

# Journal of Plant Development Sciences

(An International Monthly Refereed Research Journal)

Volume 11

Number 4

April 2019

## Contents

---

### RESEARCH ARTICLES

- Understory dynamics in different sites of Sarguja forest division (Chhattisgarh), India  
—S.S. Rajput, D.K. Yadav and M.K. Jhariya----- 177-188
- Effects of organic, inorganic and bio-fertilizers on the growth of maize under Subabul (*Leucaena leucocephala*) based agroforestry system  
—Mukesh Yadav, Rajiv Umrao and Sandeep Rout----- 189-199
- Floristic composition and diversity in the forest fragments of dry and moist tropical forest  
—Dhiraj Kumar Yadav, Lekha Ghosh and Manoj Kumar Jhariya ----- 201-212
- Performance of osmo-protectants and antioxidants in amelioration of terminal heat stress in wheat (*Triticum aestivum* L.)  
—Shabnam, Rashpal Singh Sarlach and Rohit Chhabra----- 213-220
- Impact of integrated nutrient management on quality seedling production in *Flemingia semialata* Roxb  
—Kameshwar Kumar Rajak, Ravi Hunje and Krishna A. ----- 221-227
- Pattern of prices and market integration of major pulse crops in Gujarat  
—Ganga Devi, K.S. Jadav and Priyanka Changela----- 229-235
- Divergence studies in Indian cluster bean (*Cyamopsis tetragonoloba* L. Taub.) for developing variety for vegetable purpose  
—Smaranika Mishra, T.S. Aghora and R. Venugopalan----- 237-242
- Price behaviour and co-integration of green gram in Gujarat  
—Ganga Devi, K.S. Jadav, Pooja Gamit and Priyanka Changela----- 243-248
- Investigation on quality of coir wastes biochar for soil amendment and soil carbon sequestration applications  
—Shalini Ramesh and Pugalendhi Sundararaju ----- 249-252
- Physical characteristics and chemical constituents in crude plants methanolic extract of selected medicinal plants based on literature and traditional knowledge  
—V.P.S. Bhadauria, and Varsha Gupta ----- 253-256

## UNDERSTORY DYNAMICS IN DIFFERENT SITES OF SARGUJA FOREST DIVISION (CHHATTISGARH), INDIA

S.S. Rajput, D.K. Yadav and M.K. Jhariya\*

*Department of Farm Forestry, Sant Gahira Guru Vishwavidyalaya, Sarguja,  
Ambikapur-497001 (Chhattisgarh), INDIA  
Email: [manu9589@gmail.com](mailto:manu9589@gmail.com)*

*Received-30.03.2019, Revised-05.04.2019*

**Abstract:** The rapid growth and development in urban area through industrialization leads rapid socio-economic deviations throughout the world, especially in Asian region which exert substantial impact over agricultural, forestry and other inter-related ecosystems. The increasing population also intensifies the global wood demand and these scenarios were more drastic in the developing countries due to demand and supply gap. These gaps can be overcome through the application of plantation forestry. In this connection we studied five vegetation stands (i.e., Teak, Sal, Mangium, Eucalyptus and Bamboo) of the Sarguja forest division in Chhattisgarh, India to assess the understory vegetation stratum, associated floral diversity and litter biomass through stratified random sampling technique. Total 6 herb species distributed into 4 families and 9 shrub species of 8 families were recorded across the sites. The total density of herb ranged from 72000-244000 individual ha<sup>-1</sup> across the site being highest under teak plantation and lowest under bamboo stand. The shrub density ranged from 50-640 individual ha<sup>-1</sup> in different sites being highest under teak stand and least in bamboo stand. The Shannon index for herb layer was lowest under bamboo stand and higher under mangium stand. In case of shrub the lowest value of Shannon index was recorded for sal stand and highest under both mangium and eucalyptus stand. The total forest floor biomass varied from 0.86-3.01 t/ha being lowest in bamboo stand and highest under sal stand. The information related to understory vegetation and its dynamics is essential towards management of vegetation stand.

**Keywords:** Herb, Diversity, Forest floor biomass, Plantation, Shrub

### INTRODUCTION

The plantation forestry has gain special attention throughout the world due to its rapid growth, higher productivity and managerial perspectives over the natural forest ecosystem. However, plantations are less diverse in terms of biodiversity as compared to the natural stands (Ito *et al.* 2004; Jhariya and Yadav, 2018). The area under plantation is increasing throughout the world due to past encroachment and felling of the natural forest land, population burst, urbanization, industrialization and pressure of the demand and supply of the forest based resources (Yadav *et al.* 2017; Jhariya *et al.* 2019). These figures are more drastic in the developing countries of the world. Therefore, the area under plantation is rapidly growing and

\*Corresponding Author

increased in developing countries than the previous scenario. Plantation leads to simplified stand composition, structure and least biodiversity (Ito *et al.* 2004). Further, plantation also signifies the ecological and environmental concern due to increase in short rotation forestry practices. Understory composition is altered and regulated by land-use pattern (Ito *et al.* 2004). The incorporation of leguminous species in plantation activities may meet the sustainable development through improved site condition and soil sustainability (Jhariya *et al.* 2018).

Understory vegetation is diversified in nature and has a substantial role in vegetational diversity and also supports various ecological processes. Ground vegetation and its biodiversity is associated with both ecosystem services in and offering

several benefits for human civilization (Berendse et al. 2015; Jhariya, 2017a). The development of the understory in plantation sites depends upon the soil seed bank, canopy openness, natural and biotic disturbance regimes, edaphic condition, etc. (Zobel et al. 2007). The upperstory also influence and determined the flourishing of ground vegetation and its dynamics through resource partitioning and litter deposition (Barbier et al. 2008). There are few reports are available about understory species variation under the plantation of tropical deciduous species. Forest floor biomass and litterfall have key role in nutrient cycling and improving the forests soil. Litterfall and forest floor biomass therefore gains ecologists attention because these are an instrumental feature towards ecosystem dynamics (Jordan, 1985; Tandon et al. 2012; Jhariya, 2017b). Therefore, in the present work, we investigated the understory vegetation composition, structure, diversity and forest floor biomass under the tropical deciduous species in the tropics of Chhattisgarh, India.

## MATERIAL AND METHODS

### Study Area

The state Chhattisgarh is one among the 29 states of India located towards centre-east of the country. The state is ranked 10th among the largest state on geographical area basis. The Chhattisgarh state is rich in natural resources. The northern and southern parts of the Chhattisgarh are hilly. The present study was carried out at Sarguja district which is located towards northern portion of Chhattisgarh (Figure 1). The entire area situated at 23°37'25" to 24°06'17" north latitude and 81°34'40" to 84°04'40" east longitude. The Sarguja district posses good and dense forest cover and rich in mineral deposits, coal reserves and the dense forests are rich in wildlife. The states Jharkhand, Orissa, Uttar Pradesh and Madhya Pradesh are adjoining to the district. The Chhattisgarh is comes under tropical climate. The average height of the Sarguja district area is above 2000 ft (600 metres).

There are three river basins in Sarguja district i.e., Hasdeo, Rihand and Kanhar river. The minimum and maximum temperature ranged between 50C to 460C. Monthly average temperature ranged from 15.340C in January and 31.540C in May, while it was 23.310C on mean annual basis. Average precipitation of the district is 1161.42 mm annually (Sinha et al. 2014, 2015; Yadav et al. 2015; Yadav and Jhariya, 2017; Jhariya and Yadav, 2018).

### Experimental Design

The present investigation was carried out at 5 sites (comprising 4 plantations i.e., teak, mangium, eucalyptus and bamboo plantation and one is natural stand of sal) of Sarguja forest division. The stratified random sapling technique was opted to measure the understory vegetation. Total 150 quadrats were laid out to measure the herbs, shrub and forest floor biomass of different sites. The shrub was measured within 10 m x 10 m sized quadrates. While the herb and forest floor biomass was quantified through 50 cm x 50 cm sized quadrates. The herb and shrubs were counted at species level for each quadrats. Diameter at collar height of shrubs was measured by using callipers. As per Curtis and McIntosh (1950), we quantitatively analysed the collected data on understory for frequency, density and abundance analysis. The distribution pattern was analysed by abundance to frequency (A/F) ratio (Curtis and Cotton, 1956) and the IVI (Importance Value Index) was calculated following Phillips (1959). The species rarity or commonness were calculated through species frequency class (Raunkiaer, 1934). The diversity indices for understory were evaluated using Shannon-Weaver diversity index (Shannon and Weaver, 1963), concentration of dominance through Simpson's index (Simpson, 1949), species richness following Margalef (1958), equitability as suggested by Pielou (1966) and Beta diversity as advised by Whittaker (1972). The forest floor material was collected from different study sites and then characterised into diverse components. The weight of samples were taken after drying on component basis (Singh, 1995; Jhariya, 2017b).

## RESULTS AND DISCUSSION

### Understorey Structure

#### Herb Layer

A total of 6 herb species with 4 families were recorded in different sites of Sarguja (Table 1). The highest herb species and density were found in teak plantation site. The total herb density ranged from 72000-244000 individual's ha<sup>-1</sup> being lowest in bamboo plantation and highest under teak stand. In teak plantation site the maximum density was recorded for *Cynodon dactylon* (104000 individual's ha<sup>-1</sup>), while the minimum for *Achyranthes aspera* (4000 individual's ha<sup>-1</sup>). The frequency varied from 10-90 for individual herbaceous species. The importance value index (IVI) of individual herb species ranged between 40.83-109.24, highest for *Cynodon dactylon* and lowest for *Melilotus alba*, respectively. A/F ratio indicated that *Tectona grandis* was distributed regularly and *Achyranthes aspera*, *Cynodon dactylon* and *Melilotus indica* species were distributed randomly. The total herb density in sal forest was 168000 individuals ha<sup>-1</sup> and the maximum density was recorded for *Cynodon dactylon* (116000 individuals ha<sup>-1</sup>), while the minimum for *Bauteloua dactyloides*. At mangium plantation it has total herb density of 104000 individuals ha<sup>-1</sup> and the maximum density was recorded by *Cynodon dactylon* (52000 individuals ha<sup>-1</sup>), while the minimum for *Bauteloua dactyloides* (20000 individuals ha<sup>-1</sup> for each). The frequency of individual herbaceous species varied from 20-40%. IVI of individual herb species ranged between 71.15-133.05. The eucalyptus plantation has total herb density of 168000 individuals ha<sup>-1</sup> and the maximum density was recorded by *Cynodon dactylon* (116000 individuals ha<sup>-1</sup>). IVI of individual herb species ranged between 111.18-188.82. The bamboo plantation has total herb density of 72000 individuals ha<sup>-1</sup> and the maximum density was recorded by *Cynodon dactylon* (56000 individuals ha<sup>-1</sup>). The frequency of individual herb varied from 20-40%. IVI of individual herb species ranged

between 91.91-208.08.

The herbs structure and composition is regulated by soil moisture regimes, light availability at forest floor, site condition, species mix, microclimate, silvicultural operation, management regimes at stand level, disturbance regimes, etc. (Gilliam and Roberts, 2003; Jhariya, 2010, 2014; Oraon *et al.* 2014; Khan *et al.* 2019). The less species number of herb layer is due to moisture stress and season of investigation. The upperstorey canopy openness is also determined the herbaceous composition, structure and its richness (Roberts, 2004). Jhariya and Yadav (2016) reported 18 herbs species under natural forest stand and 20 herbs species in teak plantation. The herb density ranged from 696000-832000 herbs/ha being lowest in teak stand and highest under natural forest. The higher herbaceous species were reported by Kumar *et al.* (2015) for tropics of northern Chhattisgarh. They found 43 herb species with 15 families in different plantation sites. Eucalyptus plantation representing a total of 26 species with 13 families, teak plantation contains 31 species with 13 families, whereas 25 species with 12 families were recorded under the mixed (Cassia+Mangium) plantation which were found higher than the present values. The herb density varied from 412000-708000 individuals ha<sup>-1</sup> in different plantation which are higher than present estimated herb density.

The higher species number and density of herb was also reported by Sinha *et al.* (2015). They found 27 species distributed into 15 families with density of 776000 herb ha<sup>-1</sup> for sal plantation in Sarguja. Oraon *et al.* (2014) found 108700-72000 herbs ha<sup>-1</sup> in Boramdeo wildlife sanctuary, Chhattisgarh which is comparable with present findings. Jhariya *et al.* (2012) reported total herb density varied from 112000-668000 individuals ha<sup>-1</sup> in protected area of Chhattisgarh. The favourable environmental condition leads toward ideal dispersal of species in addition to its adaptive potential. Species distribution in a given environment and site is regulated by site conditions and ecological interaction (Yadav *et al.* 2019; Jhariya *et al.* 2019).

The distribution of vegetation over an area is governed by different biotic and abiotic factors. In natural environment the regular distribution was rarely found whereas contagious distribution and random distribution patterns are more common as also seen in present investigation (Odum, 1971).

#### Shrub Layer

A total of 9 shrub species distributed into 8 families were recorded in different sites of Sarguja (Table 2). The total shrub density varied from 50-640 individuals ha<sup>-1</sup>, being highest under teak stand and lowest under bamboo plantation site. In teak plantation the total shrub density was 640 individuals ha<sup>-1</sup> and the maximum density was recorded by *Flemingia chappar* (240 individual's ha<sup>-1</sup>) whereas lowest by *Casearia graveolens* (20 individual's ha<sup>-1</sup>). The frequency varied from 10-50 for individual shrub species. IVI value of individual shrub species ranged between 14.45- 212.60. Sal stand revealed total shrub density of 360 individuals ha<sup>-1</sup> and highest density was found for *Carissa spinarum* and lowest by *Grewia rotchii*. The frequency value 20 was recorded for each species found in sal stand. IVI values ranged between 45.61-196.11. In mangium plantation site total shrub density was 280 individuals ha<sup>-1</sup> and the maximum density was recorded by *Leonotis nepifolia* (210 individuals ha<sup>-1</sup>), while the minimum for *Ziziphus xylopyrus* (20 individuals ha<sup>-1</sup>). The frequency of individual species varied from 10-30. IVI of individual shrub species ranged between 27.25-216.74. A total of 110 individuals ha<sup>-1</sup> was found in eucalyptus plantation site and the maximum density was recorded by *Lantana camara* (60 individuals ha<sup>-1</sup>). The frequency of individual species varied from 20-40% and IVI from 48.35-168.23. The bamboo plantation site has total shrub density of 50 individuals ha<sup>-1</sup> and the maximum density was recorded by *Butea superba* (30 individuals ha<sup>-1</sup>). The frequency of individual species varied from 10-20 and IVI from 119.23-180.77.

Jhariya and Yadav (2016) mentioned 5 shrub species in natural forest and 3 shrub species in teak

stand. The density of shrub was 4500 individual ha<sup>-1</sup> in natural forest and 5500 shrubs/ha in teak stand. The present values were also supported by Kumar *et al.* (2016), they found 7 shrub species with 6 families across the study sites and its density varied from 240-960 shrubs ha<sup>-1</sup>, respectively. Further they mentioned that eucalyptus plantation representing 2 species, teak plantation contains 5 species, whereas 4 species were recorded under the mixed plantation (*Mangium* + *Cassia*). Jhariya (2017a) reported that the shrub density and basal area ranged from 1250-3750 individuals ha<sup>-1</sup> and 2.79-4.92 m<sup>2</sup> ha<sup>-1</sup>. Similarly, Kumar *et al.* (2017a) mentioned nine shrub species representing eight families in different directions of study sites of northern Chhattisgarh. In the protected area of the Chhattisgarh, Jhariya *et al.* (2012) found 6-10 shrub species with the density of 1120-2480 shrubs/ha along with the basal area of 0.59-1.11 m<sup>2</sup> ha<sup>-1</sup> at pre-fire season while during the post-fire shrub species ranged between 12-15 with the density of 1920-3360 shrub/ha and basal area of 0.11-0.23 m<sup>2</sup> ha<sup>-1</sup>. The higher shrub density was also reported by Gerwing and Vidal (2002) for Amazonia forest. They found 2500 individuals/ha for liana and shrubs.

#### Understory Rarity or Commonness

In teak plantation sites in herb layer 25% reflected under rare category, 25% species was intermediate and 50% species were common or having high frequency class. Sal stand revealed that 50% of each species represented by intermediate and moderately high frequency class, respectively. At mangium plantation site 66.67% species represents low frequency class and remaining by intermediate class. Eucalyptus plantation site revealed 50% contribution each species in intermediate and moderately high frequency class. While in case of bamboo plantation low and intermediate frequency class were observed equally as 50% for each species in herb layer.

Shrub layer revealed that in teak stand 1/3rd of each species represented rare, low and intermediate frequency class. In sal stand all the species showed

intermediate frequency class. Towards mangium stand 66.66% species showed rarity while the 33.33% revealed low frequency. In eucalyptus site 66.66% species have low frequency and the 33.33% species revealed intermediate frequency. In bamboo stand 50% each of the species showed rarity and low frequency.

The law of frequency is an ecological tool which reflects the uniformity or homogeneity within stand or among various vegetation stands. This also signifies towards identification of factors which controls and regulate the species presence, absence and its concentration. The frequency class distribution or occupancy of any species over an area is governed by species composition, adaptation range or ecological amplitude of the species, resistancy of species in limiting environment and competitiveness ability of a species, etc. In this connection Raunkjær (1934) suggests that species in a community are either rare or common, with only few species having intermediate occupancies which supports the present findings of species distribution as per the law of frequency. It is reported that biotic interference may directly or indirectly alter the regeneration of species which leads toward decline in frequency class (Stephene and Lambin, 2004). Danjuma et al. (2017) found that frequency class A constitutes thirty three species (66%), class B constitute 8 (16%), C constitutes 5 species (10), class D has three species (6%) while class E has one species (2%) which is well comparable with present findings. In another study at Yabo area of Sokoto State revealed no occupancy of species in frequency classes D and E (Dangulla 2013). Kumar et al. (2017a) mentioned that the most of the plant life forms reflected that there were most of the species which occurred singly in a habitat. They also reported that most of species were of rare category and of low frequency class which supports the present findings.

