, Na%, RSC, PI, KR, MH and hardness varied from 4.03 to 24.16 $(mmol\ l^{-1})^{1/2}$, 53.55 to 93.00%, 0 to 9.2 meq l^{-1}, 57.27 to 148.99, 1.11 to 13.14, 64.29 to 81.11 and 29.92 to 2403.30 mg l^{-1}, respectively. The analysis of the various parameters indicated the moderate suitability of groundwater for irrigation purpose.

Key Words: Groundwater, Kelly's ratio, Permeability index, Residual sodium carbonate, Sodium adsorption ratio

Water is a universal solvent, having the ability to dissolve most of the organic or inorganic substances. It is found both above and below the surface of earth. The water found underground in the cracks and spaces in soil, sand and rock is referred to as groundwater. Water resources of the globe have been categorised in different types based on their availability and suitability for different purposes. The shrinking of global surface water resources due to the exploitation and contamination with various chemical and biological sources is adding enormous pressure on groundwater resources (Singh *et al*., 2006). Presently groundwater is the most important source of irrigation in India, thus deserving considerable attention for use in a sustainable way quantitatively and qualitatively. Evaluation of groundwater quality for irrigation is of paramount importance to arid and semi-arid regions of the world in general and to developing countries like India in particular. Good quality water is needed to feed the rapidly expanding population, for expansion of irrigated farming and mushroom growth of industrial settings (Toumi *et al*., 2015). The suitability of any source of water for irrigation purpose depends on the quality of water, its elemental composition, type of soil, salt tolerance characteristics of the plants, climate and drainage features of the soil. On similar terms, suitability of groundwater for irrigation purposes is characterised based on its quality, varying both spatially as well as temporally. The spatial variations are due to its natural hydrogeological setting, while the temporal variability in a particular area is often assigned to anthropogenic reasons (Adhikari *et al*., 2012).

Measurable quantities of dissolved substances, usually referred as salts, are always present in irrigation water. These salts include comparatively small but significant amounts of dissolved solids arising from dissolution or weathering of rocks and soil and dissolving of lime, gypsum and other salt sources. The quantity and kind of salt present will determine the suitability of water for irrigation. The poor quality water creates several soil and cropping problems, which then requires specific management practices for its alleviation and maintenance of crop productivity. Consequently, with good quality water, there ought to be very occasional or no problems affecting productivity (Ayers and Westcot, 1976).

The association of chloride/sulphate and/or carbonate/bicarbonate with excess of sodium ions characterizes the water as saline or alkaline. Subsequently, the soils develop salinity or sodicity problems when irrigated with such type of water; more particularly in absence of drainage and soil management. Although, studies were made in the past to characterise water quality zones in Haryana state, but major alteration has occurred over years owing to overuse of groundwater and change in cropping pattern (Phogat *et al*., 2008). The present study was undertaken to ascertain the hazards of groundwater vis-a-vis its suitability for irrigation in block Gohana, Sonipat of the Haryana state.

MATERIAL AND METHODS

The study area, located at Gohana block, Sonipat,

Haryana, India, at latitudes of 28º 57' and 29º 12' N and longitudes of 76º 38' and 76º 52' E, forms a part of the Indo-Gangetic plains and displays flat terrain with general slope from north to south. The area is devoid of any high topographic features; however, a natural depression exists in north and northwest of block. The maximum elevation of the plain is about 230 m above mean sea level (Central Groundwater Board, 2008).

In order to assess water quality of the study area, 81 groundwater samples were collected to cover the entire study area and the map is presented in (Fig. 1). Sampling was carried out using pre-cleaned plastic bottles, which were rinsed three times with sample water prior to sample collection. Before analysis of groundwater, the instruments were calibrated in accordance with the manufacturer's recommendations. The chemical analysis was accomplished at CCS Haryana Agricultural University, Hisar, India as per the standard methods relevant to the analysis of groundwater (Table1). Electrical Conductivity (EC) was measured by conductivity meter (Jenway 4510 Conductivity meter) and pH by Genway 3510 digital pH meter. Sodium (Na^+) and potassium (K^+) were measured by flame photometer (Jenway model PFP6). Calcium and magnesium were determined with standard EDTA solution titrimetrically. Carbonate and bicarbonate were estimated by titration with H_2SO_4, Chloride by titrating against standard silver nitrate ($AgNO_3$) solution. The colorimetric analysis of sulphate, nitrate and fluoride was done by spectrophometer. Measurements were done in triplicate to ensure reliability and good quality control. Sodium Percentage, Sodium Adsorption Ratio, Residual Sodium Carbonate, Magnesium Hazard, Permeability Index, Kelly's Ratio and Total Hardness were computed, using the standard formulae:

a) Sodium percentage (Na%):

$$\frac{Na \quad K}{Ca^2 \quad Mg^2 \quad Na \quad K} \quad 100$$

b) Sodium adsorption ratio (SAR) {Ayers and Westcot 1976}

$$SAR \ mmoll^{1} \ ½ \quad \frac{Na}{\sqrt{\frac{Ca^2 \quad Mg^2}{2}}}$$

c) Residual sodium carbonate (RSC) (Eaton 1950):

$$RSC \ meql^{1} \quad HCO_3 \quad CO_3^2 \quad Ca^2 \quad Mg^2$$

d) Magnesium hazard (MH) (Szabolcs and Darab, 1964):

$$\frac{Mg^2}{Ca^2 \quad Mg^2} \quad 100$$

e) Permeability Index (PI) (Doneen, 1964):

$$\frac{Na \quad \sqrt{HCO_3}}{Ca^2 \quad Mg^2 \quad Na} \quad 100$$

f) Kelly's Ratio (KR) (Kelly, 1940):

$$\frac{Na}{Ca^2 \quad Mg^2}$$

g) Total hardness: $CaCO_3 \quad 2.5 \ Ca^2 \quad 4.1 \ Mg^2$

RESULTS AND DISCUSSION

Sodium and magnesium were dominant cations which separately accounted for 72.05 and19.48% of the total cations, respectively. Calcium and potassium ions were secondary in importance (6.75 and 1.72%, respectively) while as chloride and bicarbonate were the major anions accounting for 60.88 and 21.49%, of total anions in the study area. Sulphate ions were of secondary importance (16.81%). Bicarbonates, nitrate and fluoride were however negligible. Nevertheless, sodium is crucial in irrigation water as it is extremely harmful to plants. Potassium was present in negligible concentration. Calcium and magnesium are also essential for irrigation, as in some cases the ions help to counterbalance the effects of sodium (Singh *et al.*, 2005). Based on pH, 56.8% samples were normal, 42% had moderate and 1.2% samples had severe problem (Table 2); more than half of the samples were neutral in reaction

Electrical conductivity: Irrigation water quality classification based on salinity shows that 66.7, 29.6 and 3.7% of water samples belong to excellent, good and permissible categories, respectively (Table 2). None of the sample was found to be unsuitable for irrigation as per this classification (Richards, 1954).

Chloride: In the present study, 29.6% samples were found highly suitable, 28.4% were moderately suitable for irrigation. However, 42% samples were unsuitable for irrigation because of severe chloride hazard (Table 2).

Nitrate: Nitrate concentrations in the groundwater samples varied from 0.59 to 55 mg l^{-1} with the average of 12.24 mg l^{-1} (Table 2). The pollution of groundwater by nitrates has been ascertained enormously across the world during recent years (Nas and Berktay, 2006). The concentration of nitrate greater than 45 mg l^{-1} causes a disease in humans called as methemoglobinemia or blue baby syndrome. The possible origin of nitrate in agricultural areas include fertilizer, animal waste and mineralization of soil organic N (in plant residues, bacterial biomass and soil constituents). Due to intensive agriculture, large amounts of N fertilizers commonly urea, nitrate or ammonium compounds are applied which result in higher concentration of nitrate in the areas of intensive arable production (Jalali, 2005).

For accomplishing maximum crop productivity, the water used for irrigation should be of good quality. Thus, for classification and evaluation of groundwater quality the chemical parameters play a significant role. Therefore, to

Table 1. Methods used for estimation of different hydrochemical parameters of groundwater in the study area

Parameters	Method used
pH	Glass electrode (Richards, 1954)
EC (Electrical Conductivity)	Conductivity Bridge method (Richards, 1954)
Na^+ (Sodium)	Flame Photometric method (Osborn and Johns, 1951)
K^+ (Potassium)	Flame Photometric method (Osborn and Johns, 1951)
Ca^{2+} (Calcium) and Mg^{2+} (Magnesium)	EDTA titration method (Richards, 1954)
CO_3^{2-} (Carbonate) and HCO_3^- (Bicarbonate)	Acid titration method (Richards, 1954)
Cl^- (Chloride)	Mohr's titration method (Richards, 1954)
NO_3^- (Nitrate)	Spectrophotometric method (Richards, 1954)
SO_4^{2-} (Sulphate)	Turbidity method using $CaCl_2$(Chesnin and Yien, 1950)
F^- (Fluoride)	Cyanine-R Lake Method (Megregian, 1954)

assess water quality for different uses, water quality indices such as SAR, RSC, Mg-hazard (MH), permeability index, Kelly's ratio, hardness and sodium percentage were calculated from the chemical analyses of 81 groundwater samples.

Percent Sodium: As per the classification suggested by Wilcox (1955) for Na%, the value of <60 in groundwater is suitable for irrigation purposes. The percent sodium values of the study area varied from 53.55 to 93.00%. Only 1.2% samples showed Na% within permissible limits, while as, 70.4% and 28.4% samples were doubtful and unsuitable for irrigation purposes, respectively (Table 2). The higher Na may be attributed to long residence time of water, dissolution of minerals from lithological composition and addition of chemical fertilizers with irrigation waters (Subba Rao *et al.,* 2002).

Sodium Adsorption Ratio (SAR): The SAR values ranged from 4.03 to 24.16 (mmol $l^{-1})^{1/2}$ and according to the Richards classification of SAR 50.6%, 44.4% and 4.9% samples belonged to the excellent, good and doubtful categories, respectively (Table 2). However, none of the samples was found unsuitable for irrigation as per this classification. SAR can indicate the degree to which irrigation water tends to enter into cation-exchange reactions in soil. Sodium replacing adsorbed calcium and magnesium is a hazard as it causes damage to the soil structure and the soil becomes compact and impervious (Raju, 2007).

Residual Sodium Carbonate (RSC): Based on RSC, 58% samples were of good quality and safe for irrigation, 4.9% were classified as permissible and 37% samples were found unsuitable for irrigation (Table 2).

Magnesium Hazard (MH): Magnesium hazard less than 50 is considered suitable for irrigation whereas greater than 50 is insidious and unsuitable for irrigation, decreasing the yield of crops and making the soil more alkaline. The values of MH in the study area varied from 64.29 to 81.11 indicating that the water is unfit for irrigation (Table 2).

Permeability Index (PI): Permeability index is a crucial parameter for assessing the suitability of irrigation water. In accordance with PI, water can be classified as Class I, II and III. Class I and II water are categorized as good for irrigation with 75% or more of maximum permeability. Class III water is unsuitable with 25% of maximum permeability (Table 2). The PI values of the groundwater samples varied from 57.27 to 148.99 with a mean of 90.55.

Kelly's Ratio (KR): Waters with a KR value <1 are regarded suitable for irrigation, while those with higher values are considered unsuitable (Table 2). KR values of groundwater varied from 1.11 to 13.14, therefore, water analysed is unsuitable for irrigation in accordance with Kelly's ratio.

Hardness: Determination of water hardness is a utilitarian test to evaluate quality of water for domestic, agricultural and industrial uses (Sappa *et al*., 2014). The hardness of water is generally caused by calcium and magnesium. However, total hardness of water can be classified into two types, i.e., temporary and permanent hardness. Since, the temporary hardness almost can be removed by boiling the water; nevertheless, the permanent hardness can not be removed by boiling. Total hardness is the summation of temporary and permanent hardness.

Sawyer and McCarty (1967) classified water that contains <75 mg l^{-1} $CaCO_3$ as soft, 75–150 mg l^{-1} $CaCO_3$ as moderately hard, 150 –300 mg l^{-1} $CaCO_3$ as hard and >300 mg l^{-1} $CaCO_3$ as very hard (Table 2). The total hardness values of groundwater samples varied from 29.92 to 2403.30 mg l^{-1}. As per this classification, more than 60% samples were found hard to very hard type. The classification of water based on total hardness shows that most of the groundwater samples fall between moderately hard and very hard water type. The hydrochemical characteristics of groundwater in the study area are shown in Table 3 by descriptive statistics method.

Table 2. Classification of groundwater based on various parameters

Parameter	Range	Water Class	Number of Samples	Percentage
pH	6.5-8.4	No problem	46	56.8
	5.1-6.4 and 8.5-9.5	Moderate	34	42.0
	0-5.0 and 9.5+	Severe	1	1.2
EC (ìScm $^{-1}$)	<250	Excellent	0	0
	250-750	Good	11	13.58
	750-2250	Permissible	42	51.85
	>2250	Unsuitable	28	34.57
Cl^- (me l^{-1})	<4	No problem	24	29.6
	4-10	Moderate	23	28.4
	>10	Severe	34	42.0
NO_3^- (mg l^{-1})	<5	No problem	19	23.5
	5-30	Moderate	60	74.1
	>30	Severe	2	2.5
Na (%)	<20	Excellent	0	0
	20-40	Good	0	0
	40-60	Permissible	1	1.2
	60-80	Doubtful	57	70.4
	>80	Unsuitable	23	28.4
SAR (mmol l^{-1})$^{1/2}$	<10	Excellent	41	50.6
	10-18	Good	36	44.4
	18-26	Doubtful	4	4.9
	>26	Unsuitable	0	0
RSC (meq l^{-1})	<1.25	Safe	47	58.0
	1.25-2.50	Permissible	4	4.9
	>2.50	Unsuitable	30	37.0
MH	<50	Suitable	0	0
	>50	Unsuitable	81	100
PI	<25(Class III)	Unsuitable	0	0
	25-75(Class II)	Good	12	14.82
	>75(Class I)	Excellent	69	85.18
KR	<1	Suitable	0	0
	>1	Unsuitable	81	100
Hardness ($CaCO_3$ mg l^{-1})	<75	Soft	9	11.1
	75-150	Moderately hard	21	25.94
	150-300	Hard	25	30.86
	>300	Very hard	26	32.1

Sodium and magnesium were the dominant cations, while as chloride and bicarbonate as the dominant ions in saline and/or alkaline water. The assessment for other elements like fluoride, nitrate is also important for quality food production and sustainable land use, as their high concentration in irrigation water makes the soil sick. Though EC, RSC, SAR are the main indices describing water quality, but they are well reported in literature from time long. Other indices, like MH, PI, KR and total hardness are also important indices describing water quality. MH represents the dominance of Mg^{2+} with respect to concentration of Ca^{2+} and Mg^{2+}. PI is used as a criterion, representing the soil permeability as affected by long term use of irrigation water. KR, indicated as the fraction of Na^+ with respect to Ca^{2+} and Mg^{2+}, shows the dominance of Na^+ in irrigation water, a good index of water quality. Total hardness is a utilitarian test to evaluate quality of water for domestic, agricultural and industrial uses.

Table 3. Statistical evaluation of groundwater quality parameters by descriptive statistics method

Parameter	Minimum	Maximum	Mean	Std. deviation	Variance	Skewness	Kurtosis
EC (ìScm $^{-1}$)	290	15760	2743.33	23.52	8.26	2.41	7.18
pH	7.19	9.72	8.18	0.55	0.30	0.16	-0.68
CO_3^{2-} (meq l^{-1})	0	4.0	0.24	0.45	0.20	7.26	60.50
HCO_3^- (meq l^{-1})	0.5	12.4	4.81	2.92	8.52	0.75	-0.36
Cl^- (meq l^{-1})	0.8	115.4	17.79	22.83	521.34	2.23	5.90
SO_4^{2-} (meq l^{-1})	0.15	31.39	4.92	6.18	38.27	2.37	6.22
NO_3^- (mg l^{-1})	0.59	55.00	12.25	9.39	88.22	1.30	4.02
F^- (mg l^{-1})	0.08	1.52	0.915	0.43	0.18	-0.26	-1.13
Ca^{2+} (meq l^{-1})	0.2	12.0	1.93	2.29	5.25	2.55	7.90
Mg^{2+} (meq l^{-1})	0.4	36.2	5.56	6.68	44.72	2.50	7.57
Na^+ (meq l^{-1})	2.85	114.60	20.58	19.84	393.94	2.34	6.95
K^+(meq l^{-1})	0	1.0	0.49	0.23	0.05	0.26	-0.42
SAR (mmol $l^{-1})^{1/2}$	4.03	24.16	10.59	4.14	17.14	0.74	0.22
RSC (meq l^{-1})	0	9.2	2.22	2.82	7.93	1.03	-0.20
Hardness (mg l^{-1})	29.92	2403.30	373	446.79	19900	2.51	7.69
Na %	53.55	93.00	76.52	6.61	43.70	-0.07	1.24
Kelly's ratio	1.11	13.14	3.61	1.96	3.86	2.96	11.28
Permeability index	57.27	148.99	90.54	15.04	226.34	0.80	1.79
Magnesium hazard	64	81	73.90	3.19	10.21	-0.55	0.74

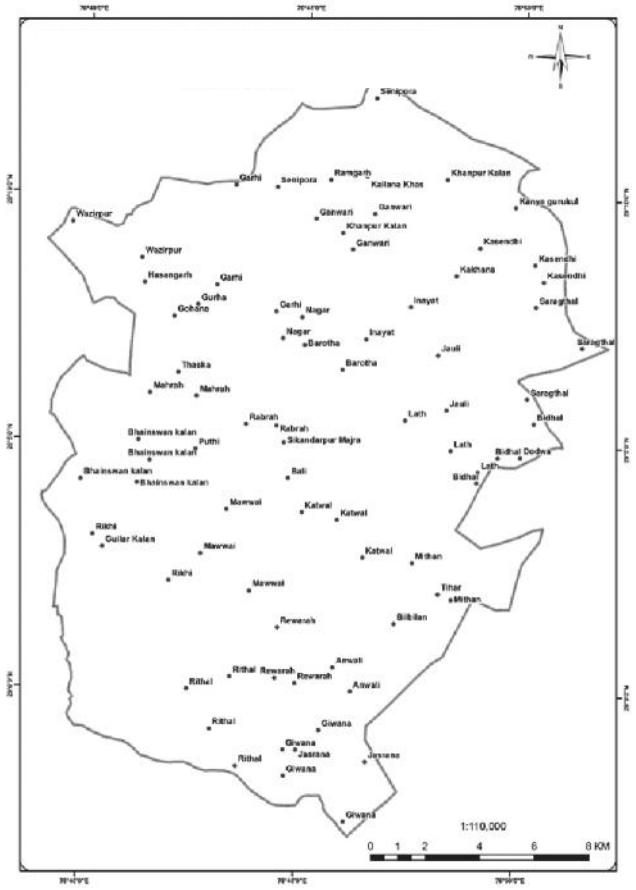

Fig. 1. Map of the groundwater sampling locations in Gohana block

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Water Management Strategies for Sustainable Agriculture

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***Abstract*:** The present study entitled "Water Management Strategies for Sustainable Agriculture" focused on declining water table in central Punjab, water-logging and brackish water in south- western parts and erratic rainfall and water run-off in *Kandi* areas are major problems in Punjab to be tackled. Declining water resources is an Alarm Bell for Agriculture. This paper discussed agronomic practices affecting the environment and prevailing issues and concerns related to agricultural water management. A variety of measures such as laser land leveling, transplanting of paddy in second fortnight of June, bed planting of wheat, Direct seeded rice, zero tillage, Tensiometer aided irrigation, drip irrigation, sprinkler irrigation, happy seeder, mulching, water saving cropping systems, protected cultivation: poly-houses and low tunnels, rain water harvesting, micro irrigation, etc. could greatly augment the utility of water resources. The crop diversification and adoption of short breeding varieties should be adopted for resource conservation. The government policy decisions to arrest the trend of rapidly falling groundwater are also discussed.

***Key Words*:** Agronomic practices, Sustainable agriculture, Water management

Water is the very basis of life and is the foundation for human survival and development. Sustainable and equitable use of water over millennia has been ensured by cultural adaptation to water availability through water conservation technologies, agricultural systems and cropping patterns adapted to different climatic zones, and conservation-based life styles. But in the last few decades the consequences of climate change, population growth, industrialisation and urbanisation, and the associated consumerist culture, have interfered with the natural hydrological cycle of rainfall, soil moisture, groundwater, surface water and storage of all sizes. India is the largest groundwater user in the world, with an estimated usage of around 230 km^3 per year. Agricultural demand for irrigation is already the single largest draw on India's water, yet estimates by the Ministry of Water Resources indicate that by the year 2050 irrigation needs will rise by 56%. From the climate change viewpoint, India's groundwater hotspots are concentrated in the seven states i.e. Punjab, Rajasthan, Maharashtra, Karnataka, Gujarat, Andhra Pradesh, and Tamil Nadu (Shah, 2009). Northwestern India is the country's breadbasket. The state like Punjab, having semi-arid climate and highly seasonal monsoon precipitation, with only 1.57% of the total geographical area, is contributing 27–40% rice, 55–65% wheat and 18–25% cotton to the central pool since the last three decades. But these contributions to nation's central pool mean that this lush productivity comes at a cost. The dropping water levels in this region are largely attributed to unsustainable consumption of groundwater for irrigation and other uses along with increased runoff and/or evapo-transpiration, which climate change may further exacerbate.

According to Water Policy and Action Plan 2020, the proper management of our limited water resources will be essential to ensure food security for our growing population and to eliminate poverty. It will be essential to avoid the growing conflicts and the possibility of social unrest in the country in future due to water scarcity. To minimize the negative impacts of the overuse and misuse of water and to ensure that our precious water resources are used optimally in removing poverty and achieving economic and human development. Therefore, there is a need to develop water management strategies for sustainable agriculture. Provision of subsidized electricity for agricultural irrigation, national food procurement and distribution system at a guaranteed price, and traditional land and water management practices are some of the major culprits for the rapid depletion of groundwater in India (Perveen *et al.,* 2012).

MATERIAL AND METHODS

The studies relating to the practices followed by the farmers that deteriorate the environment and water management for sustainability of irrigated agriculture conducted by different scientists have been consulted and analyzed thoroughly. A critical review of the same has been specified in the results and discussion.

RESULTS AND DISCUSSION

Poor Land leveling: Leveling, smoothing and shaping the field surface is as important to the surface system as the design of laterals, manifolds, risers and outlets is for sprinkler or trickle irrigation systems. It is a process for ensuring that the depths and discharge variations over the field are

relatively uniform and, as a result, that water distributions in the root zone are also uniform. These field operations are required nearly every cropping season, particularly where substantial cultivation following harvest disrupts the field surface. The preparation of the field surface for conveyance and distribution of irrigation water is as important to efficient surface irrigation as any other single management practice the farmer employs. Sometimes farmers grow crops without level their crops which results in shrinking water resources owing to over exploitation of ground water in Punjab threatens the maintenance of agricultural productivity. As a result, the water table is falling in 90% area of the state.

Lack of Pre-treatment of seed and soil before sowing: Before sowing, certain seeds first require a treatment prior to the sowing process. This treatment may be seed scarification, stratification, seed soaking or seed cleaning with cold (or medium hot) water. The application of certain chemicals and nutrients to seed helps protect seedlings against insect pests and fungal pathogens, and counter nutrient disorders early in crop life. This treatment of the seed improves seedling establishment and has significant effects on crop yield and profitability. Seed treatment refers to the application of fungicide, insecticides or a combination of both, to seeds so as to disinfect and disinfect them from seed-borne or soil borne pathogenic organism and storage insects.

Selection of high yielding varieties: When India's government launched the Green Revolution more than 40 years ago, it pressured farmers to grow only high-yield wheat, rice and cotton instead of their traditional mix of crops. The new miracle seeds could produce far bigger yields than farmers had ever seen, but they came with a catch: The thirsty crops needed much more water than natural rainfall could provide, so farmers had to dig wells and irrigate with groundwater. The system worked well for years, but government studies show that farmers have pumped so much groundwater to irrigate their crops that the water table is dropping dramatically, as much as 3 feet every year.

Lack of soil testing: Commenting on the soil health of Punjab, Dr Johnston said, “Soil health of the world over is suffering, and the situation in Punjab is even worse because of the multiple cropping system and lack of soil testing before sowing the crops in field here. His advise to the farmers would be that they should get their soil tested for its health before they sow a crop. This way, the farmer will know the exact nutrient that his soil is lacking in, and he can replenish it.” Punjab farmers should get the soil of their fields tested for nutrients before the starting of each cropping pattern. In agriculture, a soil test commonly refers to the analysis of a soil sample to determine nutrient content, composition, and other characteristics such as the acidity or pH level. A soil test can determine fertility, or the expected growth potential of the soil which indicates nutrient deficiencies, potential toxicities from excessive fertility and inhibitions from the presence of non-essential trace minerals.

Early transplanting of rice: Early planting of rice crop during the period of peak evaporative demand results in substantial mining of ground water and threats the sustainability of rice production in Punjab, northwest India. In order to increase yield and water productivity, arrest the mining of ground water, and achieve sustainability of rice production, there is need to adopt water-saving management practices.

Over irrigation / under irrigation: The improper or excessive use of irrigation water has many ecological consequences. The disproportionate use of water in certain areas results in wastage as discernible from water logging of vast cultivated areas caused by the seepage from badly managed canals. It is estimated that nearly 38 per cent of canal water is wasted on account of seepage and evaporation due to use of flood irrigation method. Flooding also results in run off and leaching losses of available fertilizer nutrients, pesticides and soil particles. Excessive use of canal water makes the field vulnerable to soil erosion. Over irrigation because of poor distribution uniformity or management wastes water, chemicals, and may lead to water pollution (Vasisht and Singh, 2000). Under irrigation gives poor soil salinity control which leads to increased soil salinity with consequent build up of toxic salts on soil surface in areas with high evaporation. This requires either leaching to remove these salts and a method of drainage to carry the salts away. Deep drainage (from over-irrigation) may result in rising water tables which in some instances will lead to problems of irrigation salinity requiring watertable control by some form of subsurface land drainage.

Sewage irrigation: Sewage irrigation water applied to the crops particularly vegetables grown on the farms near the urban areas have adverse effects on the health of the population consuming this agricultural produce. There is adverse impact on the health of the workers who are working on sewage irrigated farms. Sewage water pollution is due to higher concentration of CO_3 + HCO_3 than Ca +Mg, presence of heavy metals and high contents of cyanides and chromium. Sewage water effects adversely as elements get deposited on surface soil and hence soil pH gets affected. Plants grown on sewage irrigated soils are found to be rich in heavy metals which enter in to human body through food. Silt drained by irrigation water decreases the fertility of soil.

Over use of Pesticides leads to pesticide pollution: Pesticides are toxic chemicals designed to be deliberately released into the environment. Although each pesticide is

meant to kill a certain pest, a very large percentage of pesticides reach a destination other than their target. Instead, they enter the air, water, sediments, and even end up in our food. Pesticides easily contaminate the air, ground and water when they run off from fields, escape storage tanks, are not discarded properly and especially when they are sprayed aerially. Pesticides can also be found in rain, ground water, streams, rivers, lakes and oceans. There are 4 major ways that pesticides can reach the water: it can drift outside of the area of where was sprayed, it may leach through the soil, it could be carried as runoff, or it may be spilled accidentally. Studies by the UK government show that pesticide concentrations exceed those allowable for drinking water in some samples of river water and groundwater.Residues of chemicals in soil, spray fall out, careless handling of pesticides and excessive and unbalanced use of pesticides cause pesticides pollution. The adverse effects of pesticide pollution are food contamination, residual effects in grains, fruits and vegetables and their accumulation in body tissues. It is noted that pesticides effects adversely on foetus of mother and causes cancer in human beings. Pesticides have made a great impact on human health, production and preservation of food, fibre and other cash crops by controlling disease vectors and by keeping in check many species of unwanted insects and plants. However, the excessive and indiscriminate use of pesticides has led to new pest problems and one of the serious problem resulted from their unregulated use is the presence of pesticides in the food chain and environment. The propagation of Integrated Pest Management approach has also helped in reduction in pesticide use especially on cotton, basmati rice and maize crops where this reduction is 30, 50 and 40 per cent respectively. If the credits of pesticides include enhanced economic potential in terms of increased production of food and fibre, and amelioration of vector-borne diseases, then their debits have resulted in serious health implications to man and his environment. There is now overwhelming evidence that some of these chemicals do pose a potential risk to humans and other life forms and unwanted side effects to the environment (Forget, 1994).

Over use of fertilizers leads to pollution: Farming places a significant demand on the organic and mineral components of soil. In farming, the minerals needed for plant growth, such as nitrogen and phosphorus, are typically removed more quickly than they can be replaced by natural processes, so farmers add fertilizers. While organic fertilizers are used by some farmers, synthetic fertilizers have been in use in Punjab. Adverse effects of fertilizer pollution are rise in concentration of nitrate in drinking water which causes a fatal disease “blue baby syndrome” in children. Fertilizer pollution leads to rise in concentration of heavy elements i.e. Zn, Mo, Pb into soil, water and food which effects adversely on human body.

Rice-wheat cropping system: Farmers are following the rice –wheat cropping system particularly in the Indo-Gangestic plains and growing crops like sugarcane which require more irrigation water result in the problem of ground water depletion. The water level is going down day by day. A study conducted by Singh and Singh (1996) in the states of Haryana and Punjab, revealed that the water level is going down by 0.3-1m per year in different districts of both the states during the last ten years due to excessive use of water for growing paddy crop especially before onset of monsoon.

Salinization: Sometimes farmers used improper irrigation schemes including: **a)** insufficient water application; insufficient drainage; irrigation at low efficiency (where most of the water leaks into the groundwater) and/or over-irrigation contribute to a high water table, increasing drainage requirements and causing waterlogging and salinity build-up in many irrigation projects of the world;Irrigation with saline or marginal quality water, which may be caused by intrusion of saline water into fresh water aquifers in coastal zones due to over pumping. b) Poor land levelling - small differences in elevation may result in salinization of the lower parts, as the water table is closer to the surface and is subject to greater evaporation. c) Misuse of heavy machinery leading to soil compaction and poor drainage. Moreover dry season fallow practices in the presence of a shallow water table. 4. Excessive leaching during reclamation techniques on land with insufficient drainage.

Deforestation: One of the causes of deforestation is to clear land for pasture or crops. In 2000 the United Nations Food and Agriculture Organization (FAO) found that "the role of population dynamics in a local setting may vary from decisive to negligible and that deforestation can result from "a combination of population pressure and stagnating economic, social and technological conditions.

Burning of paddy straw: Burning of paddy straw decline the Soil health and deteriorate environment under rice-wheat system. So it is important to manage residues of rice-wheat cropping system. While wheat straw is used as fodder for animals and is valuable to the farmers, rice straw has not much economic use and thus remains unutilized. Majority of the rice straw (about 20 million tons) is burnt by the farmers every year as it is the only available option for its quick and easy disposal. Apart from huge loss of organic matter and plant nutrients, burning of crop residues causes environmental pollution and health hazards. Thus, it needs to be recycled into soil to improve soil health and crop productivity. Punjab Agricultural University, Ludhiana has

developed 'Happy Seeder' that combines the stubble.

In many countries in Asia, open burning for agricultural land clearing is commonly practiced. In particular, open burning of rice straw after harvesting in Southeast Asia is intensive during the dry season, which may contribute significantly to the ambient air pollution. In Thailand, where rice is the major agricultural product, the area of annual harvested rice paddies, including both the major crop (growth season: May-October) and minor crop (November-April), is about 9.6 million hectare. Based on our questionnaire survey, over 90% of the rice paddies during the high harvesting season (November-December) are burned.

Water Management Technologies for Sustainable Agriculture

Laser land levelling: The uneven fields require too much water to cover the uneven high spots. On the other hand, levelled fields require less water as the water spread evenly on the levelled surface. Laser land levelling is levelling the field within certain degree of desired slope using a guided laser beam throughout the field. It saves irrigation water upto 30 per cent (Kaushal *et al.,* 2008). A study of cotton farmers in Tajikistan (Abdullaev *et al.,* 2007)observed that the average annual net income from cotton farming in the laser leveled field was 22% higher than the control field and the gross margin from the laser leveled field was on average 92% higher than the control field. A study by Arya *et al.* (2012) that almost 57% of farmers growing rice were partial adopters of laser land leveller whereas 43% adopted it fully. Among the wheat growers, 64% have partially adopted laser land leveller and 36% have adopted it fully. Overall, partial adoption is common in both the cases (Table 1).

Optimum plot size: Based on soil texture, slope and stream size in field, the cut-off ratio and basin size have been worked out for improving irrigation efficiency. Plot size of 250 m^2 in coarse textured and 500 m^2 in fine textured soil for wheat improved irrigation efficiency and saved 3-4 cm water. Number of plots per acre for different soil types, slope and discharge rate have been computed (Table 2) and recommended to farmers.