#### Understorey Diversity

The diversity indices (Table 3) of the herb layer showed that the value of Shannon index in different sites ranged between 0.77-1.48, being highest in

mangium stand while lowest for bamboo stand. Simpsons index for herbs varied from 0.38-0.66, which reflected reverse trend when compared with Shannon index. The equitability value ranged from 0.70-1.44, richness from 0.08-0.31 and beta diversity from 1.75-3.50, respectively.

Shrubs diversity indices revealed that Shannon index in different sites ranged between 0.80-1.44, Simpsons index from 0.40-0.71, equitability from 0.25-1.31, richness from 0.14-0.43 and beta diversity from 3.0-5.50, respectively (Table 3).

The diversity of a stand or habitat entails the occurrence, distribution, species richness and degree of revolution in species composition. The structure and diversity of vegetation stands have substantial role in regulating and function of ecosystem process. The biodiversity of natural ecosystem is higher as compare to the planted forest ecosystem. Therefore, increase in planted forests and its management is issues of concerns for making balance for sustainable production and towards conservation of biological diversity (Carnus *et al.*, 2006; Jhariya and Yadav, 2018). The present findings on shrub diversity are comparable with Jhariya (2017a). He revealed the value of Shannon index ranged from 2.32-3.77, Simpson's index or concentration of dominance (Cd) from 0.08-0.20, species richness from 0.56-1.58, equitability from 1.41-1.44, and beta diversity from 1.50-4.20, respectively. Kumar *et al.* (2015) mentioned the Shannon index in different plantation sites varied from 3.96-4.62, equitability from 1.22-1.36, species richness from 1.85-2.26, Simpsons index from 0.05-0.10 and beta diversity from 1.39-1.72 for herbs. Jhariya and Yadav (2016) mentioned the diversity indices for shrub layer revealed that Shannon index ranged from 1.10-2.20, least for teak stand and highest under natural forest. Simpson index was found higher in teak stand (0.57) and lowest under natural forest (0.23). Margalef index ranged from 0.23-0.48, being less in plantation site and higher under natural forest. Equitability was also higher in natural forest (1.37) and lowest in plantation site (1.0) and beta diversity showed

reverse trend as it was found higher in plantation site (2.0) and lowest under natural stand (1.20). Herb layer revealed that the value of Shannon index, species richness and equitability values were higher in teak plantation while the Simpsons index and beta diversity were found more in natural forest.

#### Forest Floor Biomass

The forest floor biomass of different sites are presented in Table 4. The total forest floor biomass of different sites varied from 0.86-3.01 ton ha<sup>-1</sup>, being highest in sal forest while lowest at bamboo plantation site. The total forest floor biomass follows the order as Sal forest > Teak plantation > Eucalyptus plantation > Mangium plantation > Bamboo plantation, respectively. While concerning the components the wood litter and fresh leaf litter were found to be higher under sal forest, whereas partially decomposed leaf litter was more in teak stand and the seed was found to be higher under mangium plantation. The mean average value of forest floor biomass was found as 0.23 ton ha<sup>-1</sup> for wood litter, 1.16 ton ha<sup>-1</sup> for fresh leaf litter, 0.38 ton ha<sup>-1</sup> for partially decomposed leaf litter, 0.10 ton ha<sup>-1</sup> for seed and 1.88 ton ha<sup>-1</sup> total forest floor, respectively. From the total average mean value of site the three plantation sites namely mangium, eucalyptus and bamboo were found to be lesser in terms of forest floor biomass accumulation.

The litter mass on forest floor through litterfall is the chief source for biogeochemical cycling. Higher litter mass improves soil health and its biota which leads toward diverse and rich vegetation stand (Jhariya, 2017b; Kumar et al. 2017a). Kumar et al. (2017b) found that the total forest floor biomass varied from 2.61-6.07 t ha<sup>-1</sup> which is comparable with present findings. Kumar et al. (2016) reported that in different plantation sites the total litter biomass ranged from 1.98-4.01 t ha<sup>-1</sup>, being lowest in teak stand and maximum in eucalyptus stand. Sahu et al. (2013) found that forest floor mass at teak stand ranged from 2.19-2.66 t ha<sup>-1</sup>. Similar to present findings Pawar et al. (2014) found the total forest floor biomass between 2.75-3.55 t ha<sup>-1</sup>. The

higher (4.20-5.65 t/ha) forest floor biomass was reported by Kumar et al. (2017a). Kumar et al. (2016) mentioned very close value in between 1.98-4.01 t/ha for plantation sites of Sarguja. Jhariya and Yadav (2018) found the forest floor biomass in natural stand was twice (5.89 t ha<sup>-1</sup>) as compared to the teak stand (2.43 t ha<sup>-1</sup>). The component of forest floor biomass revealed that leaf litter was higher in natural forest while the wood litter was measured higher in teak stand. The present estimated value of forest floor biomass was well comparable with Jhariya (2017b). He mentioned the seasonal mean total forest floor biomass among different sites were ranged from 2.00-3.65 t ha<sup>-1</sup>.

#### Nativity of Understory Vegetation

The nativity of the understory vegetation found in the different sites of Sarguja were represented in Table 5. Out of 15 species only 26.27% have their origin from India while the others are non-native. The most of the species were originated from African, European and Asian countries. In herb and shrub layer only 33.33% species for each were found to be indigenous and rest of the species are non-native of the region.

The exotic species are a key concern due to biodiversity loss at global scale (Vargas et al. 2013). The exotic species inhibits the germination, growth and colonization of indigenous species and alters the local biodiversity. Heywood (1989) reported that nearly half of the species was found to be non-native during study in New Zealand. In this context Binggeli et al. (1998) found nearly 45% exotic species in the tropics. The gap formation and canopy exposure leads towards establishment and naturalization of non-native species over indigenous flora due to resource competition and resource partitioning (Denslow 2003). Further, the level and magnitude of disturbance regimes may prosper the non-native flora under such circumstances (Gorchov et al. 2011; Vargas et al. 2013). The increment in resource availability such as light in forest stand may impose towards more abundance of non-native vegetation (Muth and Bazzaz 2002). The diversity in the present finding seems to vary

less which may be due to more abundance of non-native flora in understory. In this connection Vargas

et al. (2013) mentioned that non-native flora alter indigenous plant species diversity in greater scale.

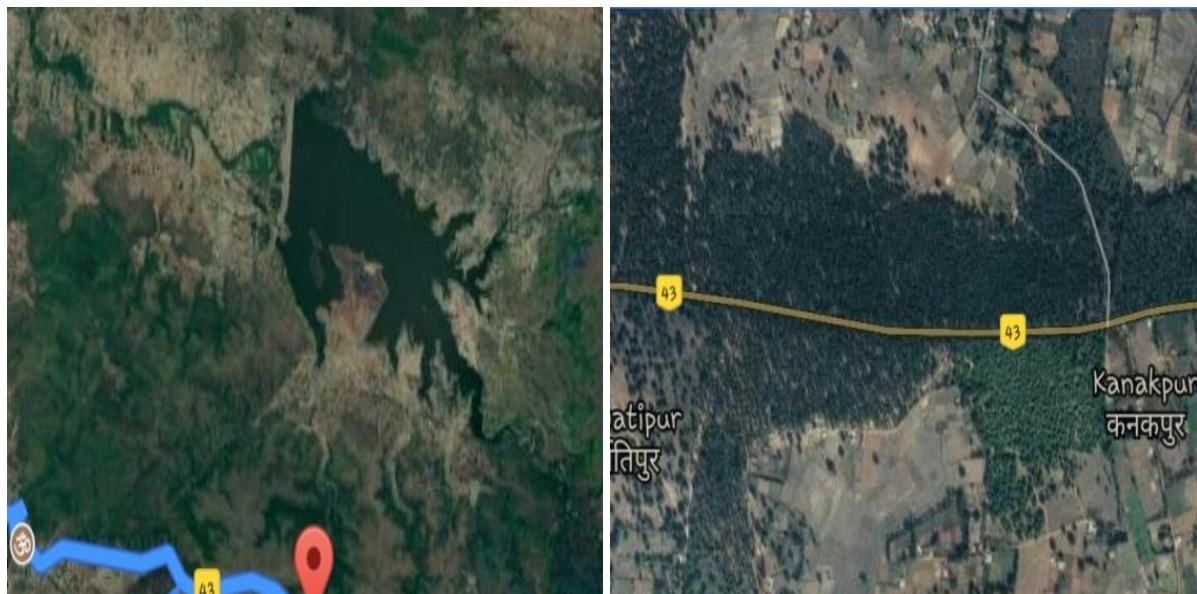
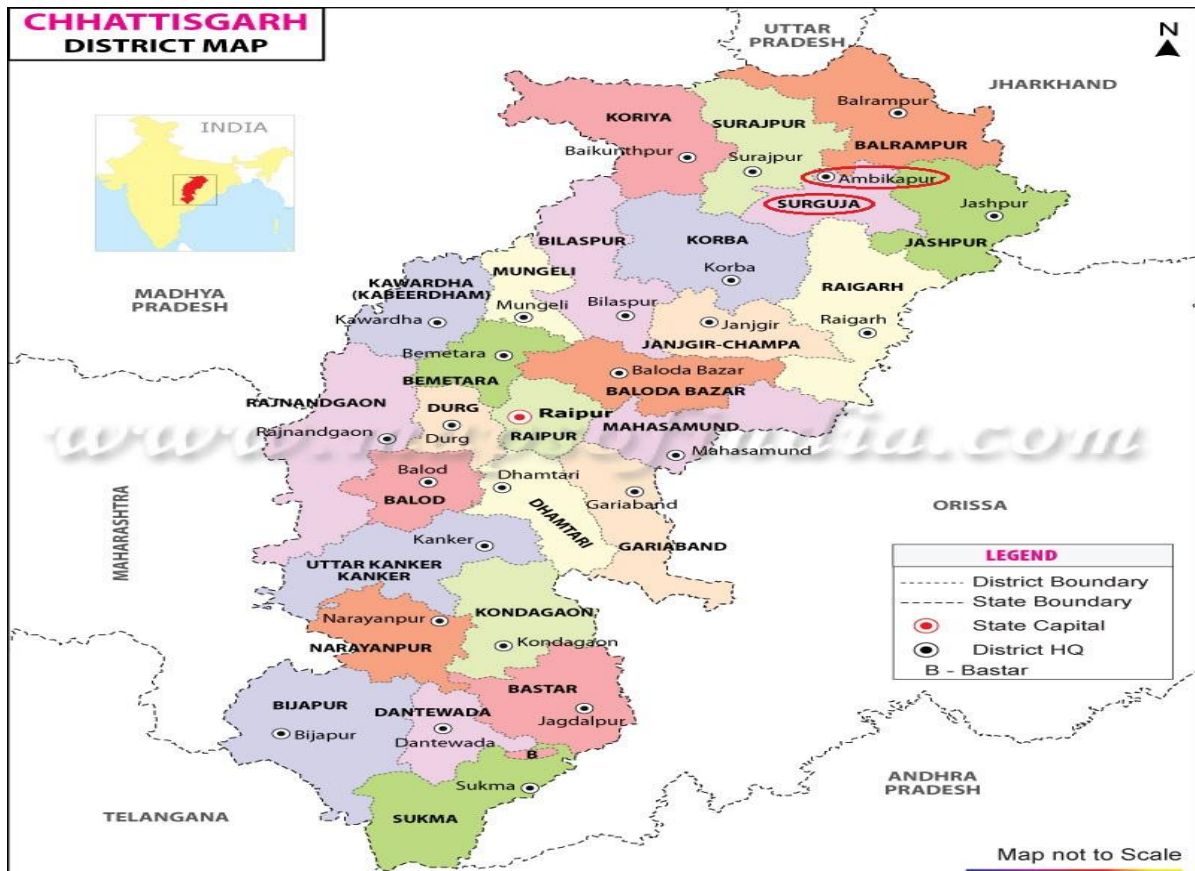


Figure 1. Location map of the study area

**Table 1.** Structure of Herb layer in different sites of Sarguja

Species	Teak					Sal					Mangium					Eucalyptus					Bamboo				
	F	D	A	IVI	A/F	F	D	A	IVI	A/F	F	D	A	IVI	A/F	F	D	A	IVI	A/F	F	D	A	IVI	A/F
<i>Achyranthes aspera</i> L.	40	4000	0.19	51.57	0.06	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Cynodon dactylon</i> L.	90	120000	0.25	109.24	0.04	70	1160	0.61	188.82	0.06	40	52000	0.38	133.05	0.081	70	116000	0.61	188.82	0.06	40	56000	0.36	208.08	0.08
<i>Melilotus indica</i> L.	80	104000	0.24	98.34	0.04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	16000	0.36	91.91	0.1
<i>Melilotus abla</i> L.	10	16000	0.04	40.83	0.40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Ocimum tenuiflorum</i> L.	-	-	-	-	-	-	-	-	-	-	30	32000	0.31	95.78	0.088	-	-	-	-	-	-	-	-	-	-
<i>Bauteloua dactyloides</i> Nutt.	-	-	-	-	-	50	5200	0.38	111.17	0.05	20	20000	0.29	71.15	0.125	50	52000	0.38	111.18	0.05	-	-	-	-	-
<b>Total</b>		<b>244000</b>		<b>300</b>			<b>168000</b>		<b>300</b>			<b>104000</b>		<b>300</b>			<b>168000</b>		<b>300</b>			<b>72000</b>		<b>300</b>	

\*Note: F= Frequency, D= Density/ha, A= Abundance, IVI= Important value index, A/F= Abundance to frequency ratio

**Table 2.** Structure of Shrub layer in different sites of Sarguja

Species	Teak					Sal					Mangium					Eucalyptus					Bamboo				
	F	D	BA	IVI	A/F	F	D	BA	IVI	A/F	F	D	BA	IVI	A/F	F	D	BA	IVI	A/F	F	D	BA	IVI	A/F
<i>Lantana camara</i> L.	50	380	0.19	212.60	0.15	-	-	-	-	-	-	-	-	-	-	40	60	0.0025	168.23	0.037	10	20	0.00034	119.23	0.2
<i>Flemingia chappar</i> Benth.	30	240	0.0042	72.95	0.26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Casearia graveolens</i> Dalz.	10	20	0.0004	14.45	0.2	20	40	0.001	58.27	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Butea superba</i> Roxb.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	30	30	0.0008	83.41	0.033	20	30	0.0004	180.77	0.075
<i>Grewia rotchii</i> DC	-	-	-	-	-	20	20	0.00048	45.61	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Carissa spinarum</i> L.	-	-	-	-	-	20	300	0.00048	196.11	0.75	10	50	0.001	56.0	0.5	-	-	-	-	-	-	-	-	-	-
<i>Ziziphus xylopyrus</i> Retz.	-	-	-	-	-	-	-	-	-	-	10	20	0.00001	27.25	0.2	-	-	-	-	-	-	-	-	-	-
<i>Leonotis nepifolia</i> L.	-	-	-	-	-	-	-	-	-	-	30	210	0.0045	216.74	0.233333	-	-	-	-	-	-	-	-	-	-
<i>Helicteres isora</i> L.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	20	0.0002	48.35	0.05	-	-	-	-	-
<b>Total</b>		<b>640</b>	<b>0.19</b>	<b>300</b>			<b>360</b>	<b>0.00196</b>	<b>300</b>			<b>280</b>	<b>0.006</b>	<b>300</b>			<b>110</b>	<b>0.0036</b>	<b>300</b>			<b>50</b>	<b>0.00074</b>	<b>300</b>	

\*Note: F= Frequency, D= Density/ha, BA= Basal area, IVI= Important value index, A/F= Abundance to frequency ratio

**Table 3.** Diversity indices of understory vegetation in Sarguja forest division

Layer	Diversity indices	Sites				
		Teak	Sal	Mangium	Eucalyptus	Bamboo
Herb	Shannon index(H)	1.13	0.99	1.48	0.89	0.77
	Simpsons index(Cd)	0.49	0.50	0.38	0.57	0.66
	Species richness(d)	0.31	0.18	0.17	0.08	0.09
	Equitability(e)	1.03	1.44	1.35	1.29	0.70
	Beta diversity(βd)	1.75	3.50	2.33	3.50	3.50
	Shannon index(H)	1.20	0.80	1.44	1.44	0.99
Shrub	Simpsons index(Cd)	0.48	0.71	0.40	0.41	0.50
	Species richness(d)	0.31	0.34	0.43	0.43	0.14
	Equitability(e)	1.09	0.73	1.31	1.31	0.25
	Beta diversity(βd)	3.67	3.00	3.00	3.00	5.50

**Table 4.** Forest floor biomass in different sites of Sarguja forest division

Components	Teak	Sal	Mangium	Eucalyptus	Bamboo
Wood litter	0.26 ± 0.18	0.32 ± 0.04	0.22 ± 0.05	0.25 ± 0.13	0.09 ± 0.11
Fresh leaf	1.35 ± 0.40	2.21 ± 0.60	0.70 ± 0.15	0.90 ± 0.23	0.64 ± 0.17
Partially decompose leaf	0.63 ± 0.12	0.43 ± 0.07	0.28 ± 0.06	0.44 ± 0.05	0.12 ± 0.10
Seed	0.04 ± 0.05	0.03 ± 0.08	0.37 ± 0.07	0.06 ± 0.12	0.006 ± 0.04
<b>Total</b>	<b>2.29 ± 0.42</b>	<b>3.01 ± 0.54</b>	<b>1.58 ± 0.15</b>	<b>1.66 ± 0.22</b>	<b>0.86 ± 0.22</b>

**Table 5.** Nativity of understory vegetation found in the different sites of Sarguja

Vegetation stratum	Family	Origin
<b>Herb</b>		
<i>Achyranthes aspera</i> L.	Amaranthaceae	South Africa and India
<i>Bauteloua dactyloides</i> Nutt.	Poaceae	North America
<i>Cynodon dactylon</i> L.	Poaceae	Africa
<i>Melilotus indica</i> L.	Fabaceae	Northern Africa, Europe, Asia
<i>Melilotus alba</i> L.	Fabaceae	Northern Africa, Europe, Asia
<i>Ocimum tenuiflorum</i> L.	Lamiaceae	India
<b>Shrub</b>		
<i>Butea superba</i> Roxb.	Fabaceae	Thailand, Vietnam, India
<i>Carissa spinarum</i> L.	Apocynaceae	Africa, Southern Asia, Australia
<i>Casearia graveolens</i> Dalz.	Salicaceae	Asia
<i>Flemingia chappar</i> Benth.	Fabaceae	Tropical region
<i>Grewia rotchii</i> DC	Tiliaceae	India and Sri Lanka
<i>Helicteres isora</i> L.	Malvaceae	Asia and Australia
<i>Lantana camara</i> L.	Verbenaceae	South America
<i>Leonotis nepifolia</i> L.	Lamiaceae	Tropical Africa & southern India
<i>Ziziphus xylopyrus</i> Retz.	Rhamnaceae	South-east Asia

**CONCLUSION**

The understory vegetation forms an important

stratification of forest ecosystem. Besides, their direct benefits, they also significantly contributes towards tropical biodiversity, ecological processes

and various functions. From plantation forestry perspective these understory vegetation (herbs and shrubs) become major challenges towards quality timber production and to plantation manager. The findings of present investigation revealed that resource availability and canopy openness provide opportunity for growth and development of understory vegetation. The non-native species was found to more and established under different stands of the study area. The highest count of understory density was recorded under teak stand and most of the dominated species were non-native throughout the studied sites. Further, the most of the species were represent the rare category as per their occurrence over the area. Therefore, conservation of the rare indigenous species should be done on priority basis to sustain their population in this regions. Further in all the stand the understory manipulation by altering the structure and composition at stand level by opting indigenous vegetation should be done through plantation activity and eliminating the exotic or non-native vegetation of less socio-economic concern. This would leads towards ecological balance of the stand and promoting the indigenous biodiversity and resilience of the stands towards invasion of non-native vegetation.