Time of sowing/transplanting: Time of sowing is

Table 1. Distribution of sample farmers by the status of adopting laser land leveling

Crops	Haryana		Punjab		Total	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Rice						
Partial adopter	59	61.5	40	50.6	99	56.6
Full adopter	37	38.5	39	49.4	76	43.4
Total	96	100	79	100	175	100
Wheat						
Partial adopter	58	60.4	65	67.7	123	64.1
Full adopter	38	39.6	31	32.3	69	35.9
Total	96	100	96	100	192	100

Table 2. Recommended plot sizes *(Kiara)* under different soil types, slopes and discharge in one acre length

Soil type	Average slope (%)	Number of border strips (Kiara) for different discharges (litre per second)					
		Tubewell delivery size			Canal discharge		
		3-4½	5½	6½	30	45	60
		7.5-10	15	20			
Light	0.3	17-18	14-15	12-13	9-10	6-7	4-5
	0.4	15-16	13-14	10-11	7-8	5-6	-
	0.5	13-14	11-12	9-10	6-7	4-5	-
Medium	0.2	12-13	9-10	6-7	4-5	-	-
	0.3	10-11	7-8	5-6	-	-	-
	0.4	8-9	6-7	4-5	-	-	-
Heavy	0.05	9-10	6-7	4-5	-	-	-
	0.15	7-8	5-6	-	-	-	-
	0.25	6-7	4-5	-	-	-	-

Source: Package of Practices for Kharif (2015)

particularly important to enhance the crop yield. Restrict to timely sowing of nursery (second fortnight of May) and timely transplanting schedule (second fortnight of June) for better grain quality and water saving. Time of sowing of Maize is last week of May to end of June however optimum sowing time of Basmati rice is 15-30 June.

Bed planting: Cultivation of wheat on beds is possible with a bed planter, which enables sowing of two wheat rows 20 cm apart on 37.5 cm wide bed with a 30 cm wide furrow between two beds. A seed rate of 30 kg/acre under bed planted wheat gives similar yield as with 40 kg/acre under conventional method. This method gives comparable or 3-4% more yield than conventional method.

Direct seeded rice (DSR): Rice can be directly seeded either through dry or wet (pregerminated) seeding. Direct seeding of paddy in medium to heavy textured soils holds significance with regards to saving time, labour, energy and input water. Input water saving in the range of 35-57 percent has been reported for dry seeded rice sown into non-puddled soil with the soil maintained near saturation or field capacity compared with continuously flooded (~5 cm) in North West India (Singh *et al.,* 2002; Sharma *et al.,* 2002). Further Kaur and Kaur (2015) reported that the number of direct seeded rice growers as well as area in Punjab increased during the last decade (Table 3).

Table 3. Percent increase in the number of direct seeded rice growers as well as area in Punjab

Year	Percent increase	
	Number of growers	Area
2009	5.33	1.67
2010	13.33	3.51
2011	28	7.75
2012	37.34	8.08

Liu *et al.* (2016) conducted a study on Dry direct-seeded rice as an alternative to transplanted- ooded rice in Central China. The findings of the study indicated that compared with transplanted-flooded rice, dry direct-seeded rice consumed 17.6, 14.9, and 15.4 % less water (puddling, irrigation, and rainfall) in Lvhan1, Huanghuazhan, and Yangliangyou6, respectively, in 2012, and 16.0, 14.1, and 13.7 % less water in 2013.

Zero tillage: No-till or zero tillage agriculture is a way of growing annual crops (from year to year) without disturbing the soil unlike traditional forms of agriculture that use tillage. It is the use of ploughs and other implements to prepare the soil for planting. Tilling the soil removes weeds and shapes the soil into rows for crop plants. In India, for the last over 20 years, efforts for development, fine tuning and technology transfer have been underway even though there are several limitations (Bhan and Beher, 2014). A lot of efforts have been made on zero-till or no-till in wheat under a rice-wheat rotation in the Indo-Gangetic plains. The study by Iqbal (2002) assessed the status of zero-tillage technology in the rice-wheat zone of Punjab. The study confirms that the zero-tillage technology enhances water and fertilizer use efficiency.

Irrigation scheduling of paddy

Irrigation at two week interval: Keep the water standing continuously in the crop for two weeks after transplanting so that the seedlings get properly established. Afterwards, apply irrigation two days after ponded water has infiltrated into the soil. The depth of standing water should not exceed 10 cm. drain away excess water before interculturing or weeding and irrigate the field after these operations. Depending upon soil type, this system of irrigation helps in saving 8-10 irrigation.

Irrigation with Tensiometer: Tensiometer is a tool to measure the requirement of water for paddy crop. In order to absorb water from soil, the plant has to overcome the suction tension of the soil. This tension is measured by the tensiometer, thus giving indication of the soil moisture at the depth in which it was placed. To save irrigation water, irrigate with tensiometer installed at 15-20cm soil depth at soil matric tension of 150±20 cm or when the water level in tensiometer enters yellow strip. Improved irrigation scheduling in rice using tensiometer can save irrigation water in non- cracking soils without a yield loss.

Irrigation scheduling of wheat: Sow wheat after a heavy pre-sowing irrigation (10cm) except when it follows rice. In case wheat sowing is likely to be delayed due to the late harvest of rice, the pre-sowing irrigation for wheat can be given to standing rice 5-10 days (depending upon soil type) before its harvest except where the crop is to be harvested with combine. This practice advances the sowing of wheat by about a week. For efficient use of irrigation water, farmers are advised to make 8 plots (Kiaras) per acre in heavy textured soils and 16 plots per acre in light textured soils.

The first irrigation should be relatively light and given after three weeks to October-sown crop and after four

Table 4. Irrigation schedule of wheat

Irrigation (7.5cm)			
Date of sowing	II	III	IV
Weeks after the previous irrigation			
Up to November 21	5-6	5-6	4
November 22 to Dec 20	5-6	3-4	2
December 21 to Jan 15	4	3	2

Source: Package of Practices for Rabi (2015)

weeks to the crop sown later. The subsequent irrigations are also determined by the date of sowing. Follow the following irrigation time-table for wheat sown on sandy loam or heavier soils on different dates.

Water Channels: The unlined, open, earthen channels lose 10 to 15 percent of irrigated water due to seepage. It can be reduced by adequate lining of conveyance channels or by laying underground pipelines or by the use of portable aluminium, PVC or plastic pipes. These practices, other than open water channels can save the area under channels and can lead to increase the yield level.

Drip irrigation: Drip irrigation is an irrigation method that saves water and fertilizer by allowing water to drip slowly to the roots of plants, either onto the soil surface or directly onto the root zone, through a network of valves, pipes, tubing, and emitters. It is done through narrow tubes that deliver water directly to the base of the plant. It is suitable for water scarcity and salt affected soils. With drip irrigation, water is conveyed under pressure through a pipe system to the fields, where it drips slowly onto the soil through emitters or drippers which are located close to the plants. Only the immediate root zone of each plant is wetted. Therefore this can be a very efficient method of irrigation. Drip irrigation is sometimes called trickle irrigation.

Sprinkler irrigation: Sprinkler irrigation is a method of applying irrigation water which is similar to natural rainfall. Water is distributed through a system of pipes usually by pumping. It is then sprayed into the air through sprinklers so that it breaks up into small water drops which fall to the ground. The pump supply system, sprinklers and operating conditions must be designed to enable a uniform application of water. It is suitable for undulating topography (sloppy lands).

Border irrigation: Borders are long, sloping strips of land separated by bunds. They are sometimes called border strips. Irrigation water can be fed to the border in several ways: opening up the channel bank, using small outlets or gates or by means of siphons or spiles. A sheet of water flows down the slope of the border, guided by the bunds on either side. Border irrigation is generally best suited to the large size fields and close growing crops. The land is divided into number of long parallel strips called borders. These borders are separated by low ridges. The border strip has a uniform gentle slope in the direction of irrigation. Each strip is irrigated independently by turning the water in the upper end. The water spreads and flows down the strip in a sheet confined by the border ridges.

Furrow irrigation: Row crops such as potatoes, cotton, sugarcane, vegetable etc. can be irrigated by furrow method. Water is allowed to flow in furrow opened in crop rows. It is suitable for sloppy lands where the furrows are made along contours. The length of furrow is determined mostly by soil permeability. It varies from 3 to 6 meters. In sandy and clay loams, the length is shorter than in clay and clay loams. Water does not come in contact with the plant stems. There is a great economy in use of water. Sometimes, even in furrow irrigation the field is divided into beds having alternate rides and furrows. On slopes of 1 to 3 percent, furrow irrigation with straight furrows is quite successful. But on steeper slopes contour furrows, not only check erosion but ensure uniform water penetration.

Happy Seeder: Happy seeder facilitates sowing of wheat directly in paddy residue in combine harvested field hence, prevents residue burning and reduces air pollution (Sidhu *et al.,* 2007; Blackwell *et al.,* 2004). This machine combines stubble mulching and seed drilling functions into the one machine. This PTO driven machine can be operated with 45 HP tractor and covers 0.2-0.3 ha/h. The efforts have been made to develop a lighter and low power Happy Seeder machine (35 HP tractors) for sowing wheat into paddy stubbles while retaining the straw as surface mulch. Government of Punjab is encouraging adoption of this technology. The machine also offers a variety of other benefits such as 60-70 percent less weed growth, water saving (particularly pre-sowing irrigation), improved soil health (through improvements in nutrient supply capacity and

Table 5. Suggested maximum border lengths and widths

Soil type	Border Slope (%)	Unit flow per metre width (l/sec)	Border Width (m)	Border Length (m)
Sand	0.2-0.4	10-15	12-30	60-90
Infiltration rate greater than 25 mm/h		8-10	9-12	60-90
	0.6-1.0	5-8	6-9	75
Loam	0.2-0.4	5-7	12-30	90-250
Infiltration rate of 10 to 25 mm/h	0.4-0.6	4-6	6-12	90-180
	0.6-1.0	2-4	6	90
Clay	0.2-0.4	3-4	12-30	180-300
Infiltration rate less than 10 mm/h	0.4-0.6	2-3	6-12	90-180
	0.6-1.0	1-2	6	90

soil structure) and environment quality improvement. The stubble is cut and picked up in front of the sowing tynes and deposited behind the seed drill as mulch.

Use of Paddy straw as a Mulch: Loss of water as evaporation from soil surface accounts for a major portion of water applied to crops particularly in summer months. These losses are more in wide spaced crops like sugarcane, maize etc. various types of mulches such as straw mulch; farm waste mulch or plastic mulches can be used. Straw mulch can be spread @6 ton/ ha. in between the two lines of crops. This practice reduces soil temperature, creates barriers for evaporation, reduces soil erosion by checking the direct beating action of rain drops, checks weed growth, which ultimately conserve soil moisture. It reduces water use by up to 75% as it protects the soil from evaporation.

Crop diversification : Replacement of crops having high evapo-transpiration, thus high water requirement with those having low evapo-transpiration, thus low water requirement can help to save water and reduce withdrawal of ground water. In Punjab, large scale adoption of rice-wheat system has been a major factor in over exploitation of ground water. In Kharif , rice may be replaced with maize (4-6 irrigations required), Basmati rice, pulses (3-4 irrigations required) and oilseeds (2-3 irrigations required); whereas in Rabi, wheat may be replaced with Raya (2-3 irrigations required) and chick pea (3-4 irrigations required). Replacing rice with less water guzzling crops like maize, soyabean, groundnut and pulses etc. could save substantial quantities of water. The maize-wheat and cotton-wheat cropping systems have been reported to have relatively low irrigation requirements (Jalota and Arora, 2002).

Breeding short duration varieties: The earlier varieties of rice were of longer duration requiring more water. For resource conservation, the recent breeding efforts are, however, for short duration varieties. The newly released rice varieties like PR 124 (released in 2015), PR 121, PR 123 (both released in 2013), PR 122 (released in 2013) required135, 140, 143 and 147 days for maturity with average yield of 30.3, 30.5, 29.0 and 31.5 quintals per acre (Package of Practices for Kharif, 2015).

Protected cultivation: polyhouses and low-tunnels: Although protected cultivation is undertaken to grow the crop under pest free environment, it offers quality production with advance maturity. Poly-net house and poly tunnels of different dimensions are in use. Punjab Agricultural University has designed a modified poly net-house in 2011 for protected cultivation of various vegetables. It uses poly film (200 micron) on top and Insect net (40 mesh) on sides. This net-house is simple to dismantle and assemble and its average life 25 years. The design has been accepted by Punjab State Farmers Commission for subsidy. Studies have been carried out for protected cultivation of various vegetables (tomato, capsicum and brinjal), flowers (rose, gerbera) and fruits (papaya). The crops growing under protected structures can be provided drip-irrigation and fertigation that saves water and fertilizers.

Rain water harvesting: Rain water harvesting is the need of the day due to the shortage of water with the growing needs of population and urbanization. The new construction of apartments today considers installation of the rain water harvesting system. The water thus saved can be used for drinking, washing, bathing, etc. or for recharging the groundwater. **Rainwater harvesting** is the accumulation and deposition of rainwater for reuse on-site, rather than allowing it to run off. Rainwater can be collected from rivers or roofs, and in many places the water collected is redirected to a deep pit (well, shaft, or borehole), a reservoir with percolation, or collected from dew or fog with nets or other tools. Its uses include water for gardens, livestock, irrigation, domestic use with proper treatment, and indoor heating for houses etc. The harvested water can also be used as drinking water, longer-term storage and for other purposes such as groundwater recharge.

The Punjab Preservation of Sub-soil Water Act-2009: The falling water table in Punjab led the state Government to regulate groundwater use by direct and indirect measures. The Punjab Preservation of Sub-soil Water Act-2009 is such a measure to conserve groundwater resource by mandatory delaying the transplanting paddy beyond 10th June to escape periods of high evapo-transpiration demands. The main purpose of the law is to preserve groundwater by prohibiting sowing paddy before May 10 and transplanting paddy before June 10. In addition, the law creates the authority to destroy, at the farmer's expense, paddy sowed or transplanted early, and the law assesses a penalty of 10,000 rupees per month, per hectare of land in violation of the law (Sekhri, 2013).

Location specific water management

Kandi Zone: Kandi Zone comprise of parts of Hoshairpur, Ropar, Gurdaspur, Nawashahar and Patiala district and is about 10 per cent of the state geographical area. Major problems of this area are (i) shortage of irrigation water in spite of high annual rainfall (annual rainfall of about 1000mm). (ii) flash floods and soil erosion (iii) dry spells even during monsoon and (iv)the discharge available from tube well is very small.

For efficient use of water resources, the following remedial measures are suggested:

(i) Soil moisture conservation measures- these includes leveling and bunding of field, opening of land before on

set of monsoon and use of mulches to reduce evaporation.

(ii) Crop management practices: grow less water consuming and short duration crops.

(iii) Construct water harvesting dams and farm-ponds. This will help in ground water recharge as well as in providing life saving irrigation to the crops

(iv) Construct soil erosion control structures

(v) For low discharge tube wells use more efficient irrigation methods like sprinkler and drip irrigation.

Central Zone: This zone comprise of central districts of Punjab like Ludhiana, Jalandhar, Kapurthala, Moga, Sangrur, Amritsar etc. Because of increase in cropping area under high yielding varieties and high water consuming crops like paddy the underground water has been over-exploited which has resulted in declining of water table. The remedial measures suggested to arrest declining of water table in central zone are as follows:

(a) Reduce groundwater withdrawal

(i) Reduce area under high water consuming crops like paddy

(ii) Transplanting of rice after mid of June instead of May

(iii) Follow recommended irrigation scheduling of crops

(b) Improve on-farm water use efficiency

(i) Reduce conveyance loses in irrigation channels

(ii) Use furrow method of irrigation for row crops

(c) Recharge the groundwater

(i) Recharge through wells

(ii) Recharge through river, drains and choes

(iii) Recharge through farm-ponds

(iv) Recharge through paddy field

(v) Recharge of roof rain water

South-Western Zone: The south- western zone comprises of south western districts of Punjab like Bhatinda, Muktsar, Faridkot, Mansa and parts of Ferozepur districts. In this area because of poor management of water resources water logging and soil salinity problems has occurred. The remedial measures suggested for this zone are as follows:

a) Reduce excessive seepage from canal network by lining PVC or plastic pipes

b) Conjunctive use of surface and groundwater resources by following techniques such as skimming wells, dilution by mixing and alternate irrigation

c) Provide drainage of both surface as well as subsurface water by providing surface drainage, subsurface drainage and bio-drainage

d) Improve on- farm water use efficiency

Super absorbent polymer hydrogel technologies: For a layman, hydrogel is a 'gel in which the liquid component is water'. Hydrogels are the 3-D network polymers that are known to swell in water solutions becoming soft and rubbery, resembling a living tissue (Soppirnath and Aminabhavi, 2002) and some possess excellent bio-compatibility. These hydrophilic materials can absorb and retain aqueous solutions hundred times their own weight. There can be natural polymers, semi-synthetic polymers and synthetic polymers. According to their formation and behavior the hydrogels can be degradable or nondegradable in soil.