#### ACKNOWLEDGEMENTS

Authors are thankful to Forest Department of Surguja, Chhattisgarh for necessary support during the experiment.

#### REFERENCES

- Barbier, S., Gosselin, F. and Blandier, P.** (2008). Influence of tree species on understory vegetation diversity and mechanisms involved- a critical review for temperate and boreal forests. *For Ecol Manage*, 254:1-15.
- Berendse, F., Van Ruijven, J., Jongejans, E. and Keesstra, S.D.** (2015). Loss of plant species diversity reduces soil erosion resistance of embankments that are crucial for the safety of human societies in low-lying areas. *Ecosystems*, 18(5):881–888.
- Binggeli, P., Hall, J.B. and Healey, R.** (1998). An overview of invasive woody plants in the tropics. School of Agriculture and Forest Science, University of Wales, Bangor Publication No. 13, 83 pp.
- Carnus, J.M., Parrotta, J., Brockerhoff, E., Arbez, M., Jactel, H., Kremer, A., Lamb, D., O’Harra, K. and Walters, B.** (2006). Planted forests and biodiversity. *J Forestry*, 104:65-77.
- Curtis, J.T. and McIntosh, R.P.** (1950). The interrelations of certain analytic and synthetic phytosociological characters. *Ecology*, 31:434–455.
- Curtis, J.T. and Cotton, G.** (1956). Plant Ecology Workbook: Laboratory Field Reference Manual. Burgess Publishing Co., Minnesota. p. 193.
- Dangulla, M.** (2013). The Diversity and Spatial Variability of Woody Species in Yabo Area, Sokoto State. MSc thesis, Ahmadu Bello University, Zaria, Nigeria.
- Danjuma, M.N., Bindawa, A.A., Babankowa, I.A. and Maiwada, B.** (2017). Frequency Class Distribution of Vegetation in the Dryland of Northwestern Nigeria. *American J Biol Life Sci*, 5(2):7-12.
- Denslow, J.S.** (2003). Weeds in paradise: thoughts on the invisibility of tropical islands. *Annals of the Missouri Botanical Garden*, 90(1):119.
- Gerwing, J.J. and Vidal, E.** (2002). Changes in liana abundance and species diversity eight years after liana cutting and logging in an Amazonia forest. *Conserv Biol*, 16:544-548.
- Gilliam, F.S. and Roberts, M.R.** (2003). Conceptual framework for studies of the herbaceous layer. In: Gilliam FS, Roberts MR (eds) The herbaceous layer in forests of Eastern North America. Oxford University Press, Oxford, Pp. 3–11.
- Gorchov, D.L., Thompson, E., O’Neill, J., Whigham, D. and Noes, D.** (2011). Treefall gaps required for establishment, but not survival, of invasive *Rubus phoenicolasius* in deciduous forest,

- Maryland, USA. *Plant Species Biology*, 26:221-234.
- Heywood, V.H.** (1989). Patterns, extents and modes of invasions by terrestrial plants. In: Drake JA, Mooney HA, di Castri F, Groves RH, Kruger FJ, Rejmánek M, Williamson M (eds) *Biological Invasions: A Global Perspective*. Scope 37/John Wiley & Sons, New York, Pp. 31-60
- Ito, S., Nakayama, R. and Buckley, G.P.** (2004). Effects of previous land-use on plant species diversity in seminatural and plantation forests in a warm-temperate region in southeastern Kyushu, Japan. *For Ecol Manage*, 196:213-255.
- Jhariya, M.K., Banerjee, A., Meena, R.S. and Yadav, D.K.** (2019). Sustainable Agriculture, Forest and Environmental Management. Springer Nature Singapore Pte Ltd., 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore. eISBN: 978-981-13-6830-1, Hardcover ISBN: 978-981-13-6829-5. DOI: 10.1007/978-981-13-6830-1. Pp. 606.
- Jhariya, M.K., Banerjee, A., Yadav, D.K. and Raj, A.** (2018). *Leguminous Trees an Innovative Tool for Soil Sustainability*. Pp. 315-345. In: Legumes for Soil Health and Sustainable Management. R.S. Meena, A. Das, G.S. Yadav and R. Lal (Eds.). Springer, ISBN 978-981-13-0253-4 (eBook), ISBN: 978-981-13-0252-7 (Hardcover). [https://doi.org/10.1007/978-981-13-0253-4\\_10](https://doi.org/10.1007/978-981-13-0253-4_10).
- Jhariya, M.K. and Yadav, D.K.** (2018). Biomass and carbon storage pattern in natural and plantation forest ecosystem of Chhattisgarh, India. *Journal of Forest and Environmental Science*, 34(1):1-11. Doi: 10.7747/JFES.2018.34.1.1.
- Jhariya, M.K.** (2017a). Vegetation ecology and carbon sequestration potential of shrubs in tropics of Chhattisgarh, India. *Environmental Monitoring and Assessment*, 189(10):1-15. 518, Doi:10.1007/s10661-017-6246-2.
- Jhariya, M.K.** (2017b). Influences of forest fire on forest floor and litterfall dynamics in Bhoramdeo Wildlife Sanctuary (C.G.), India. *J For Environ Sci*, 33(4):330-341.
- Jhariya, M.K. and Yadav, D.K.** (2016). Understory vegetation in natural and plantation forest ecosystem of Sarguja (C.G.), India. *J Appl Nat Sci*, 8(2):668-673.
- Jhariya, M.K.** (2014). Effect of forest fire on microbial biomass, storage and sequestration of carbon in a tropical deciduous forest of Chhattisgarh. PhD thesis. Indira Gandhi Krishi Vishwavidyalaya, Raipur, India.
- Jhariya, M.K., Bargali, S.S., Swamy, S.L. and Kittur, B.** (2012). Vegetational Structure, Diversity and Fuel Loads in Fire Affected areas of Tropical Dry Deciduous Forests in Chhattisgarh. *Vegetos*, 25(1):210-224.
- Jhariya, M.K.** (2010). Analysis of vegetational structure, diversity and fuel load in fire affected areas of tropical dry deciduous forests in Chhattisgarh. MSc thesis. Indira Gandhi Krishi Vishwavidyalaya, Raipur, India.
- Jordan, C.F.** (1985). Nutrient cycling in tropical forest ecosystems. Wiley, Chichester, UK, pp 190.
- Khan, N., Jhariya, M.K. and Yadav, D.K.** (2019). Population structure of vegetation in urban environment of Sarguja, Chhattisgarh, India. *Journal of Plant Development Sciences*, 11(3):133-142.
- Kumar, A., Jhariya, M.K. and Yadav, D.K.** (2015). Community characters of herbaceous species in plantation sites of Coal mine. *J Plant Dev Sci*, 7(11):809-814.
- Kumar, A., Jhariya, M.K. and Yadav, D.K.** (2016). Vegetation Dynamics in Plantation Sites of Collieries. *Nat Environ Pollut Technol*, 15(4):1285-1291.
- Kumar, A., Jhariya, M.K., Yadav, D.K. and Banerjee, A.** (2017a). Vegetation dynamics in Bishrampur collieries of northern Chhattisgarh, India: eco-restoration and management perspectives. *Environ Monit Assess*, 189:371.
- Kumar, Amit, Jhariya, M.K. and Yadav, D.K.** (2017b). Tree stratum and Forest Floor Biomass in the Proximity of Collieries. *Van Sangyan*, 4(1):55-60.

- Margalef, R.** (1958). Perspective in ecological theory. Uni-versity of Chicago Press, Chicago.
- Muth, C.C. and Bazzaz, F.A.** (2002). Tree canopy displacement at forest gap edges. *Canadian J For Res*, 32:247-254.
- Odum, E.P.** (1971). *Fundamental of Ecology*. Saunders Co., Philadelphia.
- Oraon, P.R., Singh, L. and Jhariya, M.K.** (2014). Variations in herbaceous composition of dry tropics following Anthropogenic disturbed environment. *Current World Environment*, 9(3):967-979.
- Pawar, G.V., Singh, L., Sarvade, S. and Lal, C.** (2014). Litter production and soil physico-chemical properties influenced by different degraded sites of tropical deciduous forest, Chhattisgarh, India. *The Ecoscan*, 8(3&4):349-352.
- Phillips, E.A.** (1959). *Methods of Vegetation Study*. Holt R and Winston New York USA. pp. 105.
- Pielou, E.C.** (1966). Species diversity and pattern diversity in the study of ecological succession. *J Theor Biol*, 10:370-383.
- Raunkiaer, C.** (1934). *The Life Form of Plants and Statistical Plant Geography*. Claredon Press ISBN 9978-40-943-2, Oxford.
- Roberts, M.R.** (2004). Response of the herbaceous layer to natural disturbance in North American forests. *Can J Bot*, 82:1273-1283.
- Sahu, K.P., Singh, L. and Jhariya, M.K.** (2013). Fine root biomass, forest floor and nutrient status of soil in an age series of teak plantation in dry tropics. *The Bioscan*, 8(4):1149-1152.
- Shannon, C.E. and Weaver, W.** (1963). *The Mathematical Theory of Communication*. Urbana, USA: University of Illinois Press.
- Singh, L.** (1995). Seasonal variation in biomass and nutrient content of the forest floor in a dry tropical forest. *Oecol Mont*, 4:21-26.
- Sinha, R., Yadav, D.K. and Jhariya, M.K.** (2014). Growth performance of Sal in Mahamaya central forest nursery (Ambikapur), Chhattisgarh. *Int J Sci Res*, 3:246-248.
- Sinha, R., Jhariya, M.K. and Yadav, D.K.** (2015). Assessment of Sal Seedlings and Herbaceous Flora in the Khairbar Plantation of Sarguja Forest Division, Chhattisgarh. *Curr World Environ*, 10:330-337.
- Simpson, E.H.** (1949). Measurement of diversity. *Nature*, 163:688.
- Stephene, N. and Lambin, E.F.** (2004). Scenarios of land-use change in Sudano-sahelian countries of Africa to better understand driving forces. *GeoJournal*, 61:365-379.
- Tandon, S., Sahu, S.K., Mishra, A.S.P. and Mishra, P.C.** (2012). Litter disappearance in ash mound plantation site. *The Ecoscan*, 1:83-86.
- Vargas, R., Gartner, S., Alvarez, M., Hagen, E. and Reif, A.** (2013). Does restoration help the conservation of the threatened forest of Robinson Crusoe Island? The impact of forest gap attributes on endemic plant species richness and exotic invasions. *Biodivers Conserv*, 22:1283-1300.
- Whittaker, R.H.** (1972). Evolution and measurement of species diversity. *Taxon*, 21:213-251.
- Yadav, D.K., Jhariya, M.K., Kumar, A. and Sinha, R.** (2015). Documentation and ethnobotanical importance of medicinal plants found in Sarguja district. *J Plant Dev Sci*, 7:439-446.
- Yadav, D.K. and Jhariya, M.K.** (2017). Tree community structure, regeneration and patterns of diversity in natural and plantation forest ecosystem. *Res Environ Life Sci*, 10:383-389.
- Yadav, D.K., Ghosh, L. and Jhariya, M.K.** (2017). Forest Fragmentation and Stand Structure in Tropics: Stand Structure, Diversity and Biomass. Lap Lambert Academic Publishing, Saarbrucken, 116 pp.
- Yadav D.K., Jhariya, M.K. and Ghosh, L.** (2019). Vegetation inter-relationship and regeneration status in tropical forest stands of central India. *Journal of Plant Development Sciences*, 11(3):151-159.
- Zobel, M., Kalamees, R., Pussa, K., Roosaluuste, E. and Moora, M.** (2007). Soil seed bank and vegetation in mixed coniferous forest stands with different disturbance regimes. *For Ecol Manage*, 250:71-76.

## EFFECTS OF ORGANIC, INORGANIC AND BIO-FERTILIZERS ON THE GROWTH OF MAIZE UNDER SUBABUL (*LEUCAENA LEUCOCEPHALA*) BASED AGROFORESTRY SYSTEM

Mukesh Yadav<sup>1</sup>, Rajiv Umrao<sup>1</sup> and Sandeep Rout\*

<sup>1</sup>College of Forestry, Sam Higginbottom University of Agriculture Technology & Sciences, Prayagraj, Uttar Pradesh, INDIA  
Email: [sandeeprou1988@gmail.com](mailto:sandeeprou1988@gmail.com)

Received-13.03.2019, Revised-16.04.2019

**Abstract:** A field trial was carried out at the research farm of College of Forestry, SHUATS, Prayagraj. The experimental site situated at an altitude of 90 M above the MSL at 25° 57' N latitude and 81° 51' E longitude. The experiment comprised of nine treatments replicated thrice. The maximum germination percentage (94.27%), plant height (72.10 cm) at 30DAS, 176.37 cm at 60 DAS and 183.67 cm at 90 DAS, number of cob/plant(1.22), ear length (17.90 cm), number of rows/cob (13.78), number of grains/cob (369.33), test weight (216.93), grain yield (q/ha) (38.50), stover yield (69.29) and harvest index (35.73) were recorded in T<sub>8</sub> (A Chroococcum+ Phosphate Solubilizing Bacteria+Vermicompost (3t/ha) maximize the maize growth and yield under subabul trees. Therefore, it may be concluded that A Chroococcum+ Phosphate Solubilizing Bacteria+Vermicompost (3t/ha), can be recommended for growing maize under subabul based agroforestry system for obtaining better growth and yield.

**Keywords:** Agroforestry, Bio fertilizer, Manure, Subabul

### INTRODUCTION

Agroforestry is primarily defined as an approach to land use that incorporates trees into farming systems, and allows for the production of trees and crops or livestock from the same piece of land in order to obtain economic, environmental, ecological, and cultural benefits (Thevathasan *et al.* 2004).

Diversification of existing farming systems by developing suitable Agroforestry models seems to be the need of the day to cope up with ever increasing demand for diversified products.

Agroforestry offers an economical and ecologically viable option for large scale diversification in agriculture on one hand and environmental amelioration on the other. The increasing population and rapid industrialization has increased pressure on the traditional forests for timber and other related wood products. Therefore, to save forests and meet the growing demands of wood, there is need for large scale plantations of fast growing tree species outside forests to make country self reliant in its timber requirements. Fast growing tree species with rotation of less than ten years like Poplar, Eucalypts, Leucaena, Casuarina, Willow, etc. have gained preference due to their higher productivity and acceptability in the market. On-farm timber tree plantations can also benefit from the global environmental facilities like carbon trading (Pandey, 2007 and Dogra, 2007).

Traditionally, agro-forestry had its origins in developing nations where high population densities coupled with scarce land resources have required that concurrent food and wood production may be produced on the same land base with little compromise on principal of sustainability.

Furthermore, tree- based inter-cropping systems can result in more diversified economies for both short- and long-term products and provide a market for both agronomic and forest crops. Inter-cropping systems can also play a vital role in sequestering carbon below- and above-ground plant components, thereby addressing present and critical societal concerns about global climate change (Thevathasan, et.al, 2004 and Brandle, et. al, 1992).

Agroforestry practices vary according to the agro climatic zones and socio-economic status of the farmers. Considering the tree diversity, existing cropping pattern, availability of irrigation water, soil, climate, rainfall and other agro-meteorological characteristics of the area, the state is divided into nine agro-climatic zones, viz. (i) Bhabhar and Tarai Zone, (ii) Bundelkhand Zone, (iii) Central Zone, (iv) Eastern Plain Zone, (v) Mid-Western Plain Zone, (vi) North Eastern Plain Zone, (vii) South Western Semi-Arid Zone, (viii) Vindhyan Zone and (ix) Western Plain Zone (Singh, 2014). The Gangetic Plain at the centre is large as it covers nearly two-thirds of the state. The whole region is densely populated and immensely vital for the economy of the state. The soil in the region is mostly alluvial, which is fertile. The main crops of the region include paddy, wheat, sugarcane, grams and millets. The eastern tract of this Plain is subjected to periodical floods and droughts, while, the western and central tracts are comparatively better with a well-developed irrigation system. (3) The Vindhyan Hills and plateau in the south which majorly comprises the Bundelkhand division. Rainfall is scanty and erratic with limited or scarce water resources which force the practice of dry land farming on a large scale in the region. There are two main cropping seasons in the state, viz. Rabi

\*Corresponding Author

and Kharif. The kharif cropping season is from July to October during the southwest monsoon. Paddy, maize, Jowar, Bajra, Pulses (Arhar, Black gram, and Green gram), Potato, Cotton, Groundnut and Soybean are the various crops grown in the kharif season. Rabi cropping season is from October to March, and the important Rabi crops are Wheat, Barley, Peas, Chickpea and Mustard. The state produces numerous diverse crops due to its comparative advantage of a wide range of agro-climatic conditions (Dwivedi *et. al.*, 2007 and Kareemulla *et. al.*, 2005).

Agroforestry seems to be a viable and economically feasible solution for the farmers to meet the challenges of food, nutrition, energy, employment and environmental security. Promotion and proper implementation of the recently launched Agroforestry Policy of India, 2014 is a big challenge for the Government of India, though agroforestry is one of the solutions to reduce the growing pressure on the forests, enhance tree cover and to fulfil the shortage of industrial timber. It is also considered as a good alternative for food security (Singh *et.al.*, 2014). Although land management systems, which envisage combination of agricultural crops and trees on the same land unit, are though age old, but lacked scientific inputs (Srinidhi *et al.*, 2007) literature also reveals ample vacuum regarding systematic studies on production of different agriculture crops under varied tree canopies and the interactions of both. The scanty information available reflects both positive response in some crops and inverse trend with other when raised under tree canopy. If such systems have to be recommended for adoption on large scale for sustainable production, compatibility studies among agricultural crops and tree species have to be expeditiously undertaken.

*Leucaena leucocephala* is a medium sized fast growing tree belongs to the family Fabaceae. It is native to Southern Mexico and Northern Central America (Hill, 1971). The specific name 'leucocephala' comes from 'leu' meaning white and 'cephala', meaning *L. Leucocephala* head, referring to the flowers. It is commonly known as White Lead tree, White Popinac, Jumbay and Wild Tamarind. In India, it is popularly known as kubabul or Subabul (Chandrasekhara, 1984). It has also been described as a "conflict tree" because it has been promoted for its forage production and naturally spreads like a weed. It grows up to 20 m height. Leaves are looking like that of tamarind having white flowers tinged with yellow, and having long flattened pods. Seeds are dark brown with hard shining seed coat. The tree has multifarious uses like firewood, timber, greens, fodder, and green manure; provide shade, controls soil erosion (Gardezi, 2004), is a legume and in the symbiosis with Rhizobia bacteria the tree is able to fix about 500 kg nitrogen per ha annually. The nitrogen fixing nodules are found on the small lateral roots near the soil surface (Azeemoddin, 1988).

Alley cropping is a type of Agroforestry system consisting of simultaneous combination of trees and/or shrubs, usually nitrogen-fixing species, banded interspersed with annual crops. Trees or shrubs are pruned regularly to use biomass as green manure and/or firewood, with the main objective of improving soil fertility and/or quality fodder. This system also promotes the use of green manure (Kang, 1993 and Khare, 2016) reported higher production and economical gains in *Leucaena leucocephala* alley cropping systems with maize grown in rotation with black oats.

Maize is one of the most important cereal crops of India not only in terms of hectares, but also in terms of its versatility for adoption under wide range of agroclimatic and crop growing situations. Intercropping of cereal crops between the rows of timber, fodder and fuel tree species may provide good opportunity to diversify agroforestry and increase economic returns to the farming community due to diversify agroforestry and increase economic returns to the farming community due to fast growth and valuable timber.

Maize is called "King of cereals" because of its productivity potential compared to any other cereal crop. Being an exhaustive crop, it has very high nutrient requirement and its productivity is closely depends on nutrient management system. Under the present trend of exploitive agriculture in India, inherent soil fertility can no longer be maintained on the sustainable basis. It is said that nutrient supplying capacity of soil declines steadily under continuous and intensive cropping system. The optimum levels of N, P, K failed to maintain yield levels probably due to increasing secondary and micronutrient deficiencies and also unfavorable alterations in the physical and chemical properties of soil. Organic matter improves water holding capacity of sandy soil and drainage in clayey soil. Organic manure provides nutrients for the soil microorganisms, thus increases the activities of microbes in soil, which in turn help to convert unavailable plant nutrients into available form for plant growth promotion. The bio fertilizers are found positive contribution to soil fertility, resulting in an increase in crop yield without causing any environmental, water or soil pollution hazards. Nitrogen fixing and Phosphorus solubilizing bacteria play an important role in nitrogen mobilization and phosphorus solubilization for the benefit of plant growth (Umesha *et al.*, 2014).

Bio-fertilizers are the inoculations of microbial cultures which are actually multiplied artificially of certain soil microorganisms that can improve soil fertility and crop productivity. Bio-fertilizers are economical as they cost very low and are also the renewable sources through which the plant gets nutrients which supplement chemical fertilizers. Bio-fertilizers provides nutrient supply like nitrogen and phosphorous through their activities in the soil or

rhizosphere and makes them available to the plants on the soil. Bio-fertilizers are now very important because they are properly maintaining the health of the soil and are reducing pollutions in the environment by cutting down the use of chemicals.

#### **Azotobacter**

These bacteria belong to the family of *Azotobacteriaceae*, aerobic, free living, and heterotrophic in nature. They are found in neutral or alkaline soils and *A. chroococcum* are the most common occurring species in arable soils. *A. vinelandii*, *A. beijerinckii*, *A. insignis* and *A. macrocytogenes* are other reported species. *Azotobacter* rarely exceeds of 104 to 105 g<sup>-1</sup> of soil due to lack of organic matter and presence of antagonistic microorganisms in soil. The population number of *Azotobacter* rarely exceeds of 104 to 105 g<sup>-1</sup> of soil due to lack of organic matter and presence of antagonistic microorganisms in soil.

#### **Phosphate solubilizers**

These bacterial species has the ability to solubilize insoluble inorganic phosphate compounds, which are tricalcium phosphate, dicalcium phosphate, hydroxyapatite, and rock phosphate. The examples among the bacterial genera with this are *pseudomonas*, *Bacillus*, *Rhizobium*.

The information on these aspects of subabul based agroforestry system involving organic, inorganic and bio-fertilizers on the growth of maize is meager. Keeping in the view of the importance of crops a preliminary investigation was made to study growth and yield of maize under subabul based agroforestry system.

## **MATERIALS AND METHODS**

The investigation was carried out at the nursery of College of Forestry, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj during the period of July 2016 - October 2016. Evaluation of the compatibility of maize under Subabul (6 years old) based agroforestry system was carried out. Prayagraj is situated at an elevation of 90 meters above the sea level; it is situated at 25.57°N latitude and 81.51°E longitude. Allahabad is located in the South eastern part of Uttar Pradesh and has a sub-tropical climate with extremes of summer and winter. During the summer season, the temperature reaches up to 45-48°C, while during the winter season, especially in the month of December and January temperature drops down to as low as 1-20°C, frost and during summer, hot scorching wind are common features. The average rainfall in this area is around 886.00 mm, during the monsoon i.e. July to September, with a few occasional light showers and drizzles are seen in the winter also (Maurya *et al.*, 2016) (Table.1). Prior to starting the experiment the selected plot remained fallow in Rabi season; organic manures were used for the experiment. The organic manures used were well decomposed Farm Yard Manures, Vermicompost, and Neem Cake as per the

following treatment details- T<sub>0</sub>- Control, T<sub>1</sub>- 50%NP+100%K+A. Chroococcum + Phosphate Solubilizing bacteria +FYM (5t/ha), T<sub>2</sub>- 50%NP+100%K+A. Chroococcum + Phosphate solubilizing Bacteria+Vermicompost (3t/ha), T<sub>3</sub>- 50%NP+100%K+A. Chroococcum+ Phosphate Solubilizing Bacteria+Poultry manure (5t/ha), T<sub>4</sub>- Rec. of NPK+VC (3t/ha), T<sub>5</sub>- Rec. of NPK+PM (5t/ha), T<sub>6</sub>- Rec. of NPK+FYM (5t/ha), T<sub>7</sub>- A. Chroococcum + Phosphate Solubilizing Bacteria+FYM (5t/ha), T<sub>8</sub>- A Chroococcum+ Phosphate Solubilizing Bacteria+Vermicompost (3t/ha), T<sub>9</sub>- Chroococcum + Phosphate Solubilizing Bacteria+Poultry manure (5t/ha). Pre sowing operation like ploughing, weeding and leveling, demarcation and layout application of organic fertilizer, sowing of seeds were carried out manually (Table 2 and 3). After the sowing, timely irrigation and weeding of the field were carried out as and when required. First irrigation was done immediately after sowing of the crop while the subsequent irrigations were provided at 20 and 40 Days after sowing (DAS). Two manual weeding were provided as and when required. Various post- sowing operation, i.e. inter culture operations were carried out as and when required as per the crop. The experiment was conducted in Randomized Block Design (RBD) having five treatment combinations which were replicated thrice. Harvesting was carried during morning hour after 120 days of sowing. Visually yellowing of leaves indicates the maturity stage reached. Pre-harvest observations i.e., (at 30, 60 and 90 DAS) - germination%, plant height (cm), number of cob per plants, Cob per rows, grains per cob, grain yield (t/ha), straw yield (t/ha), test weight (g) of seeds were recorded and Harvest index (%) calculated. The raw data obtained during the experimental observations were subjected to statistical analysis as per method by Gomez and Gomez, (1984). The significance and non-significance of the treatment effects were judged with the help of 'F' variance ratio test. Calculated 'F' value (variance ratio) was compared with the table value of 'F' at 5% level of significance.

## **RESULTS AND DISCUSSION**

The present study was carried out to find out the efficacy of organic, inorganic and biofertilizers (Vermicompost, Poultry manure, Farmyard manure, Azotobacter and PSB) under Subabul based Agroforestry system and to find out their best combination for growth, yield and economic feasibility of Maize crops. The results of the investigation have been presented in tables, and graphically illustrated through bar-diagrams, wherever required, and discussed in the light of the findings reported by earlier researchers. Similar findings of higher germination percentage (96.67%)

also reported in case of soybean under Subabul based agro forestry system (Khare *et al.* 2016)

#### **Germination (%)**

The data presented in table 4 revealed that the germination was significantly influenced by treatments. However, maximum germination was recorded (94.27%) with the application of A. chroococcum+Phosphate solubilizing bacteria+Vermicompost (3t/ha) (T<sub>8</sub>). This may be due to better soil condition with application of organics and biofertilizers. The results are in alignment with the results of Umsha *et al.* (2014) and Hameeda *et al.* (2008).

#### **Plant height (cm)**

The data presented in table 5 revealed that all treatment trail in this experiment produced considerable amount of changes in plant height. These varies in plant height were recorded at 30, 60, and 90 DAS and are presented as follows.

At the primary stage of grow i.e. at 30 DAS the treatment combination of maize crops produced non-significant differences in plant height. However, maximum plant height was recorded in T<sub>8</sub> (72.10), followed by T<sub>9</sub> (68.60), which were found to be at par the minimum plant height was recorded in T<sub>0</sub> (48.67) in control.

At 60 DAS, the treatment combination of crop significantly differ in plant height the maximum plant height was recorded in T<sub>8</sub> (176.37) followed by T<sub>9</sub> (174.67), the minimum plant height was recorded in T<sub>0</sub> (128.20) in control.

At 90 the treatment combination of crop significantly differ in plant height the maximum plant height was recorded in T<sub>8</sub> (183.67), followed by T<sub>9</sub> (181.67) the minimum plant height was recorded in T<sub>0</sub> (136.23) in control. Similar results in case of plant height significantly highest (66.86 cm) were also reported by Kumar *et al.* (2015) in Lin seed in teak based agroforestry system. Prakash *et al.* (2002) also reported that organic manures like FYM increases the plant height of *C. officinalis* as compared to control. These results are in conformity with the findings of Yadav *et al.* (2000) where they reported that media consisting red soil+ FYM (1:1) was the best in respect of plant height for Marigold.

#### **Number of cob per plant**

The treatment (T<sub>8</sub>) having A. chroococcum+Phosphate solubilizing bacteria+Vermicompost (3t/ha) resulted in the production of non-significantly higher number of cob per plant of maize (1.22), and (T<sub>9</sub>) also having A. chroococcum+Phosphate solubilizing bacteria+Poultry manure (5t/ha) (1.22). Organic manures not only slowly release nutrients slowly but also prevent the losses of leaching (Table.6).

#### **Ear length (cm)**

The data on Ear length (cm) are presented in table 7. It is evident that the Ear length (cm) different significantly among the different treatment combination.

The Ear length were found highest in T<sub>8</sub> (17.90), followed by T<sub>9</sub> (17.33) which were found to be at par. The lowest Ear length (cm) were found in T<sub>0</sub> (15.00) in control.

#### **Number of Rows per cob**

The data on **Number of Rows/cob** are presented in table 8. It is evident that the number of Rows/cob different significantly among the different treatment combination.

The number of Rows/cob were found highest in T<sub>8</sub> (13.78), followed by T<sub>9</sub> (13.55) which were found to be at par. The lowest number of Rows/cob were found in T<sub>0</sub> (10.78) in control.

#### **Number of grains per cob**

The data on number of grains/cob are presented in table 9. It is evident that the number of grains/cob different significantly among the different treatment combination.

The number of grains/cob were found highest in T<sub>8</sub> (369.33), followed by T<sub>9</sub> (358.00) which were found to be at par. The lowest No. of grains/cob were found in T<sub>0</sub> (234.00) in control.

#### **Test weight (g)**

The test weight of seed is presented in table 10 which differed significant the different treatment combination. Higher seed was recorded in T<sub>8</sub> (216.93) followed by T<sub>9</sub> (215.91) and minimum seed was recorded in T<sub>0</sub> (190.17) of course the maximum yield per plant was pertaining to cultivar T<sub>8</sub> never the less. The maximum test weight was recorded in T<sub>8</sub>. This might be due to bold seeded characteristic of the cultivar T<sub>8</sub>.

#### **Grain yield (q/ha)**

The data on Grain yield are presented in table 11. It is clear from the table significant variation were noticed among the variation in aspect of Grain yield. The treatment combination (T<sub>8</sub>) gave the highest yield of (38.50) per plant followed by T<sub>4</sub> (37.50). The minimum Grain yield was recorded in T<sub>0</sub> (12.13). This indicates that crop grown with incorporate with organic manures is benefited from it. It not only source of nutrients but also provides overall growth of crop and crop yield (Khare, *et al.* 2016, Thongney, *et al.* 2018)

#### **Straw Yield (q/ha)**

The data on Straw yield (q/ha) are presented in table 12. It is clear from the table significant variation were noticed among the variation in aspect of Straw yield. The treatment combination (T<sub>8</sub>) gave the highest yield of (38.50) per plant followed by T<sub>4</sub> (37.50). The minimum Straw yield was recorded in T<sub>0</sub> (12.13). This may be due to the effect of different nutrient management practice which made significant variations at different stages of crop till harvest, these findings are corroborated with the findings of Gayan *et al.* (2004).

#### **Harvest Index (%)**

The data on Harvest Index (%) are presented in table 13. It is clear from the table significant variation were noticed among the variation in aspect of

Harvest Index. The treatment combination ( $T_8$ ) gave the Harvest Index of (35.73) per plant followed by  $T_4$  (35.21). The minimum Harvest Index was recorded in  $T_0$  (21.77). Similr results were reported by Kaushik and Singh, (2001) in case of Wheat. Apart

from nutrients light is a major limiting factors for the crop growth and yeild under tree species corroborative results were also reported by Tripathi et al. (2001).

**Table 1.** Meteorological data collected during study period (July 2016 to October 2016)

SMW	Dates	Rainfall (mm)	Temperature ( $^{\circ}$ C)		Relative humidity (%)	
			Max.	Min.	I	II
27	2 <sup>nd</sup> -8 <sup>th</sup> July	21.94	38.42	27.25	82.85	52.71
28	9 <sup>th</sup> -15 <sup>th</sup> July	0.91	37.22	27.54	82.42	44.28
29	16 <sup>th</sup> -22 <sup>nd</sup> July	4	34.54	27.30	86.71	48.71
30	23 <sup>rd</sup> -29 <sup>th</sup> July	0.8	35.8	27.45	82.14	47.71
31	30 <sup>th</sup> July- 5 <sup>th</sup> Aug	17.05	35.71	26.57	85.28	48.00
32	6 <sup>th</sup> -12 <sup>th</sup> Aug	4.34	33.82	27.14	88.28	55.42
33	13 <sup>th</sup> -19 <sup>th</sup> Aug	25.94	33.14	27.00	91.71	56.71
34	20 <sup>th</sup> -26 <sup>th</sup> Aug	6.2	34.48	27.11	88.71	55.57
35	27 <sup>th</sup> Aug -02 <sup>nd</sup> Sept	6.94	35.82	27.28	90.57	53.42
36	3 <sup>rd</sup> -9 <sup>th</sup> Sept	0.65	35.14	27.20	87.85	53.85
37	10 <sup>th</sup> -16 <sup>th</sup> Sept	4.91	35.25	27.28	89.42	54.28
38	17 <sup>th</sup> -23 <sup>rd</sup> Sept	1.14	33.28	26.87	89.14	62.57
39	24 <sup>th</sup> -30 <sup>th</sup> Sept	8.08	30.25	26.22	89.42	66.28
40	1 <sup>st</sup> -2 <sup>th</sup> Oct	6.37	34.65	26.68	87.42	53.85

**Source:** Agro-Meteorological Unit, College of Forestry, SHUATS, Prayagraj (UP)

**Table 2.** Mechanical analysis of soil (Bouyoucos hydrometer methods, 1927)

Ingredients	Percentage (%)
Sand	58%
Silt	24%
Clay	18%
Texture Name	Sandy loam

**Table 3.**

Particulars	Analyzed Value	Methods employed
Organic carbon (%)	0.45	Walkley and Black(1927)
Available nitrogen ( $Kgha^{-1}$ )	221	Alkaline permanganate method of (Subbiah and Asija 1956)
Available phosphorus ( $Kgha^{-1}$ )	22.5	Olsen's colorimeter methods (1954)
Available potassium ( $Kgha^{-1}$ )	358	Flame Photometric method (Toth and Prince 1949)
Soil pH 1:2 soil water suspension (w/v)	7.8	Digital pH (Jackson 1954)
Ec (dSm-1)1:2 water suspension (w/v)	0.48	Digital conductivity meter (Jackson 1954)

**Table 4.** Effects of organic, inorganic and biofertilizers on Germination (%) of Maize (*Zea mays* L.) under Subabul (*Leucaena leucocephala*) based agroforestry system.