Synthetic Polymers: Synthetic polymers usually consist of polyacrylamides and polyvinyl alcohols. Completely synthetic polymers are non-soluble in solution due to their chemical structure. The non-chemically cross-linked polyacrylamides are useful for controlling soil erosion, reducing sedimentation in surface water and stabilization of *kutcha* (earth lined) canals.

Natural Polymers: Natural polymers (e.g., guar gum polysaccharide) are non-toxic, economical and biodegradable and are thus preferred over synthetic ones (Soppirnath and Aminabhavi, 2002), however, there are some limitations like uncontrolled hydration, decreased viscosity and microbial contamination that may limit their use. Hydrogels can absorb irrigation and rain water and thereby help to reduce deep percolation by using gravitational as well as capillary water (Abedi *et al.*, 2008). They absorb and store water hundreds of times their weight, 400- 1500 g water per dry gram of hydrogel. The absorption depends upon the chemistry and formulation conditions of the hydrogel and the chemical composition of irrigation water and soil.

Measures of adapting to climate change in Eastern Africa: The following critical elements in strengthening capacity to adapt to climate change:

(i) Increasing Soil Health: Boosting and managing healthy soils through soil and water conservation measure and practices aimed at increasing productivity on-farm and optimising the use and management of land and water resources at the catchment or watershed scale. As increasing weather / climatic variability and erratic rainfall or prolonged periods of drought are likely to reduce yields, any increase in productivity through better soil health and fertility will serve to moderate the impact of climate change on agricultural productivity. Moreover the risk of soil erosion, crop damage and flooding from increased rainfall intensity and storms can be moderated through catchment or watershed management, which optimizes and diversifies land use according to the terrain, enhances vegetation cover, rainwater capture and infiltration, and ensures safe discharge of excess runoff water in waterways and low lying land.

(ii) Water Conservation: Substantial action is required in the case of sub- Saharan Africa to ensure water harvesting,

storage and improve use efficiency of an increasingly variable resource. Adapting to climate change requires even more emphasis than is currently given to improving water management in both rainfed and irrigated systems. The project encouraged rainwater harvesting, provision of more water storage facilities to reduce exposure to dry spells, improving rainwater infiltration into soils and greater water use efficiency.

(iii) Livelihood Diversification: Capacity to cope in harsh climatic conditions and uncertain markets calls for diversification of farming systems. Better soils and water harvesting are the basis for enhanced diversification. The improved resource base (land and water) allowed building of assets through fishing, fruit growing, cover crops and crop diversification that support better diets and nutrition, while enabling more farmers to engage in marketing of cash crops, among other activities.

(iv) Strengthening Local Institutions: With climate change, management of natural resources becomes more complex and thus involvement of more people is very crucial to manage the natural resources at farm and household level for sustainable development.

CONCLUSION

It can be concluded that poor land leveling, lack of pre-treatment of seed and soil before sowing, selection of high yielding varieties, lack of soil testing, early transplanting of rice, over irrigation, over-use of pesticides, rice-wheat cropping system etc. deteriorate the environment. Climate change is likely to impact the availability of freshwater. The threats of climate change and global warming are real with alarming consequences. The impact will be felt more sternly in India whose economy is largely dependent on agriculture and is already under stress due to increasing population and prevailing demands for freshwater, food and energy. There are estimates that India will have increased demand for water in future due to creasing population and agricultural expansion. Therefore, its future water resources have to be viewed seriously in relation to the sustainability of agriculture and therefore management technologies viz. laser land leveling, transplanting of paddy in second fortnight of June, bed planting of wheat, Direct seeded rice, zero tillage, Tensiometer aided irrigation, drip irrigation, sprinkler irrigation, happy seeder, mulching, water saving cropping systems, protected cultivation: poly-houses and low tunnels, ground water recharging through rain water harvesting, renovation of village ponds and recharging through abandoned wells should be adopted to save irrigation water, solve labour scarcity problem, reduces weed infestation, protect soil from evaporation etc. for sustainable agriculture. It is essential to create awareness among the end users i.e. farming families regarding water saving technologies to mitigate the effects of climate change.

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Introduction of New Insect-Pests on Apricot and Its Preliminary Management Options in Cold Arid Region of Ladakh

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***Abstract*:** Incidence of insect-pest and diseases of fruit trees is low in trans-Himalayan Ladakh. However, acase-study was carried out to understand the outbreak and monitor the defoliating caterpillar (*Euproctis*spp.) in seven villages and aphids (*Aphis* spp.) in seventeen villages of Leh district in apricot. A loss of approximatelyRs. 539.2lakhs in apricothas been realised. Simultaneously, this defoliating caterpillar moth has caused skin rashes on humans, which were severe and persistent on sensitive individuals.The outbreak of the pests have caused extensive economic loss and issue is required to be addressed on priority.

Key Words: Apricot, Aphid, Cold arid region, Defoliating caterpillar, Economics, Remedial measures

Invasive pests that gained entry into this cold arid region of India have caused catastrophic damage on commercial agriculture, horticulture crops and forest trees. Due to climate change in past few years, many invasive pests have been introduced in this cold arid region i.e., codling moth in apple and apricot (*Cydiapomonella*), aphids in fruits and vegetable crops (*Aphis* spp.), cutworm in vegetables (*Agrotisipsilon*), maggots in onion (*Delia antique*), powdery mildew in grapes (*Uncinulanecator*), weevil in walnut (*Alcidesporrectirostris*), loose smut in wheat and barley (*Ustilagotritici*), rust in wheat and barley (*Puccinia* spp.), fungal (*Fusarium* spp.) and bacterial wilt (*Ralastoniasolanacearum*) in solanaceous vegetables and several invasive species of moths(Gupta *et al.,* 2015). Previously gypsy moth (*Lymantria* spp), willow scale (*Chionaspissalicis* L.), tent caterpillar (*Malacosoma* spp), willow leaf beetle (*Altica* spp.), goat moth (*Cossuscossus* L.), ermine moth (*Yponomeutarorellus* Hubner), poplar petiole gall insect (*Pemphigus* spp.), willow apple gall (*Pontania* spp.), etc. were major pest species found causing damage to poplar and willow (Gupta *et al.,* 2015). More than 60 per cent willow plantations were found to be infested with scale insect in Leh district, while willow apple gall inducer was found causing severe damage in Zanskar block of Kargil district and, Nubra and Khaltsi block of Leh district (Pandey *et al.*, 2007).

Apricot is the main fruit trees of Ladakh region and are widely grown in the warmer and lower belts of Ladakh like Sham, Nubra and Kargil. Traditionally the apricots are eaten fresh but traditionally sun-dried apricot is sold in the markets at the rate of Rs. 250-300 per kg. Apricot of trans-himalayanLadakh are best for its quality and unique characteristics. Number of genotypes have been explored by ICAR-Central Institute of Temperate Horticulture and Defence Institute of High Altitude Research (DIHAR), for its better development and livelihood in terms of biological and pomological traits and this region represents a great wealth of apricot germplasmdiversity. Being a cold arid region in Trans-Himalaya, possible pest incidence is comparatively low because of lower humidity followed by extreme cold and harsh winter, low cropping intensity and diversified cropping systems.Codling moth (*Cydiapomonella*) is a serious pest of apricot in fruit growing areas of Ladakh(Gupta *et al.,* 2015). To avoid and restrain itsspread to other parts of the country the Government has imposed restrictions under SRO 397 dated8th September 1981 under the Jammu and Kashmir Plant and Disease Act 1973, on the movementof apple and apricot from Ladakh. However, in recent years, severe infestation of defoliatingcaterpillar (*Euproctis*spp) was observed in Dah-Hanu belt and aphid in Sham and Turtuk-belt onapricot trees. Apricot orchards in Ladakh are attacked by various insect-pests especially defoliator and aphids. Defoliator is the only native to Europe. All other pests are accidental introductions. Fruit damage or infestation by any one of these insects may make a quality of fruit unacceptable for marketing. For these reasons, the economic thresholds of insects, which attack fruit in age-old apricot orchards are extremely low.

There is still muddle regarding the identification of the moth but the targeted insect has recently infiltrated in Ladakh region probably due to changes in climate parameters in past few years. This moth, a native of Europe,

was first found in North America in Somerville, Massachusetts, in the spring of 1897. The lack of natural control agents contributed to its rapid spread throughout the Northeast and similar situation prevails in Ladakh for the spread of insect. This insect was reported in 2010 from Kargil district, it extended to Dha and Bhema areasin 2014, and recently in 2016,it was reported from Turtuk village of Nubra valley. In Near future, many threats are waiting to invade unexpected areas in Leh region.

Hosts range: The caterpillars feed on leaves of many hardwood trees and shrubs including apricot, apple, peach, pear, cherry, poplar, willow, robinia, rumex, seabuckthorn, geranium, walnut, rose, etc. but major economic loss has been recorded in apricot and apple.

Economic impact of pest on apricot: In general, pests caused 33% of total production losses in agriculture. But Ladakh region being locked territory with changing climate has suffered seriously by infiltrated insect pests. An effort has been made to document and monitor the affected villages like Dha-Biama, Hanu-Thang, Achinathang, Skurbuchan, DomakharBarma, DomkharDho, Thikmachik, etc. These villages have halman/phtaingapricot – sweet seed (16834 trees) and Chuliapricot – bitter seed (9683 trees) rich genotypes, which have very high market value worth Rs. 484 and 86.9 lakhs, respectively. After infestation, total output has declined by 40% with an income loss of Rs. 223.5 lakhs. Dha-Biama, HanuThang and Achinathangwere among the most affected villages where almost 50-90% of production loss was recorded. On the other hand, aphids have affected overall 17 villages including villages of higher elevation such as Lehdho, Nurla, Khaltse, Temisgam, Tia, Gera, Mangue, Alchi, Nimmu, Basgo, Saspol, etc. which has resulted 20-40 per cent production loss.Simultaneously already established insect like codling moth is also affecting apple. Total 17 villages have 24006 and 22630 trees of halman/phating and chuliapricot with an income of approximately Rs. 690 and 203 lakhs, respectively without damage but after infestation during last two years, approximate a loss of Rs. 315.7 lakhs has been recorded. These figures have disturbed the agricultural based economy of the farmers. The scientists and policy makers are worried for making necessary arrangement to halt the huge loss to the farmers in the coming season through awareness campaign for mechanical and chemical control of the insect. Integrated control (mechanical, biological and chemical) measures are essential to produce fruitful results in checking the growing population of the pests. However, the ethical issues have to be considered for devising the strategies for sustainable crop production and protection for sustaining their livelihood and extending area under crop cultivation including fruit trees.

Effect on human-beings: The moth caterpillar hairs can cause a skin rash on humans similar to that caused by poison ivy (Plate 1). The rash can be severe and persistent on sensitive individuals. It has also been observed that this has also caused the skin infection or/ respiratory problems to several people of the infested area when came into contact or breathed the microscopic hairs, which float in the air. It has been advised to not to enter in affected areas and keep clothed fully, dry-laundry, etc. when dealing with the insect management.

Future course of action: The dominant Buddhist society in the Leh is nature loving and ethical issues of non-violence and killing of any living being is not acceptable. However, the severe damage by the insects warrant immediate action and efforts are being made to convince the Ladakh farmers especially Buddhist for use of pesticide to keep pests within acceptable limits. Severe infestation by pests caused significant fruit damage bringing down more than 50% production and total benefit. To prevent serious outbreaks of defoliator and aphids in apricot/apple orchards and its further spread, Ladakh Autonomous Hill Development Council (LAHDC), Department of Horticulture have designed an effective control strategies with the support of the research institutes working at Leh. The NGOs are also being involved for the suppression of targeted insects for further extending to other areas. Amongst the management practices, orchard sanitation has been considered the most effective and economical way to avoid many pest problems and to provide an environment that discourages pests or reduces the tree's susceptibility to damage. An effort has been made to assess the outbreak and economic loss. Participatory approach has been followed to generate the data. Keeping in view the seriousness of the issue, some remedial measures have been proposed including sanitary measures and chemical control, which probably would be taken up with the support of Leh Hill development Council through different research and developmental organisations. There is a need to wake up with the situation and age-old orchards where all the possible integrated approaches are required to be implemented by the farmers by using improved technologies with the support of field functionaries. Usually no cultural practices are followed in the orchards in the region and usually traditional adapted genotypes are adopted for cultivation. However, in recent years some improved varieties have also been introduced to enhance the production in the area but optimum management is still lacking to harvest the total potential.

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Defoliated apricot tree in village Dha by caterpillar in month of June

Defoliating caterpillar

Formation of webs by defoliator

Skin rashes caused by the exposure to the caterpillar

Plate 1. Impact of defoliating insect in Leh area

Agriculture, Department of Horticulture, Leh, DIHAR, DRDO, NGOs and allied sectors placed at Lehfor their information sharing on pest problems in fruit trees and collaboration for integrated control measures.

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Growth and Productivity of Turmeric (*Curcuma longa* L.) as Influenced by Different Types of Planting Material and Growth Regulators

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***Abstract*:** A Field investigation was carried out to study the effect of different types of planting material and growth regulators on growth and yield of turmeric. The treatments comprised of combination of three types of planting materials viz. mother rhizomes, primary rhizomes and secondary rhizomes and five types of dipping treatments viz. GA_3 (50 ppm), NAA (40 ppm), Kinetin (30 ppm), water soaked and control. The results revealed that mother rhizomes as planting material gave higher emergence count, maximum plant height, dry matter accumulation and leaf area at all crop growth stages over primary and secondary rhizomes. Mother rhizomes as planting material, gave significantly higher rhizome yield as compared to primary rhizomes, similarly primary rhizomes gave significantly higher rhizome yield as compare to secondary rhizomes. Among different growth regulators, NAA (40 ppm), Kinetin (30 ppm), water soaked and control treatments were at par but significantly better than GA_3 (50 ppm) in emergence count, plant height, leaf area and dry matter accumulation. Different types of growth regulator treatments showed that fresh, dry and processed yield was statistically at par in NAA (40 ppm) and water soaked treatments but significantly better than GA_3 (50 ppm), Kinetin (40 ppm) and control.

***Key Words*:** Growth regulators, GA_3, Kinetin, Mother rhizomes, NAA, Turmeric

Turmeric (*Curcuma longa L.*) is an annual herbaceous plant, belongs to ginger family (*Zingiberaceae*), grown for its underground rhizome, which is mainly used as spice or condiment. It has a wide range of medicinal properties. Turmeric takes long time for germination and has slow initial growth. The planting material in terms of rhizome size play important role in determining the growth and yield of turmeric. The crop grown from mother rhizomes gives higher yield and healthy crop stand as compared to the crop grown through primary and secondary rhizomes. Several researchers showed that application of different types of growth regulators improve the growth and yield in different crops. Hence, studies were undertaken to study the effect of different type of plant materials and growth regulators on growth and yield of turmeric.

The experiment was conducted during 2013-14 at Punjab Agricultural University, Ludhiana. It was laid out in factorial randomised complete block design with 15 treatments and 3 replications. The treatments consisted of combination of three types of planting material viz. mother rhizomes, primary rhizomes and secondary rhizomes and five types of dipping treatments viz. GA_3 (50 ppm), NAA (40 ppm), Kinetin (30 ppm), water soaked and control. A uniform dose of 25 kg ha^{-1} each of phosphorus and potassium were applied before planting. Farmyard manure was applied 25 tonne ha^{-1} and thoroughly mixed with the soil two weeks before planting of turmeric crop.

The soil of the experimental field was categorized as loamy-sand. It was low in organic carbon (0.24 %) and available nitrogen (182.4 kg ha^{-1}) but the available phosphorus (16.5 kg ha^{-1}) and potassium (194.6 kg ha^{-1}) status were medium. The soil pH (8.3) and electrical conductivity (0.13 dSm^{-1}) values were within the normal range. The planting was done during first week of May at a spacing of 30 cm x 20 cm. Mulching was done with the rice residues@ 6.25 t ha^{-1} immediately after planting of the crop. The harvesting of the turmeric was done manually during first fortnight of January. The yield of turmeric was recorded at the time of harvesting of the crop. The growth parameters like plant height, dry matter accumulation, leaf area and number of tillers per plant were recorded from 5 randomly selected plants from each plot 180 days after sowing. Statistical analysis of the data was done as suggested by Cochran and Cox (1967).