Treatment no.	Treatment	Germination %
T <sub>0</sub>	Control	89.33
T <sub>1</sub>	50%NP+100%K+A. Chroococcum + Phosphate Solubilizing bacteria + FYM (5t/ha)	93.00
T <sub>2</sub>	50%NP+100%K+A. Chroococcum+Phosphate solubilizing bacteria+Vermicompost (3t/ha)	93.57
T <sub>3</sub>	50%NP+100%K+A. chroococcum+Phosphate solubilizing bacteria+Poultry manure (5t/ha)	93.87
T <sub>4</sub>	Rec. of NPK+VC (3t/ha)	92.97
T <sub>5</sub>	Rec. of NPK+PM (5t/ha)	93.40
T <sub>6</sub>	Rec. of NPK+FYM (5t/ha)	93.57
T <sub>7</sub>	A. chroococcum+Phosphate solubilizing bacteria+FYM (5t/ha)	93.43
T <sub>8</sub>	A. chroococcum+Phosphate solubilizing bacteria+Vermicompost (3t/ha)	94.27
T <sub>9</sub>	A. chroococcum+Phosphate solubilizing bacteria+Poultry manure (5t/ha)	93.77
	<b>Mean</b>	<b>93.12</b>
	<b>Range</b>	Min
		Max
		89.33
		94.27
	F – Test	<b>S</b>
	SE ±d	<b>1.13</b>
	CD (5%)	<b>2.38</b>

**Table 5.** Effects of organic, inorganic and biofertilizers on Plant Height (cm) of Maize (*Zea mays*L.) under Subabul (*Leucaena leucocephala*) based agroforestry system at different intervals after sowing

Treatment no.	Treatment	Plant Height		
		30 DAS	60DAS	90 DAS
T <sub>0</sub>	Control	48.67	128.20	136.23
T <sub>1</sub>	50%NP+100%K+A. Chroococcum + Phosphate Solubilizing bacteria + FYM (5t/ha)	59.97	156.03	160.33
T <sub>2</sub>	50%NP+100%K+A. Chroococcum + Phosphate solubilizing Bacteria+Vermicompost (3t/ha)	60.70	166.80	170.87
T <sub>3</sub>	50%NP+100%K+A. chroococcum+Phosphatesolubilizing bacteria+Poultry manure (5t/ha)	59.40	160.93	165.80
T <sub>4</sub>	Rec. of NPK+VC (3t/ha)	59.43	151.67	154.87
T <sub>5</sub>	Rec. of NPK+PM (5t/ha)	58.60	152.70	152.73
T <sub>6</sub>	Rec. of NPK+FYM (5t/ha)	54.83	152.57	155.97
T <sub>7</sub>	A. chroococcum+Phosphate solubilizing Bacteria+FYM (5t/ha)	67.83	173.80	180.07
T <sub>8</sub>	A. chroococcum+Phosphate solubilizing bacteria+Vermicompost (3t/ha)	72.10	176.37	183.67
T <sub>9</sub>	A. chroococcum+Phosphate solubilizing bacteria+Poultry manure (5t/ha)	68.60	174.67	181.67
	<b>Mean</b>	<b>61.01</b>	<b>159.37</b>	<b>164.22</b>
	<b>Range</b>	Min		
		Max		
		48.67	128.20	136.23
		72.10	176.37	183.67
	F - Test	<b>S</b>	<b>S</b>	<b>S</b>
	SE ±d	<b>3.58</b>	<b>4.75</b>	<b>2.68</b>
	CD (5%)	<b>7.53</b>	<b>9.99</b>	<b>5.64</b>

**Table 6.** Effects of organic, inorganic and biofertilizers on Number of Cob / Plant of Maize (*Zea mays*L.) under Subabul (*Leucaena leucocephala*) based agroforestry system.

Treatment no.	Treatment	Number of cob/plant
T <sub>0</sub>	Control	1.00

<b>T<sub>1</sub></b>	50%NP+100%K+A. Chroococcum + Phosphate Solubilizing bacteria + FYM (5t/ha)	1.00
<b>T<sub>2</sub></b>	50%NP+100%K+A. Chroococcum+Phosphate solubilizing bacteria+Vermicompost (3t/ha)	1.00
<b>T<sub>3</sub></b>	50%NP+100%K+A. chroococcum+Phosphate solubilizing bacteria+Poultry manure (5t/ha)	1.00
<b>T<sub>4</sub></b>	Rec. of NPK+VC (3t/ha)	1.00
<b>T<sub>5</sub></b>	Rec. of NPK+PM (5t/ha)	1.00
<b>T<sub>6</sub></b>	Rec. of NPK+FYM (5t/ha)	1.00
<b>T<sub>7</sub></b>	A. chroococcum+Phosphate solubilizing bacteria+FYM (5t/ha)	1.00
<b>T<sub>8</sub></b>	A. chroococcum+Phosphate solubilizing bacteria+Vermicompost (3t/ha)	1.22
<b>T<sub>9</sub></b>	A. chroococcum+Phosphate solubilizing bacteria+Poultry manure (5t/ha)	1.22
	Mean	<b>1.04</b>
	Range	Min
		Max
		F – Test
		SE ±d
		CD (5%)

**Table 7.** Effects of organic, inorganic and biofertilizers on Ear Length (cm) of Maize (*Zea mays* L.) under Subabul (*Leucaena leucocephala*) based agroforestry system.

Treatment no.	Treatment	Ear length (cm)
<b>T<sub>0</sub></b>	Control	10.49
<b>T<sub>1</sub></b>	50%NP+100% K+A. Chroococcum + Phosphate Solubilizing bacteria + FYM (5t/ha)	15.00
<b>T<sub>2</sub></b>	50%NP+100%K+A. Chroococcum+Phosphate solubilizing bacteria+Vermicompost (3t/ha)	15.90
<b>T<sub>3</sub></b>	50%NP+100%K+A. chroococcum+Phosphate solubilizing bacteria+Poultry manure (5t/ha)	15.67
<b>T<sub>4</sub></b>	Rec. of NPK+VC (3t/ha)	15.10
<b>T<sub>5</sub></b>	Rec. of NPK+PM (5t/ha)	14.20
<b>T<sub>6</sub></b>	Rec. of NPK+FYM (5t/ha)	14.30
<b>T<sub>7</sub></b>	A. chroococcum+Phosphate solubilizing bacteria+FYM (5t/ha)	16.73
<b>T<sub>8</sub></b>	A. chroococcum+Phosphate solubilizing bacteria+Vermicompost (3t/ha)	17.90
<b>T<sub>9</sub></b>	A. chroococcum+Phosphate solubilizing bacteria+Poultry manure (5t/ha)	17.33
	Mean	<b>15.26</b>
	Range	Min
		Max
		F – Test
		SE ±d
		CD (5%)

**Table 8.** Effects of organic, inorganic and biofertilizers on Number of Rows/Cob of Maize (*Zea mays* L.) under Subabul (*Leucaena leucocephala*) based agroforestry system.

Treatment no.	Treatment	Number of Rows/cob
<b>T<sub>0</sub></b>	Control	10.78
<b>T<sub>1</sub></b>	50%NP+100%K+A. Chroococcum + Phosphate Solubilizing Bacteria + FYM (5t/ha)	13.11
<b>T<sub>2</sub></b>	50%NP+100%K+A. Chroococcum+ Phosphate Solubilizing Bacteria+Vermicompost (3t/ha)	13.33
<b>T<sub>3</sub></b>	50%NP+100%K+A. Chroococcum+ Phosphate Solubilizing bacteria+Poultry manure (5t/ha)	13.11
<b>T<sub>4</sub></b>	Rec. of NPK+VC (3t/ha)	12.67

T <sub>5</sub>	Rec. of NPK+PM (5t/ha)	12.67
T <sub>6</sub>	Rec. of NPK+FYM (5t/ha)	12.22
T <sub>7</sub>	A. Chroococcum + Phosphate Solubilizing Bacteria+FYM (5t/ha)	13.33
T <sub>8</sub>	A. Chroococcum + Phosphate Solubilizing Bacteria+Vermicompost (3t/ha)	13.78
T <sub>9</sub>	A. Chroococcum+PhosphateSolubilizing Bacteria + Poultry Manure (5t/ha)	13.55
	<b>Mean</b>	<b>12.85</b>
	<b>Range</b>	<b>Min</b>
		<b>Max</b>
		10.78
		13.78
	F – Test	<b>S</b>
	SE ±d	<b>0.52</b>
	CD (5%)	<b>1.09</b>

**Table 9.** Effects of organic, inorganic and biofertilizers on Number of Grains / Cob of Maize (*Zea mays* L.) under Subabul (*Leucaena leucocephala*) based agroforestry system.

Treatment no.	Treatment	Number of grains/cob
T <sub>0</sub>	Control	234.00
T <sub>1</sub>	50%NP+100%K+A. Chroococcum + Phosphate Solubilizing Bacteria + FYM (5t/ha)	300.67
T <sub>2</sub>	50%NP+100%K+A. Chroococcum+ Phosphate Solubilizing Bacteria+Vermicompost (3t/ha)	314.67
T <sub>3</sub>	50%NP+100%K+A. Chroococcum+ Phosphate Solubilizing bacteria+Poultry manure (5t/ha)	312.00
T <sub>4</sub>	Rec. of NPK+VC (3t/ha)	301.33
T <sub>5</sub>	Rec. of NPK+PM (5t/ha)	298.33
T <sub>6</sub>	Rec. of NPK+FYM (5t/ha)	300.00
T <sub>7</sub>	A. Chroococcum + Phosphate Solubilizing Bacteria+FYM (5t/ha)	350.00
T <sub>8</sub>	A. Chroococcum + Phosphate Solubilizing Bacteria+Vermicompost (3t/ha)	369.33
T <sub>9</sub>	A. Chroococcum+PhosphateSolubilizing Bacteria + Poultry Manure (5t/ha)	358.00
	<b>Mean</b>	<b>313.83</b>
	<b>Range</b>	<b>Min</b>
		<b>Max</b>
		234.00
		369.33
	F – Test	<b>S</b>
	SE ±d	<b>12.84</b>
	CD (5%)	<b>26.98</b>

**Table 10.** Effects of organic, inorganic and biofertilizers on Test Weight (gm.) of Maize (*Zea mays* L.) under Subabul (*Leucaena leucocephala*) based agroforestry system.

Treatment no.	Treatment	Test weight (gm.)
T <sub>0</sub>	Control	190.17
T <sub>1</sub>	50%NP+100%K+A. Chroococcum + Phosphate Solubilizing Bacteria + FYM (5t/ha)	205.70
T <sub>2</sub>	50%NP+100%K+A. Chroococcum+ Phosphate Solubilizing Bacteria+Vermicompost (3t/ha)	209.93
T <sub>3</sub>	50%NP+100%K+A. Chroococcum+ Phosphate Solubilizing bacteria+Poultry manure (5t/ha)	207.70
T <sub>4</sub>	Rec. of NPK+VC (3t/ha)	203.63
T <sub>5</sub>	Rec. of NPK+PM (5t/ha)	201.33
T <sub>6</sub>	Rec. of NPK+FYM (5t/ha)	198.50
T <sub>7</sub>	A. Chroococcum + Phosphate Solubilizing Bacteria+FYM (5t/ha)	213.03
T <sub>8</sub>	A. Chroococcum + Phosphate Solubilizing Bacteria+Vermicompost (3t/ha)	216.93

<b>T<sub>9</sub></b>	A. Chroococcum+PhosphateSolubilizing Bacteria + Poultry Manure (5t/ha)		215.91
	<b>Mean</b>		<b>206.28</b>
	<b>Range</b>	<b>Min</b>	190.17
		<b>Max</b>	216.93
	F – Test		<b>S</b>
	SE ±d		<b>3.08</b>
	CD (5%)		<b>6.49</b>

**Table 11.** Effects of organic, inorganic and biofertilizers on Grain yield(q/ha)of Maize (*Zea mays* L.) under Subabul (*Leucaena leucocephala*) based agroforestry system.

<b>Treatment no.</b>	<b>Treatment</b>	<b>Grain yield (q/ha)</b>	
<b>T<sub>0</sub></b>	Control	12.13	
<b>T<sub>1</sub></b>	50%NP+100%K+A. Chroococcum + Phosphate Solubilizing Bacteria + FYM (5t/ha)	31.40	
<b>T<sub>2</sub></b>	50%NP+100%K+A. Chroococcum+ Phosphate Solubilizing Bacteria+Vermicompost (3t/ha)	32.67	
<b>T<sub>3</sub></b>	50%NP+100%K+A. Chroococcum+ Phosphate Solubilizing bacteria+Poultry manure (5t/ha)	32.27	
<b>T<sub>4</sub></b>	Rec. of NPK+VC (3t/ha)	31.23	
<b>T<sub>5</sub></b>	Rec. of NPK+PM (5t/ha)	28.97	
<b>T<sub>6</sub></b>	Rec. of NPK+FYM (5t/ha)	27.83	
<b>T<sub>7</sub></b>	A. Chroococcum + Phosphate Solubilizing Bacteria+FYM (5t/ha)	35.83	
<b>T<sub>8</sub></b>	A. Chroococcum + Phosphate Solubilizing Bacteria+Vermicompost (3t/ha)	38.50	
<b>T<sub>9</sub></b>	A. Chroococcum+PhosphateSolubilizing Bacteria + Poultry Manure (5t/ha)	37.10	
	<b>Mean</b>	<b>30.79</b>	
	<b>Range</b>	<b>Min</b>	12.13
		<b>Max</b>	38.50
	F - Test		<b>S</b>
	SE ±d		<b>1.74</b>
	CD (5%)		<b>3.65</b>

**Table 12.** Effects of organic, inorganic and biofertilizers on Stover yield(q/ha)of Maize (*Zea mays* L.) under Subabul (*Leucaena leucocephala*) based agroforestry system.

<b>Treatment no.</b>	<b>Treatment</b>	<b>Straw yield (q/ha)</b>	
<b>T<sub>0</sub></b>	Control	44.03	
<b>T<sub>1</sub></b>	50%NP+100%K+A. Chroococcum + Phosphate Solubilizing Bacteria + FYM (5t/ha)	63.73	
<b>T<sub>2</sub></b>	50%NP+100%K+A. Chroococcum+ Phosphate Solubilizing Bacteria+Vermicompost (3t/ha)	63.76	
<b>T<sub>3</sub></b>	50%NP+100%K+A. Chroococcum+ Phosphate Solubilizing bacteria+Poultry manure (5t/ha)	60.08	
<b>T<sub>4</sub></b>	Rec. of NPK+VC (3t/ha)	63.58	
<b>T<sub>5</sub></b>	Rec. of NPK+PM (5t/ha)	64.11	
<b>T<sub>6</sub></b>	Rec. of NPK+FYM (5t/ha)	62.35	
<b>T<sub>7</sub></b>	A. Chroococcum + Phosphate Solubilizing Bacteria+FYM (5t/ha)	64.69	
<b>T<sub>8</sub></b>	A. Chroococcum + Phosphate Solubilizing Bacteria+Vermicompost (3t/ha)	69.29	
<b>T<sub>9</sub></b>	A. Chroococcum+PhosphateSolubilizing Bacteria + Poultry Manure (5t/ha)	68.94	
	<b>Mean</b>	<b>62.46</b>	
	<b>Range</b>	<b>Min</b>	44.03
		<b>Max</b>	69.29

	F – Test	<b>S</b>
	SE ±d	<b>5.14</b>
	CD (5%)	<b>10.80</b>

**Table 13.** Effects of organic, inorganic and biofertilizers on Harvest Index of Maize (*Zea mays* L.) under Subabul (*Leucaena leucocephala*) based agroforestry system.

Treatment no.	Treatment	Harvest Index (%)
T <sub>0</sub>	Control	21.77
T <sub>1</sub>	50%NP+100%K+A. Chroococcum + Phosphate Solubilizing Bacteria + FYM (5t/ha)	33.07
T <sub>2</sub>	50%NP+100%K+A. Chroococcum+ Phosphate Solubilizing Bacteria+Vermicompost (3t/ha)	34.07
T <sub>3</sub>	50%NP+100%K+A. Chroococcum+ Phosphate Solubilizing bacteria+Poultry manure (5t/ha)	35.10
T <sub>4</sub>	Rec. of NPK+VC (3t/ha)	32.90
T <sub>5</sub>	Rec. of NPK+PM (5t/ha)	31.17
T <sub>6</sub>	Rec. of NPK+FYM (5t/ha)	30.97
T <sub>7</sub>	A. Chroococcum + Phosphate Solubilizing Bacteria+FYM (5t/ha)	35.78
T <sub>8</sub>	A. Chroococcum + Phosphate Solubilizing Bacteria+Vermicompost (3t/ha)	35.73
T <sub>9</sub>	A. Chroococcum+PhosphateSolubilizing Bacteria + Poultry Manure (5t/ha)	35.21
	<b>Mean</b>	<b>32.57</b>
	<b>Range</b>	
	<b>Min</b>	21.77
	<b>Max</b>	35.78
	F – Test	<b>S</b>
	SE ±d	<b>1.65</b>
	CD (5%)	<b>3.47</b>

## CONCLUSION

The different growth and yield parameters of maize Viz. Maximum germination % germination percentage (94.27%), plant height (72.10 cm) at 30DAS, 176.37 cm at 60 DAS and 183.67 cm at 90 DAS, number of cob/plant(1.22), ear length (17.90 cm), number of rows/cob (13.78), number of grains/cob (369.33), test weight (216.93), grain yield (q/ha) (38.50), stover yield (69.29) and harvest index (35.73) were recorded in T<sub>8</sub> (A Chroococcum+ Phosphate Solubilizing Bacteria+Vermicompost (3t/ha) maximize the maize growth and yield under Subabul based agroforestry system. So it may be concluded that T<sub>8</sub> can be recommended to the grower for the cultivation of Maize under Subabul based agroforestry system during the Kharif Season in Prayagraj Condition.

## REFERENCES

- Azeemoddin, G., Rao, Jagan Mohan. and Rao, S. Thirumala (1988). *J Food Sci Technol.* 25: 158.
- Brandle, J.R., Wardle, T.D. and Bratton, G.F. (1992). Opportunities to increase tree plantings in shelterbelts and the potential impacts on carbon storage and conservation. In: Sampson RN, Hairs D (eds) *Forests and global change.* American Forests, Washington DC. 1(9):157–175.
- Dogra, A.S. (2007). Contribution of trees outside forests toward wood production and environmental amelioration. *Indian Journal of Ecology.* 38:1-5
- Dwivedi, P.R., Karemulla, K., Singh, R., Rizvi, R.H. and Chauhan, J. (2007). Socio-Economic Analysis of Agroforestry Systems in Western Uttar Pradesh. *Indian Res. J Ext. Edu.* 7(2- 3).
- Gardezi, A.K., Barcelo-Quintal, I.D., Cetina-Alcala, V.M., Bussy, A.L. and Borja Salin, M.A. (2004). Studies of phytoremediation by *Leucaena leucocephala* in association with arbuscular endomycorrhiza and *Rhizobium* in soil polluted by Cu. *Proceedings of 8th World conference on Systemics, Cybernetics and Informatics, Orlando Florida, USA.* 33-39 pp.
- Gayen, S.K., Gupta, D.K. and Sarawgi, S.K. (2004). Effect of decomposed cow dung and urine mixture with or without inorganic fertilizer, soil conditioning and PSB on the root volume and nodules performance of soybean [*Glycine max* (L.) Merrill]. *Annals of Agricultural Research.*25(4): 541-545.

- Gomez, K.A. and Gomez, A.A.** (1984). Statistical procedures for Agricultural Res. 2nd edn. John Wiley and Sons, New York, 680 pp.
- Hameeda, B., Harini,G., Rupela,O.P., Wani S.P. and Reddy, Gopala .**(2008).Growth promotion of maize by phosphate solubilizing bacteria isolated from composts and macrofauna. *Microbiological Research*.163:234-242.
- Hill, G.D.** (1971). *Leucaena leucocephala* for pastures in Tropics. *Herbae Abstracts* 4: 111-19.
- Jackson, M.L.** (1973). Soil Chemical Analysis, Prentice Hall of India Pvt Ltd., New Delhi.
- Kang, B.T.** (1993). "Changes in Soil Chemical Properties and Crop Performance with Continuous Cropping on an Entisol in the Humid Tropics". In. Mulongoy and Mercks R. (Eds). Soil Organic Matter Dynamics And Sustainability Of Tropical Agriculture. John Wiley and Sons. 297-305 Pp.
- Kareemulla, K., Rizvi, R.H., Kumar, K., Dwivedi, R.P., Singh, R.** (2005).Poplar Agroforestry Systems in Western Uttar Pradesh: A Socio – economic analysis Forests. *Trees and Livelihoods*. 15(4):375-382.
- Kaushik, N. and Singh, J.** (2001). Performance of pearl millet-wheat in popular based agri-silvicultural system in sandy soils of southern Haryana. *Indian J. of Agro forestry*. 31(1): 51-54.
- Khare, N., Kumar, D. and Rout, S.** (2016). Effect of organic manure on growth and yield attributes of Soybean under *Leucaena leucocephala* based Agroforestry system. *Journal of Applied and Natural Science*. 8(4): 2219-2223.
- Kumar, H., Umarao, R. and Tripathi, M.K.** (2015). Varietal performance of Linseed planted at different pacing under Teak based agro forestry system. *J. Int. Acad. Res. Multidiscip*, 2(8): 261-268.
- Maurya, S.K., Nath, S., Patra, S.S. and Rout, S.** (2016). Effect of different dates of sowing on growth and yield of pearl millet (*Pennisetum glaucum* L.) varieties under Allahabad condition. *International Journal of Science and Nature*. 7(1): 62-69.
- Pandey, D.N.** (2007). Multifunctional agroforestry in India. *Current Science*. 92(4):455-463
- Prakash, A., Sindhu, S.S., Sharma, S.K. and Prakash, A.** (2002). Effect of phosphorus and FYM on yield parameters of marigold in chloride dominated saline soil. *Haryana Journal of Horticulture Sciences*. 31(3-4): 207 -210.
- Rao, Chandrasekhara T., Lakshminarayana, G., Prasad, N.B.L., Rao, Sagan Mohan S., Azeemoddin, G., Atchynta Ramayya, D., Thirumala Rao, S.D.**(1984). *J Am Oil Chem Soc*. 61: 1472-3.
- Singh, P.**(2014). Population and agro climatic zones in India: an analytical analysis. *Proc. Soc. Behav. Sci*.120: 268–278
- Srinidhi, H.V., Chauhan, S.K. and Sharma, S.C.** (2007) SWOT analysis of Indian agroforestry. *Ind. J. Agrif. 9*:1-11.
- Subbiah, B. V. and Asija, G. L.** (1956). A rapid procedure for estimation of available nitrogen in soils. *Current Science*. 25: 259-260.
- Thevathasan, N.V., Gordon, A.M.** (2004). Ecology of tree intercropping systems in the north temperate region: Experiences from southern Ontario, Canada. *Agroforest Syst*. 61:257–268.
- Thevathasan, N.V., Gordon, A.M., Simpson J.A., Reynolds P.E., Price G. and Zhang P.**( 2004). Biophysical and ecological interactions in a temperate tree-based intercropping system. *J Crop Improvement*. 12 (1–2): 339–363.
- Thongney, P.L., Khare, N., Rout, S. and Debbarma, R.** (2018). Effect of different level of vermi-compost and FYM organic manures on quality parameters of Cucumber intercropped with Citrus based agroforestry system. *International Journal of recent scientific research*.9 (12A):29847-29850.
- Tripathi, M.K., Saini, B.C. and Chaturvedi, S.** (2006). Growth and yield of intercropped wheat under Salix-Dalbergia agro forestry system. *Annals of Bio. of Agric. and Tech.*, Pantnagar, Uttrakhand, India. 22(2):189.
- Umesha, S., Srikantaiah, M., Prasanna, K.S., Sreeramulu, K.R., Divya, M. and Lakshmi pathi, R.N.** (2014). Comparative effect of organics and biofertilizers on growth and yield of maize (*Zea mays* L.). *Curr. Agr. Res. J.* 2: 55-62.
- Yadav, P.K., Singh, S. Dhindwal, A.S. and Yadav, M.K.** (2000). Effect of N and FYM application on floral characters and yield of African marigold. *Haryana Journal of Horticulture sciences*.29 (1-2): 69-71.



## FLORISTIC COMPOSITION AND DIVERSITY IN THE FOREST FRAGMENTS OF DRY AND MOIST TROPICAL FOREST

Dhiraj Kumar Yadav<sup>1</sup>, Lekha Ghosh<sup>2</sup> and Manoj Kumar Jhariya\*

<sup>1</sup>*Department of Farm Forestry, Sant Gahira Guru Vishwavidyalaya, Sarguja, Ambikapur-497001 (Chhattisgarh), INDIA*

<sup>2</sup>*Chhattisgarh State Medicinal Plant Board, Raipur-492012 (Chhattisgarh), INDIA*  
*Email: manu9589@gmail.com*

*Received-16.02.2019, Revised-18.04.2019*

**Abstract:** The stand attributes in terms of structure and diversity across the forest fragments by forest types have been poorly investigated previously. Therefore, in the present investigation stand attributes i.e., floristic composition, structure and diversity of vegetation growing into two different forest types viz., dry tropical forest (DTF) and moist tropical forest (MTF) of the Chhattisgarh, India is examined. By using field data, collected through random sampling techniques from forest fragmented landscape in the dry and moist forests of Chhattisgarh, India, we were able to visualize the effects and influence on tropical forests. We observed changes in species composition, stand structure and diversity of concerned forest types. The most diverse families were Leguminosae (10), Anacardiaceae (7), Euphorbiaceae (4), Combretaceae (3), Myrtaceae (3), Rhamnaceae (3), Rubiaceae (2) and Rutaceae (2). In the present study a total of 8120 trees ha<sup>-1</sup> in all the forest sites representing 50 species and 23 families were encountered. The total density of trees varied from 390-2130 trees ha<sup>-1</sup>, being highest in DTF I while least in MTF II. The diversity indices values reflected that Shannon index recorded for various forest fragments ranged from 2.39-3.62, equitability from 0.75-1.25, species richness from 2.65-6.61, beta diversity from 6.02-20.0 and concentration of dominance from 0.12-1.0, respectively. The present reports highlights the sites conditions for phytosociological attributes at stand levels, which may enriched the information towards sustainable strategies, plan and management of these resource in addition to conservation priority.

**Keywords:** Biomass, C stock, Diversity, Forest fragments, Structure, Tropical forest

### INTRODUCTION

Plants are the basis of life, assets in the landscape and central to people's livelihoods. They deliver natural conservation, ecological balance and benefits in addition to aesthetic values on earth, and people are closely associated to their ecosystem and live in harmony with nature (Kumar et al. 2017; Yadav et al. 2017; Jhariya 2017a; Jhariya et al. 2019). Biodiversity is key aspect for human survival, economic well-being, ecosystem functioning and stability (Singh 2002). The local, regional and global biodiversity of the natural ecosystems is under threat due to forest fragmentation (Wu 2013). The process of forest fragmentation is detrimental and has been under alarming situation worldwide, especially in tropics (Yadav et al. 2017). Fragmentation leads towards reduction of habitat into smaller patches beside loss of forest cover and biodiversity (Collinge 2009). Naturally some habitats are patchy due to site conditions, but biotic interferences have laid noticeably fragmented world's landscapes (Haddad et al. 2015). Consequently, knowing the origin and consequences of fragmentation is critical for biodiversity conservation and appropriate ecosystem functioning.

On a global scale 90% of tropical forests situated outside protected areas (WWF 2002), and it experienced with loss of forest cover as well as biodiversity due to biotic disturbances even within

protected woodlands (Majumdar and Datta 2015; Oraon et al. 2014 & 2015; Jhariya and Yadav 2016; Yadav et al. 2019). The alteration in land-use is a determining factor which have key impact on vegetation, site conditions, ecosystems structure and functions (Pimm and Raven 2000; Bihn et al. 2008; Jhariya 2010, 2014; Jhariya et al. 2012, 2014; Kagezi et al. 2016; Jhariya 2017b). India houses nearly 47,513 species of plant (Singh and Dash 2014), which represents 11.40% of global flora (Arisdason and Lakshminarasimhan 2016). Tropical ecosystems are perceived to be rich biodiversity reserves due to diverse environmental and ecological conditions (Apguaua et al. 2015; Gandiwa et al. 2016). Species diversity differs from site to site in tropics due to variation in bio-geography and disturbance regimes (Sundarapandian and Karoor 2013; Kumar et al. 2017; Jhariya 2017a). In India, habitat destruction, over-exploitation, deforestation and species introduction are identified as major causes of diversity loss (UNEP 2001; Panda et al. 2013; Mutiso et al. 2015), and nearly 3.5% annual loss of forest is reported for India (Puyravaud et al. 2010). Increasing fragmentation resulted in the loss of a valuable portion of the forest ecosystem. Tree species with small populations, will be the first to be lost in the process of forest fragmentation. Information on vegetation structure is important key to understand the forest ecosystems (Naidu and Kumar 2016) and it correspondingly respond to

\*Corresponding Author

alteration governed by natural or anthropogenic means (Sundarapandian and Karoor 2013; Jhariya et al. 2014; Yadav and Jhariya 2017; Yadav et al. 2019). The floristic composition of the forests stand depicts the health of these ecosystems (Krishnamurthy et al. 2010; Jhariya et al. 2012; Tinh et al. 2015; Yadav and Jhariya 2017). The assessment of stand biomass and vegetation carbon is key determinant which defining the role and function of vegetation stands towards global climate (Jhariya and Yadav 2018). In Indian perspectives, the precise estimation of vegetation attributes and ecological services assist by different vegetation in different forest types are limited. Measures of community structure and diversity may better inform how fragmentation affects these biotic communities (Haddad et al. 2015). Here, we present the forest fragments study related to its impact on structure and diversity in different sites by forest type in Chhattisgarh, India.

## MATERIALS AND METHODS

### Study Site

The study was carried out at Barnawapara wildlife sanctuary (North Raipur, Raipur Forest Division) and Achanakmar-Amarkantak biosphere reserve (Achanakmar, Bilaspur Forest Division). The study includes five site viz. DTF I (Bar), DTF II (Ravan) and DTF III (Lavan range) of Barnawapara wildlife sanctuary (BWS), and MTF I (Game range, Paschim Chaparawa) and MTF II (Shiv Tarai range) of Achanakmar-Amarkantak biosphere reserve (AABR).

BWS is located between 21°20'0" to 21°25'47" north latitudes and 82°21'17" to 82°26'27" east longitudes. The general topography of area is undulating and the area adjoining Nawapara forest village has a number of hillocks scattered all over the area. Dry deciduous forest, grasslands, agriculture lands and human habitations surround the study area. The climate of study area is dry humid tropical. The average annual rainfall in the study area ranges from 1200-1350 mm. The mean monthly maximum temperature ranges from 27.3°C in January to 41.8°C in May and mean monthly maximum temperature ranges from 12.7°C in December to 27.3°C in May. Soils of study area are grouped into three classes viz., *Inceptisols*, *Alfisols* and *Vertisols*. The teak forest, sal forest, mixed dry forest and bamboo brakes are major vegetation types found in this region (Champion and Seth 1968).

AABR lies between 22° 15' to 22° 58' north latitude and 81° 25' to 82° 5' east longitude, having an area of 3835.51 km<sup>2</sup>, partly falling in Madhya Pradesh and partly falling in Chhattisgarh state. This region comprised by varying topography, geology and variety of landforms are major attributes of AABR. The area has source of origin of Narmada, Sone and Johilla major river system. The biosphere area has a

typical monsoon climate. The forest area of the AABR represents tropical deciduous vegetation and can be classified into Northern tropical moist deciduous and Southern dry mixed deciduous forests (Champion and Seth 1968).

### Experimental Details

The study was conducted after repeated reconnaissance survey of BWS and AABR. The stratified random sampling procedure was adopted for characterization of vegetation. The phytosociological analysis in each forest fragment was carried by randomly laying sample plots of 10 x 10 m<sup>2</sup> in size. In each quadrat, GBH (Girth at Breast height) of each individual was measured at species level. The vegetation data in each forest fragment was quantitatively analyzed for frequency, density and abundance by using following expressions (Curtis and McIntosh 1950). Basal area of trees was calculated as cross sectional area of stem at breast height i.e. at 1.37 m from the ground level. The relative density, relative frequency, relative basal area, relative abundance was calculated. The Importance Value Index (IVI) was determined as the sum total of relative frequency, relative density and relative dominance (Phillips 1959). The diversity indices were calculated following Sagar and Singh (1999). The data thus generated were synthesized and diversity of each fragment was characterized and correlated with the structure parameters (IVI, basal area, density, etc.).

## RESULTS AND DISCUSSION

### Stand Structure

In the present study a total of 8120 trees ha<sup>-1</sup> in all the forest sites representing 50 species and 23 families were encountered. The most diverse families were Leguminosae (10), Anacardiaceae (7), Euphorbiaceae (4), Combretaceae (3), Myrtaceae (3), Rhamnaceae (3), Rubiaceae (2) and Rutaceae (2). Out of which 2130 trees ha<sup>-1</sup> were encountered in DTF I, 1930 trees ha<sup>-1</sup> in DTF II, 1030 trees ha<sup>-1</sup> in DTF III, 2640 trees ha<sup>-1</sup> in MTF I and 390 ha<sup>-1</sup> trees in MTF II was observed. Results on phytosociological analysis in various forest fragments are given in the table 1. In DTF I total of 25 species representing 14 families were encountered, in the DTF II 22 species comprising 13 families were recorded while in the DTF III total 10 species having 9 families were encountered. In MTF I total of 25 species distributed in 15 families were encountered whereas MTF II showed 11 species representing 8 families were noticed. The MTF I and DTF I were found to be most diverse and rich in terms of species richness and taxonomic family presence.

It is evident that in the DTF I *Terminalia tomentosa* was the most dominant tree followed by *Cleisthenus collinus* and *Lagerstroemia parviflora*. Highest density was recorded in *Cleisthenus collinus*

followed by *Terminalia tomentosa*, *Lagerstroemia pariviflora*, *Buchanania lanzan* and *Anogeissus latifolia*. Lowest density was recorded by *Ficus hispida*, *Holoptelea integrifolia*, *Shorea assamica* and *Delonix regia*. In DTF II *Cleisthenus collinus* was the most dominant species followed by *Diospyros melanoxylon* and *Lagerstroemia pariviflora*. Lowest density was recorded by *Syzygium cumini*, *Bridelia retusa*, *Pterocarpus marsupium*, *Embllica officinalis*, *Dalbergia paniculata*, *Buchanania lanzan* and *Andidesma acidum*. It revealed that *Lagerstroemia pariviflora* was the most dominant tree followed by *Ougeinia oojeinensis* and *Diospyros melanoxylon* in DTF III. Lowest density was recorded for *Terminalia tomentosa* and *Limonia acidissima*. It observed in MTF I that *Shorea robusta* was the most dominant tree followed by *Terminalia tomentosa* and *Miliusa tomentosa*. Lowest density was recorded by *Ventilago calyculata*, *Semecarpus anacardium*, *Zizyphus xylopyra*, *Garuga pinnata*, *Cassia fistula* and *Bauhinia racemosa*. In MTF II *Diospyros melanoxylon* was the most dominant tree layer followed by *Terminalia tomentosa* and *Buchanania lanzan*. Lowest density was recorded for *Anogeissus latifolia*, *Butea monosperma*, *Tectona grandis*, *Embllica officinalis* and *Semecarpus anacardium*.