Emergence count: The results showed that mother rhizomes resulted in higher emergence count at 30, 45 and 60 DAP over primary and secondary rhizomes (Table 1). Similarly primary rhizomes showed significantly better emergence count than secondary rhizomes at 30 and 45 DAP. The higher and quick emergence with mother rhizomes might be due to more retention of moisture in it as well as more storage of assimilates.

The growth regulators showed significant effect on emergence count at 30, 45 and 60 DAP (Table 1). The data revealed that at 30 DAP, NAA (40 ppm) recorded significantly better emergence count than all other treatments, but at 45

DAP all other treatments were at par except GA_3 (50 ppm) and control treatments. At 60 DAP all other treatments were at par but significantly better than GA_3 (50m ppm). At 30 and 45 days after planting stage the water soaked rhizomes showed significantly more emergence count over control, however at 60 days after planting stage both water soaked and control treatments were at par.

Plant height : The mother rhizomes showed significantly higher plant height over secondary rhizomes but mother and primary rhizomes were statistically at par among themselves (Table 1). The large sized rhizomes have more stored food material, which might have resulted in quick emergence and more vigorous plants, thus , the plants from mother rhizome had attained more and height. Mother rhizome as planting material had produced taller plant has been reported by different workers (Padmadevi *et al.,* 2012; Singh *et al*., 2013). The result showed that all growth regulator treatments were at par except GA_3 (50 ppm) at 180 days after sowing stage.

Dry matter accumulation: The crop raised from mother rhizome planting material accumulated significant more dry matter at than primary rhizome planting material. Mother rhizomes when used as planting material produced more dry matter has also been reported by Manhas and Gill (2010).

There were significant differences in dry matter accumulation when different types of dipping treatments were used. The growth regulator treatments viz. NAA (40 ppm), Kinetin (30 ppm), water soaked and control recorded significantly more dry matter accumulation over GA_3 (50 ppm) treatment.

Leaf area: The data showed that among different types of planting material, mother rhizomes gave significantly better leaf area than primary and secondary rhizomes at 180 days after sowing (Table 1). This might be due to the early emergence and more plant height, when mother rhizomes were used as planting material than primary and secondary rhizomes.The treatments including NAA (40 ppm), kinetin (30 ppm), water soaked and control were at par but significantly better than GA_3 (50 ppm).

Number of shoots per plant: The mother rhizome planting material produced maximum number of shoots per plant (2.66) and it was significantly better than primary (2.20) and secondary (1.60) rhizomes (Table 1). Similarly, the numbers of shoots produced by using primary rhizomes were significantly more than secondary rhizomes planting material. Less availability of stored food material along with delayed and decreased emergence were the possible reasons for lower number of shoots per plant in secondary rhizomes planting material treatment. Mother rhizomes produced more shoots per plant has been reported by different workers (Deshmukh *et al*., 2005).

Effect of different growth regulators was significant and data showed that among different growth regulator treatments NAA (40 ppm), Kinetin (30 ppm), water soaking and control treatments were statistically at par with each other but significantly better than GA_3 (50 ppm).

Fresh yield: Different planting materials had significant effect on fresh and dry rhizome yield (Table 2). The use of mother rhizome as planting material resulted in significantly more fresh and dry rhizome yield than the primary rhizomes which was also significantly better than the secondary rhizomes. Increased rhizome yield in mother rhizome planting material might be attributed to better crop growth in terms of quick emergence, higher plant height, more dry matter accumulation and more tillers per plant which ultimately contributed towards significantly higher yield of the crop. Difference in performance of different sizes of rhizomes

Table 1. Effect of different treatments on the growth of turmeric

Treatment	Emergence count (%)			Plant height (cm)	Dry matter accumulation (g plant^{-1})	leaf area (cm^2 plant^{-1})	Number of shoots plant^{-1}
Planting material	30 DAP	45 DAP	60 DAP				
Mother rhizomes	40.26	75.20	89.33	96.13	20.85	2409.52	2.66
Primary rhizomes	35.86	71.73	87.73	82.66	14.10	2125.26	2.2
Secondary rhizomes	23.46	60.00	82.66	74.20	9.91	1632.19	1.6
CD (p=0.05)	10.06	6.25	NS	9.52	5.01	454.81	0.32
Growth regulators							
GA_3 (50 ppm)	11.55	18.22	57.33	63.22	11.49	1414.17	1.66
NAA (40 ppm)	56.88	86.66	94.66	94.00	20.18	2719.33	2.33
Kinetin (30 ppm)	39.55	82.22	92.44	87.44	16.84	2117.02	2.22
Water soaked	35.55	82.66	94.55	89.44	17.65	2101.22	2.30
Control	22.44	75.11	92.88	82.55	16.62	1926.54	2.22
CD (p=0.05)	12.99	7.07	13.93	12.29	3.60	887.16	0.41

Table 2. Effect of different treatments on the fresh yield and dry yield of turmeric

Treatment	Fresh yield (t ha^{-1})	Dry yield (t ha^{-1})
Planting material		
Mother rhizomes	33.56	7.76
Primary rhizomes	28.01	6.35
Secondary rhizomes	18.75	4.48
CD (p=0.05)	5.51	1.30
Growth regulators		
GA_3 (50 ppm)	14.91	3.51
NAA (40 ppm)	33.42	8.08
Kinetin (30 ppm)	26.43	6.74
Water soaked	32.78	7.12
Control	26.31	5.73
CD (p=0.05)	5.11	1.31

can be relied on the source-sink relationship as the mother rhizomes constitute a strong sink than the primary and secondary rhizomes. Translocation and mobilization of assimilates and nutrients are more in mother rhizome thereby making the mother rhizomes planting material qualitatively and quantitatively superior. Thus, the plants resulting from mother rhizomes planting material were more vigorous and yielded better as compared to primary and secondary rhizomes. Tayde and Deshmukh (1986) also recorded significantly higher fresh yield (25.70 t ha^{-1}) with mother rhizome planting material as compared to primary (19.50 t ha^{-1}) and secondary (15.90 t ha^{-1}) rhizomes when used as planting material.

Among different growth regulator treatments, the result showed that fresh and dry yield was statistically at par in NAA (40 ppm) and water soaked treatment, whereas, all other dipping treatments recorded significantly lower fresh rhizome yield (Table 2). Kumar (2005) and Philips (1983) also recorded significantly higher dry yield of turmeric with whole mother rhizome as planting material as compared to primary and secondary rhizomes. This might be due to early emergence, better plant height, more leaf area, more dry matter accumulation and more number of tillers in NAA (40 ppm) treatment.

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Genetic Diversity Analysis in Egyptian Cotton (*Gossypium barbadense* L.)

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Abstract: Substantial variation for fibre quality traits is known to exist in *Gossypium barbadense*. Multivariate analysis employing Mahalanobis D^2 analysis classified the twenty genotypes into seven clusters. Cluster II was the largest consisting of six genotypes followed by cluster I and cluster IV with five genotypes each. The inter cluster distances were maximum when compared to intra-cluster distances, indicated presence of wide genetic diversity among the genotypes of different clusters than those of same cluster. The hybridisation programme with parents selected by considering inter cluster distances may produce high magnitude of heterosis or desirable segregants, which would be meaningful for improvement in yield and quality attributes of cotton.

***Key Words*:** D^2 statistics, Genetic divergence, *Gossypium barbadense*

Genetic divergence is of considerable practical interest in any crop improvement. Since success of any crop breeding programme is based on the knowledge and availability of genetic variability for efficient selection. Genetic divergence estimates among genotypes are helpful in selecting parental combinations for creating segregating populations so as to maintain genetic diversity in a breeding programme and the classification of germplasm into heterotic groups for hybrids development (Ali *et al*., 2008). Hybrids between genotypes of diverse origin display a greater heterosis than those hybrids involving closely related parents.

The multivariate analysis using Mahalanobis' D^2 statistic and principal component analysis provides a very useful statistical tool for measuring the amount of genetic diversity in a given germplasm with respect to the characters considered together (Panse and Sukhatme, 1978). Further, the problem of selecting divergent parents for hybridization programme can be narrowed, if one can identify the characters responsible for the discrimination between populations.

The present study was conducted at Regional Agricultural Research Station (RARS), Lam, Guntur, Andhra Pradesh during *kharif*, 2013-14. Twenty Egyptian cotton genotypes were planted in randomised complete block design with three replications. All the recommended package of practices was followed for raising a healthy crop. In each replication from each genotype five plants were randomly selected and observations were recorded for 16 characters viz., days to 50% flowering, plant height (cm), number of monopodia plant^{-1}, number of sympodia plant^{-1}, number of bolls plant^{-1}, boll weight (g), lint index (g), seed index (g), ginning out-turn (%), 2.5% span length (mm), micronaire value (10^{-6}g/inch), bundle strength (g/tex), uniformity ratio, fibre elongation (%), seed cotton yield plant^{-1} and lint yield plant^{-1} (g). The lint quality parameters were studied at Central Institute for Research on Cotton Technology (CIRCOT) Regional Center, Lam, Guntur, Andhra Pradesh. The genetic divergence was worked out by using Mahalonobis D^2 statistic described by Rao (1952). On the basis of D^2 values, the genotypes were grouped into different clusters by employing Tochers's method as outlined by Rao (1952).

The analysis of variance showed highly significant differences among genotypes for all the characters studied and infers existence of considerable genetic diversity among genotypes. Hence, further analysis was carried out for relative magnitude of D^2 values for all the characters and all the genotypes were grouped into seven clusters. The mutual relationships among the clusters were presented diagrammatically (Fig. 1). The average intra- and inter-cluster D^2 values and the proximity and divergence among seven clusters estimated are presented in Fig. 2.

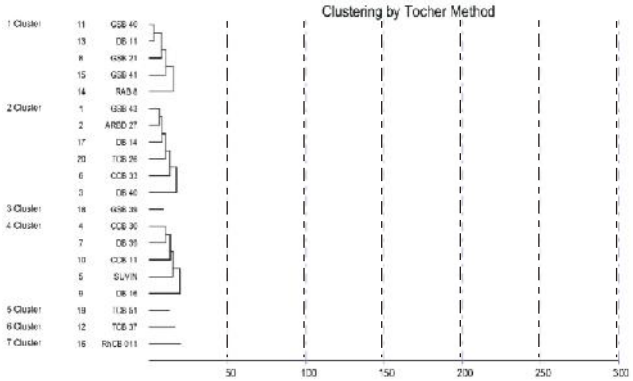

Fig. 1. Dendrogram showing relationship of 20 Egyptian cotton (*Gossypium barbadense* L.) genotypes in seven clusters based on Mahalanobis' D^2 values

Among the clusters obtained the maximum number of germplasm accessions (6) were included in cluster II followed by Cluster I and Cluster IV five genotypes each, while clusters III, V, VI and VII included one genotype each. Thus, the grouping of genotypes into different clusters was at random and no relationship between the genetic divergence and geographical origin of the genotypes was observed. The geographical distribution of genotypes is not the only factor that causes genetic diversity. However, this is an inferential criterion and it may not be so effective in quantifying or differentiating various populations. This may be due to exchange of breeding material over the locations and further selections at different locations which could result in genetic drift. These results are in confirmation with the earlier findings of Haritha and Ahamed (2013), Kavithamani *et al.* (2013), Malik *et al.* (2013), Araujo *et al*. (2014), Bhailume *et al.* (2014), Ravikesan *et al*. (2014) and Tulasi *et al. (*2014) and Sirisha (2015). Hence, it indicated that the geographic diversity though important, might not be the only factor in determining genetic divergence. Therefore, choice of the parents for hybridization should be decided on the basis of genetic diversity rather than geographical diversity.

In the present study, inter cluster distances were found to be greater than intra cluster distances, revealing considerable amount of genetic diversity among genotypes. The maximum intra-cluster distance recorded by cluster IV (55.49) followed by cluster II (42.93) and cluster I (38.76). Clusters III, V, VI and VII had zero intra-cluster distances and monogenotypic. Presence of high genetic diversity among the genotypes present in the cluster IV indicated by high intra-cluster distance. Whereas, the maximum inter-cluster distance (263.35) was observed between cluster III and VI followed by 236.01 (clusters IV and VI), 212.57 (clusters IV and V), 208.17 (clusters V and VI) and 203.82 (clusters V and VII). The minimum inter-cluster distance of 57.57 was recorded between cluster III and IV. These results revealed presence of wide genetic diversity between the clusters. Maximum genetic divergence between the clusters indicates that the hybridization between the genotypes of distant clusters would produce potential and meaningful hybrids and desirable segregants. Use of genetically distant genotypes as parents to get the most promising breeding material had also suggested by Basavaraddi and Katageri (2011), Asha *et al.* (2013) and Bayyapu Reddy (2015).

The clusters mean values for all the sixteen characters are presented in Table 1. By the study of cluster means, it was understandable that considerable differences were noticed between the cluster means for different traits. Cluster I exhibited high mean values for number of sympodia plant^{-1} (18.58), boll weight (2.84) and ginning out-turn (33.63);

Table 1. Mean values of seven clusters estimated by Tocher's method from 20 genotypes of Egyptian cotton (*Gossypium barbadense* L.)

Cluster No.	Days to 50 % flowering	Plant height (cm)	No. of mono podia plant^{-1}	No. of sympodia plant^{-1}	No. of bolls plant^{-1}	Boll weight (g)	Lint index (g)	Seed index (g)	Ginning out turn (%)	2.5% span length (mm)	Uniformity ratio	Micronaire value (10^{-6} g/inch)	Budnlest rength (g tex^{-1})	Fibre elongation (%)	Seed cotton yield plant^{-1} (g)	Lint yield plant^{-1} (g)
1	72.40	147.33	1.29	18.58	43.43	2.84	4.99	9.86	33.63	33.34	46.42	2.86	25.66	5.28	104.87	35.33
2	72.83	130.87	1.52	15.79	45.55	2.70	4.23	9.45	30.95	31.04	47.18	2.86	24.28	5.25	104.91	32.68
3	73.00	130.29	1.22	12.21	48.90	2.37	3.53	8.67	28.96	30.57	45.80	2.83	23.17	5.21	98.48	28.65
4	72.93	137.60	1.07	15.91	42.15	2.37	3.85	8.11	32.14	34.58	46.48	2.73	26.20	5.21	84.42	27.21
5	70.00	146.63	2.00	15.83	35.77	2.55	4.57	10.17	30.98	28.27	48.31	2.67	21.73	4.90	77.37	23.96
6	72.00	130.44	1.67	18.00	40.67	2.48	5.67	11.20	33.61	37.83	45.56	3.09	29.49	5.54	85.61	28.81
7	71.33	149.34	0.67	16.55	57.22	2.75	4.43	9.77	31.22	29.18	48.03	3.20	24.42	5.52	133.20	41.59

Note: Bold figures are minimum and maximum values

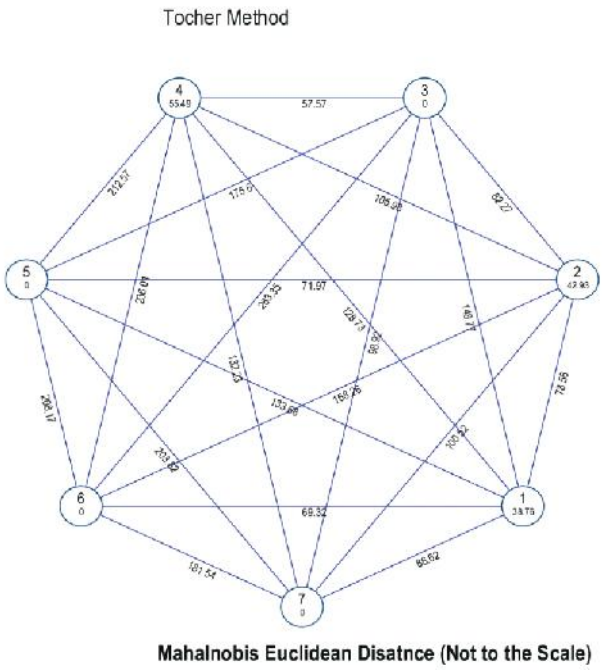

Fig. 2. Intra-and inter-cluster distance of 20 Egyptian cotton (*Gossypium barbadense* L.) genotypes in seven clusters based on Mahalanobis Euclidean distance

Cluster III recorded high mean values for days to 50 % flowering (73.00); cluster V recorded high mean for number of monopodia plant^{-1} (2.00) and uniformity ratio (48.31); cluster VI recorded high mean for seed index (11.20), lint index (5.67), 2.5 % span length (37.83), bundle strength (29.49) and fibre elongation (5.54); cluster VII recorded high mean for plant height (149.34), number of bolls plant^{-1} (57.22), micronaire value (3.20), seed cotton yield plant^{-1} (133.20) and lint yield plant^{-1} (41.59). From the above mean values we can infer that cluster I and IV recorded high mean values for important yield contributing traits like number of sympodia plant^{-1}, boll weight and number of bolls plant^{-1}. So genotypes from these clusters can be used for cotton yield improvement. Among the quality attributes high mean values for 2.5 % span length, bundle strength and fibre elongation (37.83, 29.49 and 5.54) were recorded in cluster VI and cluster V for uniformity ratio (48.31). So genotypes from these clusters can be used for cotton fibre quality improvement.

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Knowledge Status of Masumbi (*Citrus sinensis)* Cultivating Farmers of Haryana (India): A Sustainable Fruit Crop

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Abstract: Overall knowledge level of masumbi (*Citrus sinensis*) crop was medium to high since 65% respondents belonged to these categories. Knowledge status of farmers was measured by the scores on the basis of magnitude of the problems. Study revealed that time of planting (knowledge index 91.67), irrigation (89.58), recommended cultivars (87.50) and manure and fertilizer (82.08) knowledge level was high, whereas, knowledge level was low of packaging (46.67), diseases and their control (35.83) and insect pest and their control (35). Study revealed that association between the personality traits such as education (r=0.625), socio-economic status (r=0.218), extension contact (r=0.343) and mass media exposure (r=0.434) had positive and significant correlation with the knowledge level of masumbi (*Citrus sinensis) cultivation. Whereas, age,* education, socio-economic status, extension contact and mass media exposure was significant in case of the partial regression coefficient.

***Key Words*:** Correlation and Regression, Knowledge level, Masumbi citrus

The orange (Sweet Orange) is the fruit of the citrus species, *Citrus sinensis* in the family Rutaceae. India is the second largest producer of fruits after China, with a production of 88977 thousand MT (million tons) of fruits from an area of 7216 thousand hectares while in Haryana, the citrus is grown on an area of 19.4 thousand ha with production 235.4 thousand MT (Anonymous, 2013-14).

The study was conducted to: overall knowledge status of masumbi (*Citrus sinensis) cultivating* farmers of Haryana state, association between various socio-psychological traits and knowledge level of improved masumbi (*Citrus sinensis*) cultivation practices.

To collect the primary data on knowledge level of *Citrus sinensis* cultivation, the respondents were selected with multistage sampling and average citrus orchard age was 5-6 years. Among fruit growing states of India, Haryana was purposively selected being emerging state in citrus cultivation as well as direct access to the investigators. From state, Bhiwani district was also selected purposively because it fall in Southern Haryana cluster of NHM scheme for development of citrus cultivation due to suitable climate and soil requirement along with maximum area under drip irrigation. Further 3 blocks viz. Dadri, Badhra and Loharu were selected purposively. From each block 40 farmers were selected randomly, making a total of 120 respondents. The data were selected with the help of well-structured and pre-tested interview schedule. The responses were obtained on three-point continuum scale in case of knowledge Level (full knowledge, partial knowledge and no knowledge) and scores were given as 3, 2 and 1, respectively. After that frequency was multiplied with the score (3, 2 or 1) and total weighted score was obtained and total weighted score was divided by total respondents (120) for mean score. The data were analyzed with percentage, mean score, knowledge index, rank order, correlation coefficient and regression.

Overall knowledge level of masumbi (*Citrus sinensis*) cultivating practices: Result pertaining to overall knowledge level of masumbi (*Citrus sinensis*) crop presented in Table 1 clearly show that The majority of farmers has medium (42.5%) knowledge level followed by low level (35%) and only 22.5% belonged to high level. It can be calculated that only 65% of the respondents had medium to high knowledge level. Similar findings have been recorded by Singh and Varshney (2010) who found that weak extension activities such as technical training at village level were the major constraint.

Knowledge status of masumbi (*Citrus sinensis*) cultivating practices: The results presented in Table 2 regarding knowledge status show that 'time of planting' recommended by CCSHAU, Hisar practice is high among all and ranked first with knowledge index 91.67, followed by 'irrigation', 'recommended cultivars' and 'manure and fertilizer' ranked second, third and fourth with knowledge index 89.58, 87.5 and 82.08, respectively (Table 1). The study got strength from Rohila *et al.* (2015) who reported that sowing knowledge of farmers was high. 'Intercultural operation' and 'fruit drop' ranked fifth with knowledge index 80.00. Present study also shows that 'Post-harvest technology', 'inter-cropping', 'method of propagation' and 'packaging' ranked sixth, seventh, eighth and ninth with

Table 1. Overall knowledge level of masumbi (*Citrus sinensis*) cultivating practices

(n=120)

Knowledge status	Knowledge score	Percentage
Low	18-31	35.00
Medium	32-37	42.50
high	38-43	22.50

knowledge index 72.08, 70.83, 50.00 and 46.67, respectively. These findings are in line with the findings of Choudhary *et al*. (2013) who concluded that lack of proper market and lack of need based training were major constraints. Present Study concluded that 'Disease and their control' and 'insect pest and their control' ranked tenth and eleventh with knowledge index 35.83 and 35.00. All these constraints could be minimize by providing training and also by distributing the literature regarding the technical know-how to the farmers as it requires specialized skills in certain operations. The study gets support from Singh (2004) reported that inadequate training for technical skills was major constraint.

Table 2. Distribution of *Citrus sinensis* growers based on their knowledge level

(n=120)

Practices	Knowledge Level	No. of Growers	Percentage	Mean Score	Knowledge index	Rank Order
Time of planting	Low	00	0	1.83	91.67	I
	Medium	20	16.67			
	High	100	83.33			
Irrigation	Low	05	4.17	1.79	89.58	II
	Medium	15	12.50			
	high	100	83.33			
Recommended cultivars	Low	0	0	1.75	87.5	III
	Medium	30	25			
	High	90	75			
Manure and Fertilizer	Low	13	10.83	1.64	82.08	IV
	Medium	17	14.17			
	High	90	75			
Intercultural operation	Low	18	15	1.60	80.00	V
	Medium	12	10			
	High	90	75			
Fruit drop	Low	08	6.67	1.60	80.00	V
	Medium	32	26.67			
	High	80	66.66			
Post-harvest technology	Low	28	23.33	1.44	72.08	VI
	Medium	11	9.17			
	High	81	67.50			
Inter-cropping	Low	30	25	1.41	70.83	VII
	Medium	10	8.33			
	High	80	66.67			
Method of propagation	Low	24	20	1.0	50.00	VIII
	Medium	72	60			
	High	24	20			
Packaging	Low	40	33.33	0.90	46.67	IX
	Medium	48	40			
	High	32	26.67			
Disease and their control	Low	47	39.17	0.71	35.83	X
	Medium	60	50			
	High	13	10.83			
Insect pest and their control	Low	43	35.83	0.7	35.00	XI
	Medium	70	58.33			
	High	07	5.84			

Association between farmers' personality traits and their knowledge level of improved masumbi (*Citrus Sinensis*) cultivation practices: The data in Table 3 shows that the association between the personality traits like education (r=0.625), socio-economic status (r=0.218), extension contact (r=0.343) and mass media exposure (r=0.434) with the knowledge level had positive and significant correlation. This means that masumbi grower having higher education, socio-economic status, extension contact and mass media exposure possessed higher level of knowledge of recommended practices for masumbi cultivation. While all the remaining factors namely age, family education, land holding, risk orientation, scientism and economic motivation did not show any significant association with knowledge level of farmers. It can be concluded that these variables are not associated with the knowledge level of masumbi growers. Findings are in agreement with the study of Chavan *et al.* (2013) who reported that variables such as age, education, innovativeness, risk preference and extension contact etc. was non-significant relationship with knowledge of recommended cultivation practices.

Table 3. Association between farmers' personality traits and their knowledge level

(n=120)

Variables	Correlation Coefficient
Age	0.120^{NS}
Education	0.625*
Family Education	0.135^{NS}
Land holding	0.085^{NS}
Socio-economic status	0.218*
Extension Contact	0.343*
Mass Media exposure	0.434*
Risk Orientation	0.145^{NS}
Scientism	0.156^{NS}
Economic motivation	0.154^{NS}

Significant at 0.05 level of probability

Multiple regression analysis of knowledge level of farmers with their socio-economic variables: The partial regression coefficient of age, education, socio-economic status, extension contact and mass media exposure were significant. In other words, unit change in age may lead to a corresponding change of 0.030 units in the knowledge level of the respondents regarding package of practices of masumbi cultivation while the remaining independent variables, viz., family education, land holding, risk orientation and economic motivation did not significantly contribute to the knowledge status of masumbi growers. It revealed that all the seven independent variables included in the study jointly contributed 53 per cent variation in the knowledge of the respondents regarding masumbi cultivation practices when other factors were kept constant.

Table 4. Multiple regression analysis of farmers' knowledge level with their personality traits

Variables	Regression Coefficient	't' values
Age	0.030	1.208*
Education	1.955	6.858*
Family education	0.010	0.137
Land holding	0.105	0.430
Socio-economic status	0.189	3.168*
Extension contacts	0.171	2.137*
Mass media exposure	0.399	2.437*
Risk orientation	-0.005	-0.049
Scientism	0.111	1.754*
Economic motivation	-0.002	-0.019
	R^2=0.53	

Dependent variable- knowledge
Significant at 0.05 levels

Mostly respondents overall knowledge level was medium. Study emphasized that time of planting, irrigation, recommended cultivars and manure and fertilizer knowledge level was high, whereas, knowledge level was low of packaging, diseases and their control and insect pest and their control. The government should address the problem of better technical support and credit facilities for wider adoption this fruit crop as perceived remunerative as well as increasing demand of fruit which ensure the food nutrition security in the region being most feasible fruit for diversification.

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Expectations of Fishers from Different Service Providers: A Case of Tehri Reservoir, Uttarakhand

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***Abstract*:** The majority of fishers of Tehri reservoir, Uttarakhand, had expectations to have better infrastructure and transportation facilities, fishing right for their community, better marketing services, training programs for fishers and community welfare. It is recommended that co-management practices in the reservoir and empowerment at the community level can uplift the fisheries as well as socio-economic status of fishers. Integration of fisheries and aquaculture in the reservoir must be carried out by the support of all service providers to fulfill the expectations of fishers.

***Key Words**:* Fishers, Service providers, Tehri reservoir

Fishery is an important sector in developed and developing countries of the world from the perspective of food production, income and employment generation. FAO (2014) estimated that fisheries and aquaculture assure livelihoods to 10–12 per cent of the world's population. According to FAO (2014) capture fisheries and aquaculture supplied the world with about 158 million tonnes of fish in 2012, out of which around 7.1% (11.3 million tonnes) came from inland capture fisheries. Out of this, India contributes about 5.42% to total world fish production. Total fish production in India during 2013-14 was 9.58 million metric tonnes. Out of this, inland sector contributed 6.14 million metric and marine sector contributed 3.44 million metric tonnes with the contribution of 0.8% to national GDP and 5.5 % of agricultural GDP (Anonymous, 2014), with a total export value of Rs. 30,213.26 crores of 9,83,756 MT (MPEDA, 2013).

India has a large spread of fresh water resources in the form of rivers, reservoirs, lakes, ponds. Total inland water bodies are 73.59 lakh ha, and area of reservoirs is 29.07 lakh ha. Reservoirs form an important source of fish production in India. Presently, area under reservoir fisheries in the country has been estimated at about 3.15 million hectares. There are 56 large reservoirs, 180 medium reservoirs and 19,134 small reservoirs covering a water area of 1.14 million ha, 0.527 ha and 1.485 million ha respectively (Sugunan, 1995). At present, there are 4857 completed large dams in world and 341 large dams are under construction in India. Among many states in India, Uttarakhand is one of the newly formed states. Uttarakhand has 18 completed large dams and 4 large dams are under construction (Anonymous, 2014).

In Uttarakhand, the Tehri reservoir is one of Asia's highest reservoirs (260.5 meters height, and the eighth highest in the world). Tehri reservoir was constructed on Bhagirathi and Bhilangana rivers 2007, and used multipurpose like power generation, drinking water supply, irrigation, and flood control. Tehri reservoir which has a vast area about 42 km^2 of water resources has not yet been exploited to the fullest extent from the fisheries point of view. It has been reported that primary productivity of Tehri reservoir is quite optimum (Agrawal and Thapliyal, 2005) and can support more productive fishery (Ayoade *et al*., 2009). However, lack of appropriate policy framework, institutional arrangements, fisheries management and government support, fisheries of Tehri reservoir has remained under-exploited.

Different agencies like Tehri Hydro Development Corporation (THDC), State Government and Department of Fisheries have the mandate of providing services to the fishers dependent on the reservoir. Fishers have different expectation from service providers. Thus, the present study was done with an objective to explore expectations of fishers from different service providers with reference to fisheries.

The study was carried out in Tehri reservoir of Tehri district of Uttarakhand state. To achieve research objective fishers were selected as an obvious target population. Simple random sampling was used to select 80 fishers. Data were collected using structured interview schedule. The different service providers are Tehri Hydro Development Corporation (THDC), State Government, Department of Fisheries, marketing agents, and credit suppliers. Expectations of fishers from these service providers were noted and statistical tools such as frequency and per cent analysis were used to analyze the data.

THDC has its fisheries management plan to provide technical assistance and intensive culture. The State

government of Uttarakhand has the policy to develop a fisheries policy in this regard so that fisheries can help in providing livelihood security to fishers as well as economic growth of the State. Department of Fisheries has mandated to increase fish production in the State by judicious management of all the fisheries water resources; to develop reservoir fishery of the State and popularization of reservoir fisheries schemes in the State. Marketing agents are the functionaries (wholesalers, retailers and middlemen) involved in a span of product from producer to ultimate consumer. Credits suppliers are the person or organization, who provides financial assistance to fishers, i.e. governments, NGOs, Self-Help Groups, fisher associations and financial institutions.

Expectation of fishers from Tehri Hydro Development Corporation (THDC): A total of 41 per cent of respondents expected to have a facility of ferry boats for traveling from one village to another bank of reservoirs villages. At present, there are fewer numbers of ferry boats for traveling. In addition, 15 per cent respondents also expected a bridge to be constructed. One of the most immediate consequences created soon after the Tehri reservoir constructed was a disconnection of travel routes and transportation (Wilmot, 2012). Fishing rights to fish in the reservoir are presently absent. A total of 24 per cent fishers expected that fishers should get fishing rights and 19 per cent respondents expected to have alternative livelihood opportunities like sports fisheries, angling, and tourism. Some studies have also reported that recreational or sports fisheries are very good livelihood option in reservoirs. THDC has a mandate of fisheries and aquaculture development, and the expectations of fishers fall well within the mandate of THDC.

Expectations of fishers from state government: The majority of the respondents (70%) expected to have a licensing scheme for fishing. The licensing system should be intervened as rights to fisheries. Capistrano (2009) has stated that the rights to fisheries are fundamental not only as a key tool in fisheries management and conservation, but also as an integral ingredient in the pursuit of secure livelihoods on the part of indigenous peoples**.**

The 32 per cent fishers expected to have fish landing centers in the vicinity of the reservoir while the 29 per cent fishers wanted better education and health facilities for their families. About 20 per cent respondents expected that State Government should hand over the reservoir water body to them for fishing and its management. The best strategy for sustainable and equitable reservoir management is to introduce co-management. It is a partnership arrangement in which the community of local resource users (fishers), government, other stakeholders (boat owners, fish traders, boat builders, business people, etc.) and external agents (non-governmental organizations (NGOs), academic and research institutions) share the responsibility and authority for the management of the fishery (Pomeroy, 2006). A total of 15 per cent respondents expected that state government should develop infrastructure from tourism perspective in the surrounding villages of Tehri reservoir. The State Government can adopt Institutional arrangements such as co-management system, which is considered in fishery management as a way of decentralizing resource management decisions, improving participatory democracy and compliance (Ostrom, 2005), and take up activities for the overall development of fisheries in the reservoir as well as promote tourism by developing infrastructure for the same.