In DTF I highest basal area was observed in *Terminalia tomentosa* followed by *Cleisthenus collinus*, *Anogeissus latifolia*, *Embllica officinalis* and *Terminalia chebula*. Basal area and density of individual tree species varied from 0.02-12.72 m<sup>2</sup> ha<sup>-1</sup> and 10-410 stems ha<sup>-1</sup>, respectively. In DTF II maximum basal area was observed in *Cleisthenus collinus* followed by *Terminalia tomentosa* and *Diospyros melanoxylon*. Basal area and density of individual tree species varied from 0.02-8.54 m<sup>2</sup> ha<sup>-1</sup> and 10-850 stems ha<sup>-1</sup>, respectively. It reflected that in DTF III higher basal area value was observed in *Ougeinia oojeinensis* followed by *Lagerstroemia pariviflora* and *Diospyros melanoxylon*. Basal area and density of individual tree species varied from 0.17-8.76 m<sup>2</sup> ha<sup>-1</sup> and 10-340 stems ha<sup>-1</sup>, respectively. MTF I showed that highest basal area was observed in *Shorea robusta* followed by *Terminalia tomentosa* and *Miliusa tomentosa*. Lowest basal area was recorded in *Semecarpus anacardium*, *Zizyphus xylopyra* and *Cassia fistula*. Basal area and density of individual tree species varied from 0.01-22.77 m<sup>2</sup> ha<sup>-1</sup> and 10-1460 stems ha<sup>-1</sup>, respectively. In MTF II highest basal area was observed in *Diospyros melanoxylon* followed by *Terminalia tomentosa* and *Semecarpus anacardium*. Basal area and density of individual tree species varied from 0.01-3.43 m<sup>2</sup> ha<sup>-1</sup> and 10-100 stems ha<sup>-1</sup>.

In DTF I *Terminalia tomentosa* showed highest value of IVI (53.67) followed by *Cleisthenus collinus* (40.72) and *Lagerstroemia pariviflora* (23.29). In DTF II *Cleisthenus collinus* showed highest value of IVI (81.69) followed by *Diospyros melanoxylon*

(33.24) and *Lagerstroemia pariviflora* (27.29). In DTF III *Lagerstroemia pariviflora* showed highest value of IVI (81.58) followed by *Ougeinia oojeinensis* (63.87) and *Diospyros melanoxylon* (63.15). In MTF I *Shorea robusta* showed highest value of IVI (128.23) followed by *Terminalia tomentosa* (21.63) and *Miliusa tomentosa* (13.4). In MTF II *Diospyros melanoxylon* showed highest value of IVI (73.93) followed by *Terminalia tomentosa* (51.75) and *Buchanania lanzan* (47.25).

Tree basal cover in the present study varied from 10.61-50.90 m<sup>2</sup> ha<sup>-1</sup> for various forest fragments. These basal cover values were higher than the values reported for several dry tropical forest communities in Vindhyan region by Jha and Singh (1990) between 6.58 and 23.21 m<sup>2</sup> ha<sup>-1</sup> and from 3.84-10.36 m<sup>2</sup> ha<sup>-1</sup> by Singh and Singh (1991). The present values were comparable with 17-40 m<sup>2</sup> ha<sup>-1</sup> for dry tropical forest and 20-75 m<sup>2</sup> ha<sup>-1</sup> for wet forest (Murphy and Lugo 1986a). Basal cover in a Puerto Rican sub-tropical dry forest was 19.8 m<sup>2</sup> ha<sup>-1</sup> (Murphy and Lugo 1986b). In the present study, tree density ranged between 390-2640 for various forest fragments in dry and moist deciduous forest. Compared to the present study the density of forest in Thailand, of dry *Dipterocarp* forest, was 554-789 (Visaratana et al. 1986); of mixed deciduous forest was 253 (Sahunalu et al. 1979) and tropical rain forest was 818-1540 (Kiratiprayoon 1986). Tree density in the Vindhyan region ranges between 294-627 stems ha<sup>-1</sup> for several dry tropical forest communities (Jha and Singh 1990; Singh and Singh 1991). However, Rodgers (1990) reported a very high value of basal cover (131 m<sup>2</sup> ha<sup>-1</sup>) for the forests of Sariska Tiger Reserve.

Inverse relationship between density and GBH showed small structure of the forests where only 28.57% individuals reflecting in the class exceeding 50 cm GBH. This may be related to faster turnover, biotic removal or low capacity of biomass accumulation. Relating tree density with GBH, in Puerto Rican tropical dry forest, Murphy and Lugo (1986b) have found that only 2.3% individual exceeds 10 cm DBH. Singh and Singh (1991) reported that only 3-5% individuals were in the classes exceeding 50 cm GBH. Similarly, Jhariya (2014) reported that forest possessed small structure as 86.37-91.71% individuals represented by ≤10 cm girth class and nearly 8.29-13.63% represented by exceeding 10 cm girth class whereas 1.58-2.18% individuals were found to exceeding > 50 cm girth class.

The inverse relationship between density and GBH distribution was found. The relationship between girth class (cm) and number of trees for the different forest fragments are illustrated in figure 1. The relationship followed an exponential model [(y = exp (a-bx))] in DTF I, DTF II and DTF III, Logarithmic model in MTF I (ln y = a-b ln x) and followed by the Linear model (y = a+bx) in DTF III. The relationship for DTF I was y = exp (80.69 - 6.028 x), for DTF II

$y = \exp(51.03 - 0.026x)$  and for MTF II  $y = \exp(6.47 - 0.01x)$ , respectively. The relationship for MTF I was logarithmic,  $(\ln y = 98.28 - 20.37 \ln x)$  and in case of DTF III the relationship was linear,  $y = (17.15 - 0.12x)$ . In all the forest sites studied most of the trees i.e. 71-90% species comes under middle girth class. This indicates that the forest of this study area is under middle aged. Hence, they should be managed on sustainable basis for the future use.

Small fragments of forests have very different ecosystem characteristics than the large forest fragments, supporting more light loving species, more trees with wind or water dispersed seeds and relatively few understorey species (Laurance 1999). Conservation strategies need to ensure the preservation and restoration of large un-fragmented forest habitats in each region (Aksins 1995). It is argued that if environmental changes produced by disturbance are large; it may become lethal to greater numbers of established species than are, or can be immediately replaced by immigrants. Disturbance such as logging, usually cause an immediate decline in biodiversity followed by a recovery, although not necessarily of the same species (Noble and Dirzo 1997). Species richness of the site experiencing disturbances, therefore, will be cumulative outcome of differential responses of species to disturbance. Some species may tolerate the disturbance and the other may disappear.

Collins *et al.* (2009) reported that forest fragmentation has great impact on populations, communities, ecosystems and suggesting that tract will continue to species loss and declines in ecosystem functions for long time. Pawar *et al.* (2014) reported that 6-12 species of trees were recorded among different sites. The density of tree varied from 100-510 stems  $ha^{-1}$  and value of basal area ranged from 11.47-26.67  $m^2 ha^{-1}$ . Bargali *et al.* (2014) reported tree density was ranged from 650-1520 trees  $ha^{-1}$  in tropical forests of Chhattisgarh. Thakur and Swamy (2012) reported the number of species, tree density and basal area were ranged from 9-26, 324-733 trees  $ha^{-1}$  and 8.13-28.87  $m^2 ha^{-1}$ , respectively. Yadav and Jhariya (2017) found a sum of 10 tree species in different site and tree density varied from 520-860 individuals  $ha^{-1}$  with the basal area of 19.807-40.21  $m^2 ha^{-1}$ , which supports the present findings.

The presence of maximum number of species with only one or 1 to 10 individuals of all the forest sites may indicate the mixed nature of the forest (Richards 2002) and a marked diversity. In the present study the species represented by a single individual varied from 1-28%. Black *et al.* (1950) in the Amazonian rain forests found that among trees of at least 10 cm dbh, over one third of the species were represented by single individuals.

Many studies suggested that the heterogeneity of the environment as well as disturbance is the prime cause for patch formation in the forests (Jha and

Singh 1990). A small number of unique species on the more disturbed sites and a decrease in the total number of species along the disturbance gradient may reflect high utilization pressure (Bhat *et al.* 2000). The recurrent human intervention for collection of fuel wood and minor forest products and the practice of grazing and trampling may change the habitat fitness for many species.

In the natural environment clumped distribution of vegetation is common whereas in uniform condition random distribution is found. The clumped distribution of individuals of a species may be due to insufficient mode of seed dispersal (Richards 1996), or when death of trees creates a large gap encouraging recruitment and growth of numerous saplings (Armesto *et al.* 1986; Richards 1996). Vegetative reproduction by sucker and coppice also encourages clustering of species (Lieberman 1979). *Anogeissus latifolia*, *Diospyros melanoxylon*, *Lagerstroemia parviflora*, and *Shorea robusta* are the species, which form coppice and as a result of stem poaching, they either recover or increase in number through coppice when the disturbance is moderate. Of this coppice forming species, only *Anogeissus latifolia* and *Shorea robusta* are able to tolerate high degree of disturbance.

The uniform dispersion pattern of species in tropical forest largely enables the maintenance of high levels of diversity. The changes in the dispersion pattern may reflect the reactions of species to disturbance as well as to changes in the habitat conditions. For example, the stem density of species changing from clumped to uniform dispersion was lower and that of species changing from uniform to clumped dispersion was on the more disturbed sites. Uniform dispersion of species is possible in case of edible fruits by birds and animals e.g. *Ziziphus xylopyrus*, *Diospyros melanoxylon*, *Buchanania lanzan*, *Grewia tiliifolia*, *Terminalia chebula* etc. The study of Ramirez-Marcial *et al.* (2001) showed decreasing density and basal area with disturbance intensity. Smiet (1992) correlated the basal area with disturbance. Current study also indicated that the stem density declined with disturbance. The decline in stem density along the disturbance gradient may be due to gradual increase in the extraction of firewood, small timbers, insect attack and rotting of boles.

Changes in density and basal area of trees in different forest fragments shows that prevailing biotic factors such as exploitation of forests to meet daily requirements of fuel wood, wood for agricultural implements and house hold construction, for preparation of boundaries along the houses and farm land, unregulated grazing by domestic cattle are the key determinants of structure and function of the forest. These factors in the absence of any viable alternatives defy all regulatory measures. As a result the forest goes on degrading year after year without any hope of rejuvenation without exclusion of these

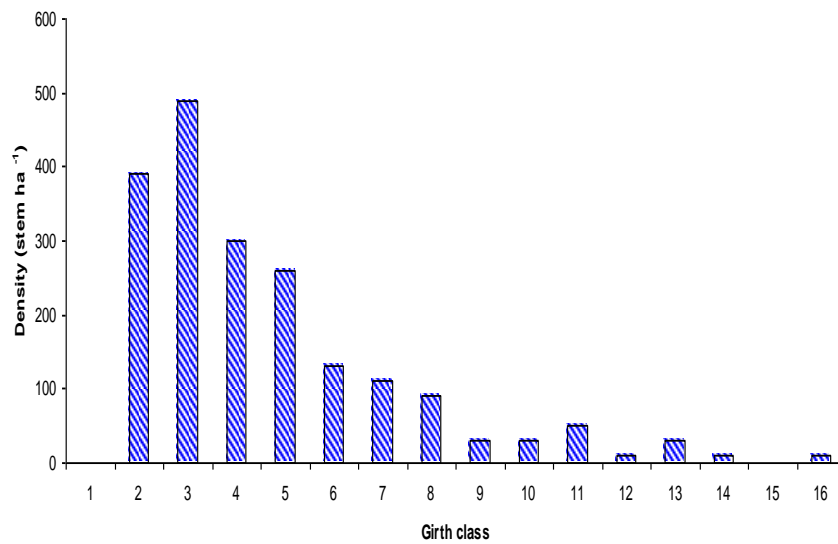


<i>Bombax malabaricum</i>	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	20	20	0.72	47.25	
<i>Bridelia retusa</i>	50	70	1.97	13.18	10	10	0.11	2.29	--	--	--	--	--	--	--	--	--	--	--	
<i>Buchanania lanzan</i>	70	160	2.64	21.13	10	10	0.38	3.01	--	--	--	--	30	40	0.81	7.45	50	80	1.19	24.37
<i>Butea monosperma</i>	10	20	0.22	2.58	--	--	--	--	--	--	--	--	20	20	0.55	4.71	10	10	0.46	10.89
<i>Caesalpinia sepiaria</i>	--	--	--	--	--	--	--	--	--	--	--	--	60	110	0.21	12.32	--	--	--	--
<i>Careya arborea</i>	10	30	0.98	4.53	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>Casearia graveolens</i>	--	--	--	--	--	--	--	--	--	--	--	--	40	60	0.17	7.75	--	--	--	--
<i>Cassia fistula</i>	20	20	0.06	3.47	--	--	--	--	--	--	--	--	10	10	0.01	1.71	--	--	--	--
<i>Chloroxylon swietenia</i>	--	--	--	--	60	80	1.52	17.04	--	--	--	--	--	--	--	--	--	--	--	--
<i>Cleistanthus collinus</i>	60	410	7.25	40.72	100	850	8.54	81.69	70	200	3.68	47.58	--	--	--	--	--	--	--	--
<i>Cordia dichotoma</i>	--	--	--	--	20	20	0.06	4.14	--	--	--	--	--	--	--	--	--	--	--	--
<i>Dalbergia paniculata</i>	--	--	--	--	10	10	0.66	3.76	--	--	--	--	--	--	--	--	--	--	--	--
<i>Delonix regia</i>	10	10	0.16	2	--	--	--	--	10	20	1.05	7.69	--	--	--	--	--	--	--	--
<i>Diospyros melanoxylon</i>	10	30	0.33	3.25	80	160	4.91	33.24	90	200	6.99	63.15	40	150	0.99	13.33	40	100	3.43	73.93
<i>Embllica officinalis</i>	40	90	4.33	17.55	10	10	0.48	3.29	--	--	--	--	60	100	0.65	13.11	10	10	0.23	8.75
<i>Eugenia heyneana</i>	--	--	--	--	--	--	--	--	--	--	--	--	30	30	0.07	5.12	--	--	--	--
<i>Ficus hispida</i>	10	10	0.41	2.49	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>Garuga pinnata</i>	50	100	2.63	15.89	--	--	--	--	--	--	--	--	10	10	0.54	3.1	--	--	--	--
<i>Gmelina arborea</i>	--	--	--	--	40	40	0.32	8.8	--	--	--	--	--	--	--	--	--	--	--	--
<i>Grewia tiliaefolia</i>	40	70	1.55	11.14	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>Holoptelea integrifolia</i>	10	10	0.02	1.72	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>Lagerstroemia parviflora</i>	70	200	2.78	23.29	30	280	3.12	27.29	100	340	7.76	81.58	30	100	0.79	9.7	--	--	--	--
<i>Lannea coromandelica</i>	--	--	--	--	50	60	1.65	14.89	20	20	0.31	7.54	--	--	--	--	--	--	--	--
<i>Lannea grandis</i>	--	--	--	--	--	--	--	--	--	--	--	--	60	60	1.18	13.02	--	--	--	--
<i>Limonia acidissima</i>	--	--	--	--	--	--	--	--	10	10	0.17	3.82	--	--	--	--	--	--	--	--
<i>Ixora arborea</i>	--	--	--	--	--	--	--	--	30	40	0.39	12.0	--	--	--	--	--	--	--	--
<i>Madhuca indica</i>	50	120	2.65	16.86	40	40	3.94	18.54	--	--	--	--	20	20	0.56	4.73	20	50	1.0	30.25
<i>Mangifera indica</i>	--	--	--	--	10	40	0.64	5.27	--	--	--	--	--	--	--	--	--	--	--	--
<i>Miliusa tomentosa</i>	--	--	--	--	--	--	--	--	--	--	--	--	50	80	1.53	13.4	--	--	--	--
<i>Mitragyna parviflora</i>	--	--	--	--	--	--	--	--	--	--	--	--	20	40	0.36	4.96	--	--	--	--
<i>Ougeinia oojeinensis</i>	--	--	--	--	--	--	--	--	80	170	8.76	63.87	20	20	0.88	5.59	--	--	--	--
<i>Pterocarpus marsupium</i>	--	--	--	--	10	10	0.51	3.36	--	--	--	--	--	--	--	--	20	20	0.57	18.52
<i>Schleichera oleosa</i>	--	--	--	--	--	--	--	--	--	--	--	--	10	20	0.39	3.08	--	--	--	--
<i>Semecarpus anacardium</i>	--	--	--	--	20	20	0.09	4.22	--	--	--	--	10	10	0.01	1.705	10	10	1.30	18.85
<i>Shorea assamica</i>	10	10	0.03	1.73	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>Shorea robusta</i>	--	--	--	--	--	--	--	--	--	--	--	--	100	1460	22.77	128.23	--	--	--	--
<i>Sterculia urens</i>	--	--	--	--	20	30	0.22	5.08	--	--	--	--	--	--	--	--	--	--	--	--
<i>Syzygium cumini</i>	--	--	--	--	10	10	0.02	2.03	--	--	--	--	20	50	0.13	4.75	--	--	--	--
<i>Tectona grandis</i>	10	70	0.32	5.13	20	40	0.44	6.18	--	--	--	--	--	--	--	--	10	10	0.01	6.67
<i>Terminalia chebula</i>	30	30	3.13	11.17	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
<i>Terminalia tomentosa</i>	90	380	12.72	53.67	40	80	4.99	23.44	10	10	0.4	4.58	50	110	4.21	21.63	50	70	1.47	51.75
<i>Ventilago calyculata</i>	--	--	--	--	--	--	--	--	--	--	--	--	10	10	0.03	1.76	--	--	--	--

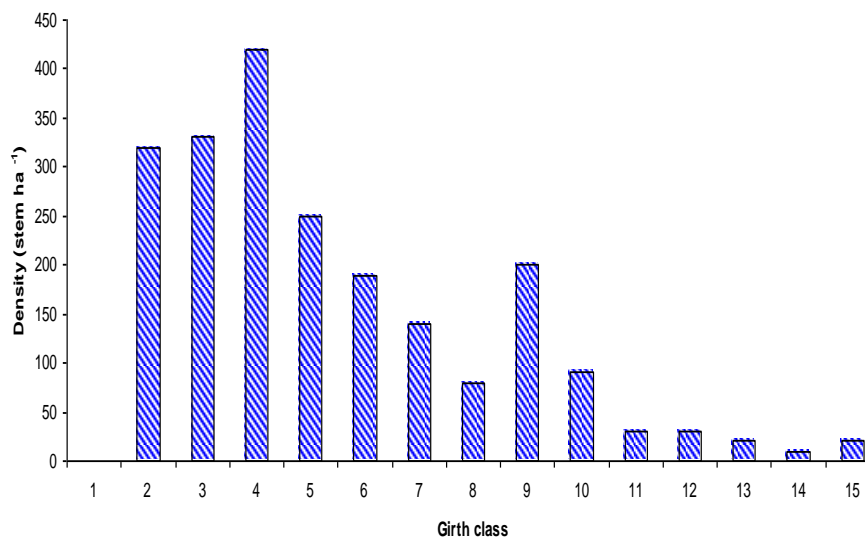
<i>Woodfordia fruticosa</i>	--	--	--	--	--	--	--	--	--	--	--	10	40	0.03	2.88	--	--	--	--	
<i>Ziziphus mauritiana</i>	20	30	0.33	4.45	--	--	--	--	20	20	0.50	8.15	--	--	--	--	--	--	--	
<i>Ziziphus xylopyrus</i>	20	20	0.25	3.83	30	30	0.34	6.88	--	--	--	--	10	10	0.01	1.7	--	--	--	
<b>Total</b>	<b>830</b>	<b>2130</b>	<b>50.90</b>	<b>300</b>	<b>680</b>	<b>1930</b>	<b>37.21</b>	<b>300</b>	<b>440</b>	<b>1030</b>	<b>30.02</b>	<b>300</b>	<b>790</b>	<b>2640</b>	<b>37.75</b>	<b>300</b>	<b>250</b>	<b>390</b>	<b>10.61</b>	<b>300</b>