Expectation of fishers from Department of Fisheries (DoF): A total of 47 per cent respondents expected that DoF should work for the welfare of fishers' community and 29 per cent respondents were expecting training programs regarding fisheries. 32 per cent respondents were having the expectation that DoF should allow them to participate in fisheries management. Mikalsen and Jentoft (2001) have reported that fish is a public resource and should be managed through institutional arrangements and local community should have rights to access, harvest, and management. There were only a few respondents (4%) who were expecting enforcement of fisheries rule and regulation, like mesh size regulation, fishing zone demarcation and closed season. At present the DoF has following functions and responsibility such as management and development of reservoir fishery, to generate employment opportunities by the fisheries activities and implementation of fisheries act and rules in the State.

Expectation of fishers from marketing agents: There are few market agents who are involved in the marketing of fish. The fish are usually sold to hoteliers directly by the fishers. However, few market agents who are available decide the market price of fish. The respondents (49%) expected that the prices of fishes should be fair and decided in consultation with them. A total of 39 per cent fishers expected that more marketing agents should be present as to reduce the competition. About 35 per cent expected that there should be a facility for assembling and selling of fish, while 25 per cent expected for a storage facility for fish so that they can easily distribute the fishes in different destinations.

Expectation of fishers from credit suppliers: The credit suppliers play an important role in providing financial assistance to fishers for purchasing crafts and gear and other inputs, thus, 39 per cent respondents expected to get interest free credit on purchasing crafts and gear. Few credit suppliers were present in this area, so 34 per cent

respondents expected that credits suppliers should be available for them to access the credit. The credit providers were mainly money lenders, bank, relative/friends and marketing agents. Usually, they charge 10% interest rate per year on given credit, so 12 per cent fishers expected low-interest rate on the loan from the credit suppliers.

It can be concluded from the results that the majority of fishers expected to have better infrastructure and transportation facilities, fishing rights, marketing facilities, training programs and community welfare. The State Government should take a more active role in building the new institutional arrangements needed for fisheries development and management. It is recommended that communities must be empowered by allowing the right to fish as well as to make decisions about fisheries management. The assistance and support of government and other service providers are needed to fulfill the expectations of fishers.

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Residual Effect of Integrated Nutrient Management Practices on Soil Nutrient Status and Yield Attributes

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Abstract: The integrated nutrient management practices (T_3: 50% N + 100%PK + green manure, T_4: 75 %N +100%PK + farmyard manure @10 t acre^{-1} and T_5: 75% N+100% K + poultry manure @ 2.5 t acre^{-1} applied to kharif rice recorded increased grain yield when compared to 100%NP and100% NPK in succeeding wheat crop. Thus, residual effect of integrated nutrient management practices adopted in rice were found sufficient to supply nutrients in wheat under rice-wheat system.

Key Words: Fertilization, Integrated nutrient management, Rice-wheat cropping system, Organic manures

Rice-wheat is the prevalent and an important cropping sequence practiced in Punjab. The inputs of nutrients in the form of inorganic fertilizers has played a major role in increasing yield levels but over applications of inorganic fertilizers lead to nutrient imbalances and reason for soil fertility depletion. Today emphasis has been shifted from individual crop to cropping system as a whole, since the responses in component crops of the cropping system are influenced by the nutrient application to preceding crops by leaving substantial effect on the succeeding crops by what is known as carry over benefit (Chatto, 2010). Low affordability and high cost of chemical fertilizers is the biggest obstacle for chemical fertilizer among small holder farmers. Moreover, mismanagement of plant nutrients have made this task more difficult. The current energy crisis, and lack of proper supply system of inorganic fertilizers calls for more efficient use of organic manure, green manure, crop residues and directing us to use integrated nutrient management practices or organic manures, which leaves a substantial residual effect on succeeding crops in different cropping systems. Hence, the present study is conducted with the aim to assess residual effect of different integrated nutrient management practices on soil nutrient status, yield and its attributes in succeeding wheat crop.

Residual effect of different integrated nutrient management (INM) practices and inorganic nutrient combination in wheat for three consecutive years (2011-12 to 2013-14) was observed at regional research station, Gurdaspur. Treatments used for study were T_1: 100%NP, T_2: 100%NPK, T_3: 50% N + 100% PK + green manure, T_4: 75 % N +100% PK + Farmyard manure, T_5: 75% N+100% K + poultry manure. Green manure (*Sesbania aculeata*) buried 6 to 8 weeks old one day before transplanting of paddy, well rotten FYM @ 10 t acre^{-1}, poultry manure @ 2.5 t acre^{-1} was applied in rice crop to evaluate the residual effect on succeeding wheat crop. The data on soil nutrient status, yield and its attributes was recorded.

Soil samples collected at a depth of 0-15 cm were analyzed for chemical properties following standard methods. Organic matter was determined by method given by Walkley and Black (Walkley and Black,1934), soil pH (1:2.5 soil: water) by glass electrode pH meter method (Michael, 1965), available P by Olsen method (Olsen *et al.,* 1954), exchangeable K by Flame photometer after extraction with 1N NH_4OAc at pH 7.0 (Black, 1965). The crop was harvested and the data on plant height, effective tillers per hill, panicle length, and filled grains per panicle was recorded. Five plants in each treatment and in each replication were randomly selected and tagged properly. Tagged plants were used for recording various observations. Grain yield was recorded at 14% moisture basis and straw yield at sun dry basis.

Plant height, ear length, spikelets/ear and number of productive tillers responded significantly to the residual effects of integrated nutrient management practices (Table 1 and 2). All the treatments gave significantly higher plant height over the 100%NP (T_1). The maximum plant height of 93.1 cm was in T_5 (75% N+100% K + poultry manure). The highest numbers of productive tillers were in T_5 and the lowest value was observed in T_1. The data represents that residual effect of different INM practices followed in rice showed maximum grain and straw yield in succeeding crop wheat however INM practices were non significant with each other. Liza *et al.* (2014) also reported increase in grain yield due to residual effect of organic manures with different levels of fertilizers. Study also showed that nutrient status and yield attributes were significantly affected by integrated use of

Table 1. Residual effect of INM practices on physico-chemical properties and soil nutrient status of wheat

Treatments	pH	EC (mmhos cm^{-1})	OC (%)	Available P (kg ha^{-1})	Available K (kg ha^{-1})
T_1	6.6	0.18	0.38	35.1	79.2
T_2	6.7	0.18	0.40	47.6	80.0
T_3	6.9	0.19	0.41	39.1	97.5
T_4	7.4	0.20	0.42	48.2	96.6
T_5	7.6	0.21	0.42	59.1	96.7
CD (p=0.05)	0.1	NS	0.02	1.2	3.4

Table 2. Residual effect of INM practices on mean values of yield and yield attributes of wheat

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Plant Height (cm)	Ear Length (cm)	Spikelets/ ear	No. of productive tillers per metre row length
T_1	33.7	43.7	86.8	10.1	19.5	84.7
T_2	37.8	45.0	90.1	10.2	19.5	86.0
T_3	38.7	45.0	89.8	10.2	19.5	88.0
T_4	37.8	47.7	91.5	10.3	19.1	90.0
T_5	38.9	51.7	93.1	10.0	19.6	97.0
CD (p=0.05)	2.5	3.2	1.8	NS	NS	2.9

NPK with green manure, farm yard manure (FYM) and poultry application in comparison to 100% NP and 100% NPK alone (Table 1). Khan *et al.* (2007) reported significantly increase in grain yield due to application of organic and inorganic fertilizers. Badruzzaman *et al. (*2002) also showed that organic manures had direct and residual effects on both rice and wheat yields and the effect of poultry manure was dominant. Residual level is also sufficient to supply plant nutrients in rice-wheat system. The integrated use of NPK with organics was found beneficial in improving physico-chemical properties of soil and residual level of INM practices provided sufficient nutrients to affect the yield performance of succeeding crop.

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Quantification of Egyptian Clover *Trifolium alexandrinum* as Source of Honey and Pollen

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***Abstract*:** Quantification of Egyptian clover *Trifolium alexandrinum* crop's value as provider of surplus honey and pollen was studied at CCS, Haryana Agricultural University, Hisar during 2012 and 2013. Colony performance parameters like area honey, nectar, pollen, brood, drone and whole bee population showed significantly higher trend during I, III, and IV weeks of May during both the years and declined marginally at end of the flowering.

***Key Words*:** Bee brood, Bee colony, Egyptian clover, Honey, Nectar, Pollen

Egyptian clover, *Trifolium alexandrinum* L. (Family, Leguminaceae, sub-family Papilionaceae. T. alexandrinum has played a key role main fodder crop during rabi season. While benefitting berssem through pollination, the symbiotic relationship is in vivid display in these complex plant-bees interactions. In North Eastern Haryana, honey bees collected surplus honey from T. alexandrinum. The beekeepers are regularly taking 1-2 honey extractions from this rich source from Haryana, Punjab, Uttar Pradesh, Himachal Pradesh, Jammu and Kashmir during the extreme hot weather.

***Apis mellifera* colony performance:** Three *Apis mellifera* colonies were equalized before migration to the *Trifolium. alexandrinum* crop. Based on general colony bearing capacity of crop, they were placed in a shady place at a distance of 100 m from the field. Colony growth parameters were recorded at weekly intervals to map colony growth as per the method of Chaudhary (2003 a,b). These included a set of 18 parameters including number of frames; colony strength; presence and quality of queen and drones; brood area with honey, nectar, pollen, egg, larva, pupa; disease prevalence; colony characters like gentleness. To measure the respective areas in frames, a specially designed "Chaudhary's brood counting frame" (Chaudhary 2007 a, b) was used. After removing the bee frame from the colony to be measured, it was jerked to dislodge adult bees into the colony and then placed on a flat platform (like top cover) or sometimes even held firmly with hands. On this frame, "Chaudhary's brood counting frame" was placed as shown in on it first face (marked A side of frame). Firstly, the numbers of squares that are full with observing characters like egg, larva, pupa, nectar, pollen, honey, etc. are counted and subsequently half or more that half-filled squares were counted. The process was repeated for the other side of the frame (marked side B) and subsequently for all the frames of the colony. The frames with less than half filled areas for the observing characters were not counted. This method provided direct observation on areas occupied in the frames and the colony by various stages and sources. Each colony constituted one replication and there were 3 replications.

Melissopalynological analysis of pollen loads: To ascertain the reward value of *T. alexandrinum* during its flowering period to the honey bees among the available flora during the time of study, melissopalynological analysis of pollen loads were conducted at regular intervals. At the hive entrance of these three colonies, incoming pollen foragers were caught with the help of a pair of forceps and their pollen loads removed gently on to a slip of clean butter paper, which was further wrapped in another paper and finally in a polythene packet to make it air-tight. Each packet was labeled properly with date, time and forager species. These samples were got analyzed from Central Bee Research and Training Institute, Pune for melissopalynological analysis following the method of Suryanarayana *et al*. (1992). A small portion of representative sample from each pollen load was temporarily mounted on glass slide and analyzed under microscope and further quantified using haemocytometer.

***Apis mellifera* colony performance:** *Trifolium alexandrinum* bloom started from last week of April and continued till end of May. Mean number of total frames (9.3) and those occupied by honey bees (8.7) in a bee hive remained static during the periods of observation indicating the presence of extra frames and space at the start of the studies (Table 1 & Fig 1,2). However, Chaudhary (2003c) recorded higher bee strength (10.2 bee frames) in May and June (9.8) with corresponding brood frames (6.0 and 5.5) and colony strength (59.4 and 55.9%, respectively).

Table 1. Mean *Apis mellifera* colony performance on *Trifolium alexandrinum* bloom

Observation periods	Total No. of frames	Bee frames	Honey*	Nectar*	Nectar + Honey*	Pollen*	Brood*	Drones*	Adult*
5 May (I)	9.3	9.0	330.4	187.5	517.9	314.5	350.03	16.8	784.8
12 May (II)	9.3	9.0	318.7	241.7	563.3	343.3	390.7	16.3	791.7
19 May (III)	9.3	9.0	350.2	298.0	647.7	379.8	392.5	15.5	808.3
26 May (IV)	9.3	8.7	361.3	256.2	618.2	375.8	311.7	13.7	740.5
2 June (V)	9.0	8.7	357.3	189.7	547.2	282.3	228.4	7.2	649.3
2012	9.3	8.7	175.2	297.9	473.4	215.5	354.0	13.5	671.7
2013	9.2	9.1	511.9	171.3	684.3	275.2	315.3	14.3	838.2
CD (p=0.05)	NS	NS	30.6	19.0	14.6	20.6	10.5	NS	17.0
SE(m)	0.3	0.3	10.2	6.4	4.9	6.9	3.5	1.5	5.7

* Inches^2

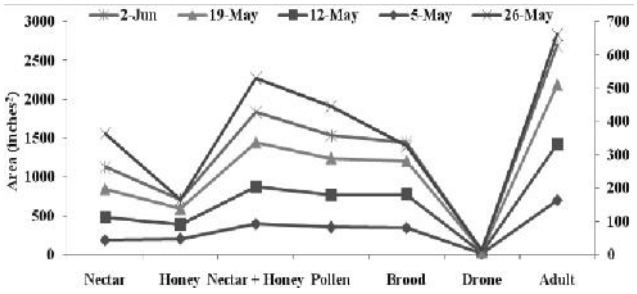

Fig. 1. *Apis mellifera* colony performance during 2012

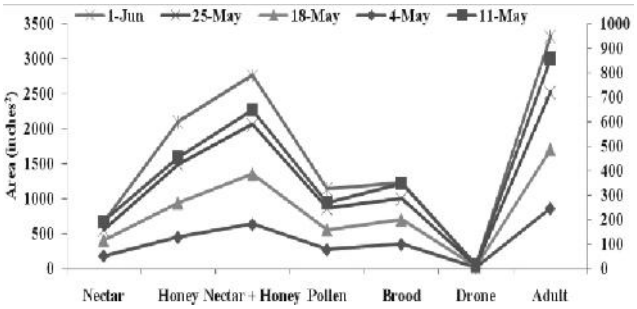

Fig. 2. *Apis mellifera* colony performance during 2013

The honey yields composite of stores of incoming nectar and capped honey- were higher in 2013 when it was stored in a mean area of 684.3 inches^2 than 2012 (473.4 inches^2). From initial levels at the beginning of season, it reached a significantly higher area of 517.9 inches^2, improved to 563.3 (2nd week) and peaked during the 3rd week to 647.7 before declining slightly in 4th week (618.2) and was still higher (547.2 inches^2) at the end of season. Chaudhary (2003c) reported one extraction of honey from *berseem* crop from North Eastern region of Haryana.

Pollen stores were higher during 2012 (215.5) than 2013 (275.2), their level increased significantly during 2nd week (343.3 inches^2), peaked during 3rd week (379.8) and were the lowest as the season finished (282.3 inches^2). The total brood area derived after combining the overlapping stages of egg, larvae and pupae was larger in 2012 (354.0 inches^2) than 2013 (315.3 inches^2). The brood area increased after one week of flowering to a high of 350.0 inches^2 and peaked during 2 and 3rd week (390.7 and 392.5 inches^2, respectively) before registering a significant decline in the 4th week (311.7 inches^2) and was the lowest at the end of season (228.3 inches^2). Chaudhary (2003c) also recorded higher number of brood frames in May (6.0) that declined marginally in June to 5.5 frames/colony. Atwal and Sharma (1970) on the other hand recorded large scale brood rearing in March 1967 (996 inches^2) that rose further in April (1400) and May (1630) but significantly lower values during 1968 (490, 620 and 800 inches^2) indicating their fluctuating yearly and seasonal pattern. Brar *et al.* (1992 a, b) also recorded peak brood rearing of *A. mellifera* from March-May.

The presence of drone brood albeit at a relatively low range of 7.2 to 16.8 inches^2 is a sure indication of successful season where ample rewards are hoarded by the honey bees in the colony leading to congestion and the initiation of drone breeding. These findings are supported by the study of Chaudhary (2003a, b, c and 2004) who termed *T. alexandrinum* crop season as a partial breeding season due to minor drone tolerance, comb construction and nectar storage in the apiary.

The increase in area was more spectacular for nectar (including honey) and pollen resources compared to the brood and adult populations. These resources were foraged at faster speed and hoarded in available cell spaces in the hive frames, leaving little space for the egg and brood stages, resulting in lower adult populations at the end.

All these parameters of colony growth clearly signal the utility of *T. alexandrinum* as a highly valuable crop both for nectar and pollen rewards to the honey bees and find support from many workers (Chaudhary, 2003b, c and 2004**).**

Mellissopalynological analysis of pollen loads: During

the *Trifolium alexandrinum* bloom period, honey bees were recorded foraging only on its pollen as was confirmed from pollen analysis, signifying *berseem* as the major sources. Chaudhary (2003a, b, c and 2004) also mellissopaly nologically confirmed the utility of *T. alexandrinum* and ranked it 7th amongst 123 bee forage plants of North Eastern region of Haryana with a total pollen load contribution of 4.4 per cent.

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Torrefaction of Bagasse for Improving its Usability as a Fuel in Cyclone Gasifier

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***Abstract*: The** torrefaction is carried out in the temperature range between 230º C to a maximum 300º C. In the present study, torrefaction was carried out for sugarcane bagasse at 230º C for the duration of 20, 30, 40, 50 and 60 minutes, respectively. The energy required for grinding of raw bagasse was 0.56 kWh/kg and that of bagasse torrefied for the duration of 20, 30, 40, 50 and 60 minutes was found to be 0.46, 0.14, 0.14, 0.14 and 0.14 kWh/kg, respectively. On this basis, it is recommended that torrefaction be done for a period of 30 minutes to minimize power requirements and simultaneously achieve satisfactory grinding characteristics. For 30 minutes duration, the particle obtained between 0.18 to 0.70 mm sizes were 78.6% of the total powdered bagasse. Compared to the pelletisation process used by Gabra *et al*., 1997, the torrefaction process provide better size reduction of bagasse.

Key Words: Bagasse, Cyclone gasifier, Torrefaction

About 150 million tonnes of crop residues, which are surplus, are the major source of biomass for producing bio-fuels and chemicals. Crop residues have a very low bulk density, low energy density, hygroscopic nature and are difficult to handle. Sugarcane bagasse is an important fibrous crop residue. The fibrous crop residues like sugarcane bagasse were characterised by two decomposition processes compared to one in wood and cellulose, and had comparatively lower volatiles, higher ash and char contents. The fibrous products are potential feedstocks for pyrolysis and gasification (Deepchand, 2007). Bagasse generated from the sugarcane crushing units in the sugar mills is used as a fuel in the boilers directly or in briquetted form. Bagasse can be used as briquettes in an open core downdraft gasifier as a fuel. However, briquetting of bagasse is an energy intensive process. Cyclone gasifier provides an option to use bagasse in powder form and thereby provide a scope to improve the energy efficiency. However due to its fibrous nature, the feeding of bagasse is difficult. The feeding problems experienced with crushed bagasse and cane trash in the cyclone gasifier were eliminated by pelletizing the bagasse and cane trash and then grinding the pellets to powder (Gabra *et al.,* 1997).

Torrefaction is another method for improving the properties of fibrous bagasse as a fuel. During torrefaction, the biomass loses its tenacious nature, which is mainly associated with the breakdown of the hemicellulose matrix and depolymerization of the cellulose, resulting in decreased fiber length. During the torrefaction process, the biomass tends to shrink, become lightweight, flaky and fragile, and lose its mechanical strength, making it easier to grind and pulverize. Torrefaction is used as a pre-treatment step for biomass conversion techniques such as gasification and co-firing. A typical mass and energy balance for biomass torrefaction is that 70% of the mass is retained as a solid product, containing 90% of the initial energy content. Another advantage of torrefied biomass is its uniformity in product quality (Stelt *et al.,* 2011; Tumuluru *et al*., 2011).

The bagasse supplied by the Budhewal Co-operative Sugar Mills Limited, Ludhiana, India was air-dried to a moisture content of about 10%. Approximately 400 g of this raw bagasse was taken each time and torrefaction was done at 230ºC for the duration of 0, 20, 30, 40, 50 and 60 minutes respectively. Three replications were taken each time. Bakery oven of local make was been used for torrefaction of bagasse. After torrefaction, the bagasse was grinded through a sieve size of 3 mm using 3 H.P. Single Phase grinder of local make. Sieving of torrefied and raw bagasse was done in order to know particle size range. Five sieves of size 0.18, 0.35, 0.70, 1.4 and 2.8 mm were used. The machine used for sieving purpose was Macro Rotap Sieve Shaker MSW-323 which performed oscillating as well as reciprocating motion. Each time machine was run for 5 minutes to perform sieving.

Engineering properties of powdery torrefied sugarcane bagasse are as follows: the bulk density of sugarcane bagasse was 105.0 kg/m^3, the angle of repose was 55ºC and moisture content was 3.8% . The texture and color of bagasse is shown in Fig. 1. The energy required for grinding of untorrefied raw bagasse was 0.56 kWh/kg while that of bagasse torrefied for the duration of 20, 30, 40, 50 and 60 minutes was 0.465, 0.14, 0.14, 0.14 and 0.14 kWh/kg respectively (Fig. 2).

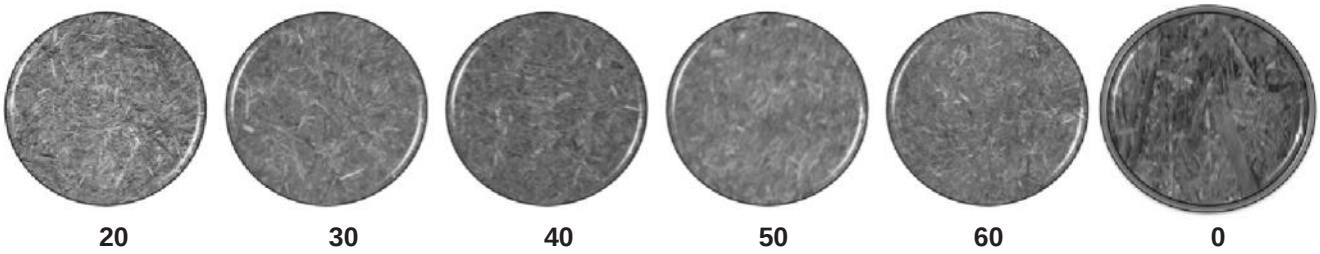

Fig. 1. Texture and color of powdery torrefied bagasse

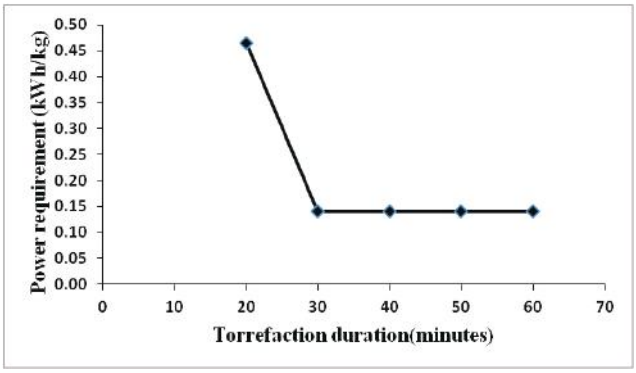

Fig. 2. Torrefaction duration versus power requirement for grinding

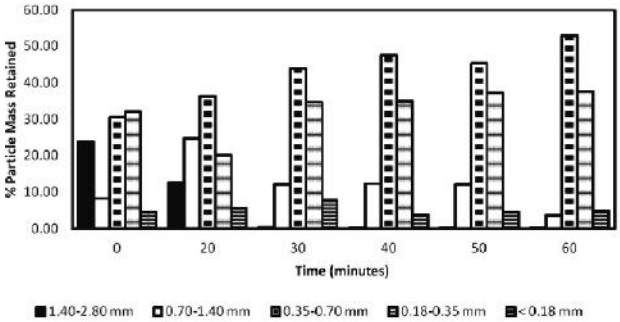

Fig. 3. Particle size distribution of powdery bagasse after torrefaction at 230ºC

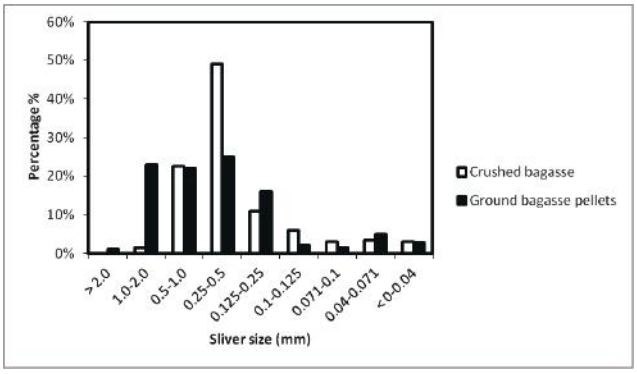

Fig. 4. Sliver size distribution of crushed and ground bagasse powder (Gabra *et al.,* 1997)

Sieving of raw and torrefied bagasse: Sieving of torrefied and raw bagasse was done in order to know particle size range. Approximately 78-89 % of particle size ranges between 0.18 to 0.70 mm for torrefied bagasse with duration of torrefaction ranging between 30 to 60 minutes while for raw bagasse particles size were uneven (Fig. 3).

It is therefore, recommended that torrefaction be done for a period of 30 minutes to minimize power requirements and to simultaneously achieve satisfactory grinding characteristics. Gabra *et al.* (1997) reported that the feeding problems experienced with crushed bagasse were eliminated by pelletizing the bagasse and then grinding the pellets to powder (Fig. 4).

This pelletisation process for improving flow properties and reducing particle size is now compared with the torrefaction process employed in this study. While the particle size distribution shifts towards the bigger particle size with pelletisation process, the particle size distribution shifts towards the smaller particle size with torrefaction process. This indicates that there is a better size reduction with torrefaction process. The energy requirement of torrefaction process at 230ºC for 30 minutes duration are also lower than those of pelletisation process (values not calculated here). For application of powdery bagasse, it is also desirable to have a more uniform size of particles after size reduction. The torrefaction process for 60 minutes duration provides a more uniform mix of particle size. The powdery bagasse obtained at this setting can be used as such without sieving of the powder (which is done to obtain particle size within a desired range). However, the difference in energy required for torrefaction at 30 and 60 minutes duration needs to be weighed against the additional step of sieving required for the powdery bagasse at 30 minutes, to select the best option out of these two. This is turn depends on the scale of operation.

On the basis of the result obtained the following

conclusions emerge that torrefaction decreases the grinding energy by about 70% and it is a better process than pelletisation for achieving size reduction and reduced flow problems in the use of bagasse as a fuel in cyclone gasifiers.

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Management of Reniform Nematode, *Rotylenchulus reniformis*on Cowpea by using Botanicals

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Abstract: A screen house study was undertaken for evaluating different plant extracts of ashwagantha (*Withania somnifera*), lantana (*Lantana camara*) and aak (*Calotropis gigantea*)as seed soaking treatment against reniform nematode, *Rotylenchulus reniformis* infesting cowpea extracts 20 and 30 per cent concentrations. The aqueous extracted soaked seeds were sown in Reniform nematode infested soil having $3J_2$/g soil. The growth parameters cowpea plants were better and reniform nematode, (*R. reniformis*) reproduction and populations were reduced in all the treatments compared to inoculated control.

Key Words: Plant extracts, *R. reniformis*, *Vignaunguiculata*

Cowpea (*Vigna unguiculata L*.) is one of the important Kharif pulse crop grown in India. It is a warm season crop, well adapted to any areas of the humid tropics and subtropical zones. In Rajasthan, crop is cultivated on 1.22 lakh ha with production of 64.36 thousand tonnes and average productivity being 529 kg ha^{-1} (Anonymous, 2010-11). The demand for cowpea in Indian and world market is increasing day by day. But the production is threatened by several biotic and abiotic stresses. Among biotic stresses nematodes are one of the major and conspicuous limiting factors for spices production. The reniform nematode is one of the major nematode responsible for severe losses in cowpea production. It attacks over 140 species of more than 115 plant genera with losses in yield of cotton, maize, finger millet, cowpea, and black gramvary from 8.1. to 14.9 per cent (Jonathan, 2001) Hence, in order to manage *R.reniformis* infesting cowpea, studies were conducted to evaluated the efficacy of different plant extracts viz., ashwagantha (*W. somnifera*), lantana (*L. camara*) and aak (*C. gigantea*) and carbosulfan as seed soaking treatment

The experiment was conducted under screen house condition in earthen pots (15 cm diam.) containing one kg *R.reniformis* infested soil with 3 larvae/g of soil. The required quantity of plant extracts formulation measured separately for each seed treatment. The cowpea seeds (**c**v. VU-89) were soaked with aqueous extract of ashwagantha (*W. somnifera*), lLantana (*L. camara*) and aak (*C. gigantea*) at @ 20 and 30 per cent concentrations. The seeds were sown in pots filled with nematode infested soil with four replications. After 10 days of germination one plant ineach pot was maintained with two control one with nematode alone (control) and other with chemical check (carbosulfan 25 EC @1 per cent).

Plants were harvested 45 days after sowing. The observation on shoot length, shoot weight, root length and root weight were taken at harvest. Then the root was washed carefully and stained with 0.1 per cent acid fuchsin (Mc Beth *et al*., 1941) and after wash kept in clear lacto phenol for 24 hrs. The roots were examined thoroughly under a stereoscopic binocular microscope for counting number of female / plant, number of egg mass / plant, number of eggs and larvae / egg mass, population / 200cc soil and total population.

After removing the plant from the pot, soil was thoroughly mixed and 200cc soil from each pot were taken and processed by Cobb´s sieving and decanting technique followed by Baermann´s funnel technique for estimation of nematode population in soil (Cobb, 1918).

All the plant extracts were found significantly effective in reducing reproduction of *R. reniformis* as compare to untreated check. The minimum hatching was with *L. camara* (1.67 per cent) followed by *C. gigantea* (2.78 per cent) and *W. somnifera* (3.89 per cent) at 7^{th} day

Among the tasted concentrations, 30 per cent concentration of all the plant extracts was found effective while extract of lantana (*L. camara*) leaves was found most effective in comparison to aak (*C. gigantea*) leaves and ashwagantha (*W. somnifera*) leaves extract in improving plant growth. Further observations on plant extract and their concentrations indicated that extract of lantana leaves followed by aak leaves and ashwagantha leaves at 30 per cent concentration were found most effective in improving plant growth and reducing the nematode reproduction over other treatments.

This investigation is in adjustable conformity with

Table 1. Efficacy of plants extracts seed soaking treatment against reniform nematode, *R. reniformis* infecting cowpea under pot experiment

Treatments	Plant growth characters				Nematode reproduction					Rf
	Shoot length (cm)	Root length (cm)	Shoot weight (g)	Root weight (g)	No. of female's plant^{-1}	No. of egg masses plant^{-1}	No. of eggs & larvae egg mass^{-1}	Larval population in 200 cc soil	Total nematode population	FNP/INP
Ashwagantha leaves (*Withania somnifera*) at 20% conc.	26.55	13.45	9.90	1.82	30.25	25.50	98.50	346.00	3409	1.13
Ashwagantha leaves (*W. somnifera*) at 30% conc.	31.87	16.68	14.15	2.25	28.00	22.25	97.25	318.00	2986	0.99
Lantana leaves (*Lantana camara*) at 20% conc.	29.82	15.85	12.02	1.95	26.25	23.75	98.25	322.00	3165	1.05
Lantana leaves (*L. camara*) at 30% conc.	35.32	19.45	16.47	3.15	22.00	20.75	92.00	296.00	2673	0.89
Aak leaves (*Calotropis gigantea*) at 20% conc.	28.52	14.50	10.85	1.92	29.50	24.25	97.50	338.00	3233	1.07
Aak leaves (*C. gigantea*) at 30% conc.	33.37	17.12	15.55	2.77	25.00	21.75	96.00	308.00	2885	0.96
Chemical check (Carbosulfan 25 EC @ 1% a.i.)	36.30	22.60	19.90	3.65	5.25	3.75	31.75	196.00	613	0.20
Untreated check	23.60	9.10	6.60	1.67	48.00	42.75	114.25	744.00	6792	2.26
CD (p=0.05)	3.47	4.87	4.00	1.11	5.53	4.80	5.95	9.85	434.52	

Note: Initial inoculum level: 3larvae/g soil. Rf: Reproduction factor, FNP- Final nematode population, INP-Initial nematode population

the finding of Umamaheswari *et al.* (2005) who reported the effectiveness of aqueous leaf extract of neem as foliar and soil application at two concentrations (10 and 15%) on *R. reniformis* infecting cowpea. Soil application with 15% extract recorded increase in growth parameters and yield (25.5 g plant^{-1}) and minimum nematode population in soil (109.5 /250cc soil) and root (10 g^{-1}). Shambhu and Sharma (2007) also found that seed treatment with mahua seed kernel at 20 per cent w/w was highly effective against *R. reniformis* on mung bean.

Hence, seed soaking with extracts of lantana leaves (*Lantana camara*), aak leaves (*C. gigantea*), and ashwagantha leaves (*W. somnifera*) at 30% w/wwere found most effective over others in reducing *R. reniformis* population and in enhancing the plant growth character.

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Author Index

Indian Journal of Ecology 43 (1-2): 2016

CONTENTS

CONTENTS

Indian Journal of Ecology (2016) 43 (2)

Indian Journal of Ecology

CONTENTS

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