**Table 2.** Diversity parameters of various forest fragments

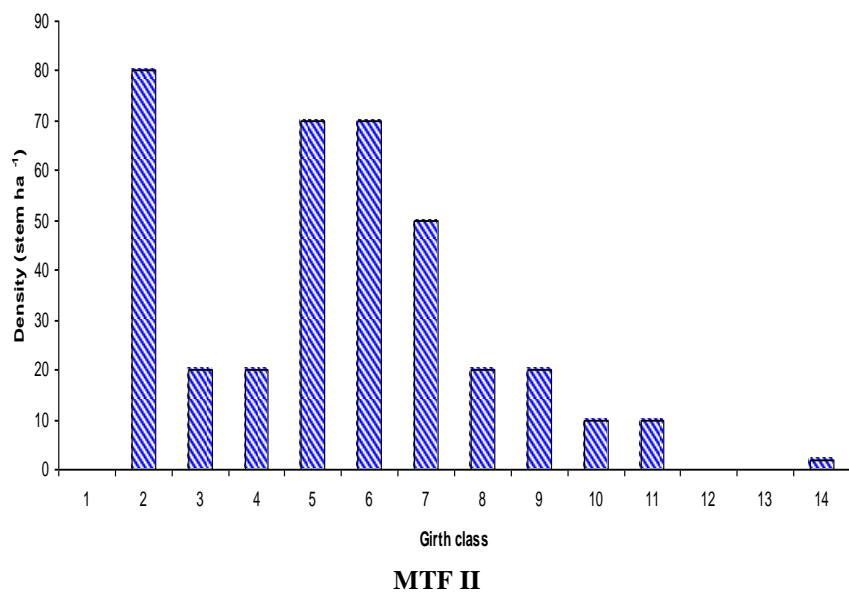
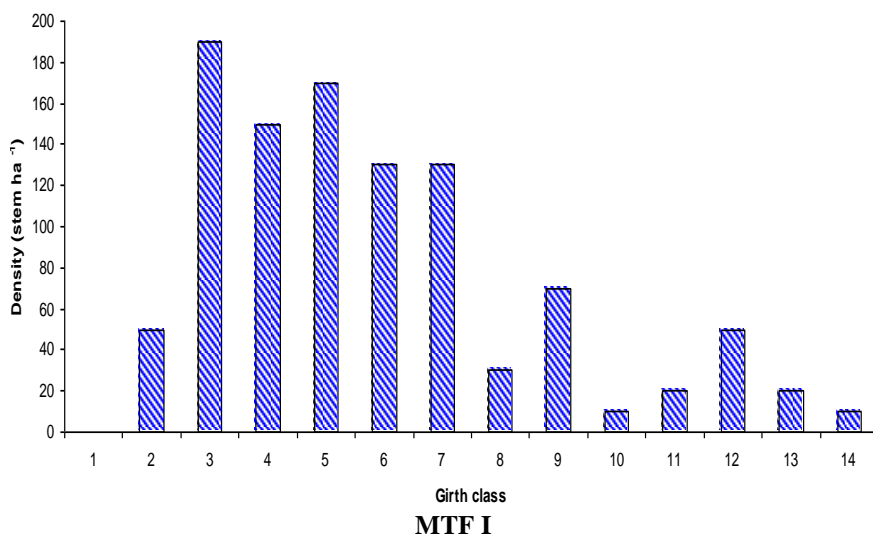
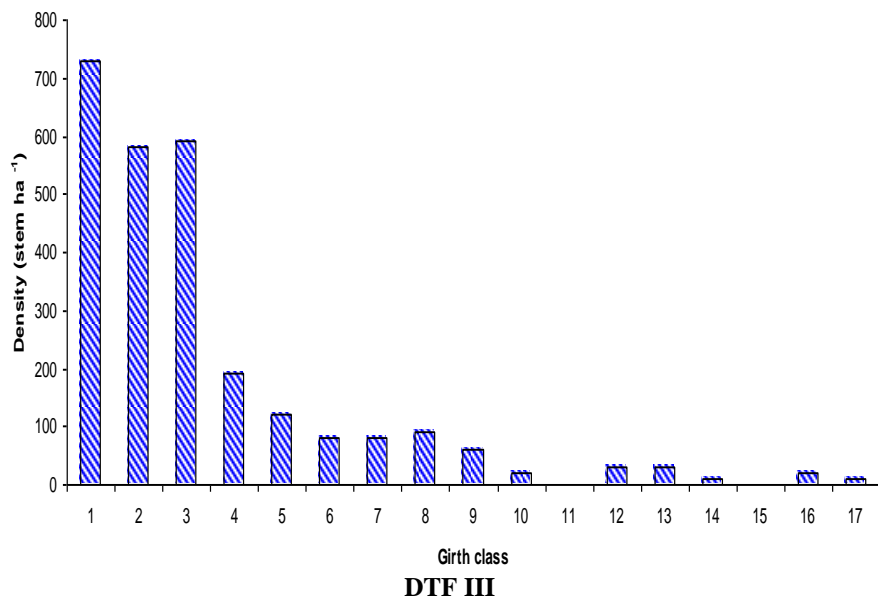
Parameters	DTF I	DTF II	DTF III	MTF I	MTF II
Species richness (d)	6.12	5.80	2.65	6.61	4.24
Shannon index (H')	3.62	3.42	2.39	2.42	2.99
Concentration of dominance (Cd)	1.0	0.12	0.22	1.00	0.17
Equitability (e)	1.12	1.11	1.04	0.75	1.25
Beta diversity (βd)	6.02	7.35	11.36	6.33	20.0



**DTF I**



**DTF II**



**Figure 1.** Woody species density and mean girth classes (cm) relationship: 1 ( $\leq 10$ ), 2 ( $>10 \leq 20$ ), 3 ( $>20 \leq 30$ )..... and so on

## CONCLUSION

The forest fragmentation significantly influenced the floristic structure, composition and diversity of studied sites. The increasing biotic interferences are degrading these forests and resulting in poor density, basal area and diversity. The changes in community and vegetation structure caused by disturbances have a significant effect on the ecosystem processes. Among the different forest fragments MTF II seems to be more affected as compared to other sites. Some species showed dominate position in forest stands, as revealed by the higher frequency, density and basal cover retained by them. If these species are protected or retained as such then it is possible to obtain long-term ecosystem services on sustainable basis. The study recommends adopting intensive conservation measures especially in degraded areas of the forest. Efforts are needed to regulate the biotic pressure in the vicinity of dwellings and protecting the forests would go a long way in rejuvenating the lost forest ecosystem.

## REFERENCES

- Alexander, H.M., Foster, B.L., Ballantyne, F. IV, Collins, C.D., Antonovics, J. and Holt, R.D.** (2012). Metapopulations and metacommunities: combining spatial and temporal perspectives in plant ecology. *J Ecol*, 100:88–103.
- Alone, R.A.** (2014). Biomass, carbon stock and carbon sequestration in an age series of teak plantation in tropical environment. Ph.D. Thesis, I.G.K.V., Raipur (C.G.), 240 p.
- Aksins** (1995). Speciation among tropical forest trees: some deductions in light of recent evidence. *Biol J Linn Soc*, 1:155-196.
- Apguaua, D.M.G., Pereira, R.M., Santos, G.C.O., Menino, G.G., Pires, M.A.L.F. and Dyp, T.N.G.** (2015). Floristic Variation within Seasonally Dry Tropical Forests of the Caatinga Biogeographic Domain, Brazil, and Its Conservation Implications. *Int For Rev*, 17(S2):33.
- Arisdason, W. and Lakshminarasimhan, P.** (2016). Status of Plant Diversity in India: An Overview. [http://www.bsienviis.nic.in/Database/Status\\_of\\_Plant\\_Diversity](http://www.bsienviis.nic.in/Database/Status_of_Plant_Diversity) in India 17566.aspx.
- Armesto, J.J., Mitzel, J.D. and Villagram, C.** (1986). A comparison of spatial patterns of trees in some tropical and temperate forests. *Biotropica*, 18:1-11.
- Baisya, R., Barik, S.K. and Upadhyay, K.** (2009). Distribution pattern of above ground biomass in natural and plantation forests of humid tropics in NE-India. *Tropical Ecology*, 50(2):295-304.
- Bargali, S.S., Pandey, V.P. and Bargali, K.** (2014). Floral composition and diversity pattern in open and closed dry deciduous forest. *Vegetos*, 27(2):149-157.
- Bhat, D.M., Naik, M.B., Patagar, S.G., Hegde, G.T., Kandade, Y.G., Hegde, G.N., Shastri, C.M., Shetti, D.M. and Furtado, R.M.** (2000). Forest dynamics in tropical rain forests of Uttara Kannada district in Western Ghats, India. *Current Science*, 79:975-985.
- Bihn, J.H., Verhaagh, M., Brandle, M. and Brandl, R.** (2008). Do secondary forests act as refuges for old growth forest animals? Recovery of ant diversity in the Atlantic forest of Brazil. *Biol Conserv*, 141:733-743.
- Black, G.A., Dobzhansky, T. and Pavan, C.** (1950). Some attempts to estimate species diversity and population density of trees in Amazonian forests. *Bot Gaz*, 111:413-425.
- Borah, N., Nath, A.J. and Das, A.K.** (2013). Aboveground biomass and carbon stocks of tree species in tropical forests of Cachar districts, Assam, Northeast India. *International Journal of Ecology and Environment Sciences*, 39(2):97-106.
- Cairns, M.A., Haggerty, P.K., Alvarez, R., De Jong, B.H.J. and Olmsted, I.** (2000). Tropical Mexico's recent land use and change: a region's contribution to the global carbon cycle. *Ecological Applications*, 10:1426-1441.
- Cairns, M.A., Olmsted, I., Granados, J. and Argaez, J.** (2003). Composition and aboveground tree biomass of a dry semi-evergreen forest on Mexico's Yucatan peninsula. *Forest Ecology and Management*, 186:125-132.
- Champion, H.G. and Seth, S.K.** (1968), *A revised Survey of the Forest Types of India*. Government of India Publication, New Delhi.
- Chauhan, D.S., Singh, B., Chauhan, S., Dhanai, C.S. and Todaria, N.P.** (2010). Regeneration and plant diversity of natural and planted sal (*Shorea robusta* Gaertn.F.) forests in the Terai Bhabhar of Sohagibarwa Wildlife Sanctuary, India. *J. American Science*, 6(3):32-45.
- Collinge, S.K.** (2009). *Ecology of fragmented landscapes*. Johns Hopkins University Press, Baltimore.
- Collins, C.D., Holt, R.D. and Foster, B.L.** (2009). Patch size effects on plant species decline in an experimentally fragmented landscape. *Ecology*, 90:2577–2588.
- Curtis, J.T. and McIntosh, R.P.** (1950). The interrelations of certain analytic and synthetic phytosociological characters. *Ecology*, 31:434-455.
- Devagiri, G.M., Money, S., Singh, S., Dadhawal, V.K., Patil, P., Khaple, A. and Hubballi, S.** (2013). Assessment of above ground biomass and carbon pool in different vegetation types of south western part of Karnataka, India using spectral modeling. *Tropical Ecology*, 54(2):149-165.
- Gairola, S., Sharma, C.M., Ghildiyal, S.K. and Suyal, S.** (2011). Live tree biomass and carbon variation along an altitudinal gradient in moist

- temperate valley slopes of the Garhwal Himalaya (India). *Current Science*, 100(10):1-9.
- Gandiwa, P., Finch, J. and Hill, T.** (2016). Vegetation structure and composition in the semi-arid Mapungubwe Cultural Landscape. *Glob J Environ Sci Manag*, 2(3):235-248.
- Haddad, N.M., Brudvig, L.A., Clobert, J., Davies, K.F., Gonzalez, A., Holt, R.D., Lovejoy, T.E., Sexton, J.O., Austin, M.P., Collins, C.D., Cook, W.M., Damschen, E.I., Ewers, R.M., Foster, B.L., Jenkins, C.N., King, A.J., Laurance, W.F., Levey, D.J., Margules, C.R., Melbourne, B.A., Nicholls, A.O., Orrock, J.L., Song, D.X. and Townshend, J.R.** (2015). Habitat fragmentation and its lasting impact on Earth's ecosystems. *Sci Adv*, 1:e1500052.
- Hoover, C.M., Leak, W.B. and Keel, B.G.** (2012). Benchmark carbon stocks from old growth forests in Northern New England, USA. *Forest Ecology and Management*, 266:108-114.
- Jha, C.S.** (1990). Land use and vegetation analysis of dry tropical forest region. Ph.D. Thesis, Banaras Hindu University, Varanasi, India.
- Jha, C.S. and Singh, J.S.** (1990). Composition and dynamics of dry tropical forest in relation to soil texture. *J Veg Sci*, 1:609-614.
- Jhariya, M.K.** (2010). Analysis of vegetational structure, diversity and fuel load in fire affected areas of tropical dry deciduous forests in Chhattisgarh. M.Sc. Thesis, I.G.K.V., Raipur (C.G.), 86 p.
- Jhariya, M.K., Bargali, S.S., Swamy, S.L. and Kittur, B.** (2012). Vegetational Structure, Diversity and Fuel Load in Fire Affected Areas of Tropical Dry Deciduous Forests in Chhattisgarh. *Vegetos*, 25(1):210-224.
- Jhariya, M.K., Bargali, S.S., Swamy, S.L., Kittur, B., Bargali, K. and Pawar, G.V.** (2014). Impact of forest fire on biomass and Carbon storage pattern of Tropical Deciduous Forests in Boramdeo Wildlife Sanctuary, Chhattisgarh. *Int J of Ecol Environ Sci*, 40(1):57-74.
- Jhariya, M.K.** (2014). Effect of forest fire on microbial biomass, storage and sequestration of carbon in a tropical deciduous forest of Chhattisgarh. Ph.D. Thesis, I.G.K.V., Raipur (C.G.), 259 p.
- Jhariya, M.K. and Yadav, D.K.** (2016). Understorey Vegetation in Natural and Plantation Forest Ecosystem of Sarguja (C.G.), India. *Journal of Applied and Natural Science*, 8(2):668-673.
- Jhariya, M.K.** (2017a). Vegetation ecology and carbon sequestration potential of shrubs in tropics of Chhattisgarh, India. *Environmental Monitoring and Assessment*, 189(10): 1-15. 518, <https://doi.org/10.1007/s10661-017-6246-2>.
- Jhariya, M.K.** (2017b). Influences of Forest Fire on Forest Floor and Litterfall in Boramdeo Wildlife Sanctuary (C.G.), India. *Journal of Forest and Environmental Science*, 33(4):330-341.
- Jhariya, M.K. and Yadav, D.K.** (2018). Biomass and carbon storage pattern in natural and plantation forest ecosystem of Chhattisgarh, India. *Journal of Forest and Environmental Science*, 34(1):1-11. DOI: 10.7747/JFES.2018.34.1.1.
- Jhariya, M.K., Banerjee, A., Meena, R.S. and Yadav, D.K.** (2019). Sustainable Agriculture, Forest and Environmental Management. Springer Nature Singapore Pte Ltd., 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore. eISBN: 978-981-13-6830-1, Hardcover ISBN: 978-981-13-6829-5. DOI: 10.1007/978-981-13-6830-1. Pp. 60.
- Kagezi, G.H., Kaib, M., Nyeko, P., Bakuneeta, C., Schadler, M., Stadler, J. and Brandl, R.** (2016). Impacts of land-use intensification on litter decomposition in western Kenya. *Web Ecol*, 16:51-58.
- Khurana, P.** (2007). Tree layer analysis and regeneration in tropical dry deciduous forest of Hastinapur. *Indian Forester*, 16(1):43-50.
- Krishnamurthy, Y.L., Prakasha, H.M., Nanda, A., Krishnappa, M., Dattaraja, H.S. and Suresh, H.S.** (2010). Vegetation structure and floristic composition of a tropical dry deciduous forest in Bhadra Wildlife Sanctuary, Karnataka, India. *Trop Ecol*, 51(2):235-246.
- Kumar, A., Jhariya, M.K., Yadav, D.K. and Banerjee, A.** (2017). Vegetation Dynamics in Bishrampur Collieries of Northern Chhattisgarh, India: Eco-restoration and Management Perspectives. *Environmental Monitoring and Assessment*, 189(8), DOI: 10.1007/s10661-017-6086-0.
- Kumar, J.I.N., Kumar, R.N., Bhoi, R.K. and Sajish, P.R.** (2010). Tree species diversity and soil nutrient status in three sites of tropical dry deciduous forest of western India. *Tropical Ecology*, 51(2):273-279.
- Laurance, W.F.** (1999). Ecology and management of fragmented tropical landscapes - introduction and synthesis. *Biol Conserv*, 91:101-107.
- Lieberman, D.** (1979). Dynamics of forest and thicket vegetation on the Accra plains, Ghana. Ph.D. Thesis, University of Ghana, Legon.
- Majumdar, K. and Datta, B.K.** (2015). Vegetation types, dominant compositions, woody plant diversity and stand structure in Trishna Wildlife Sanctuary of Northeast India. *J Env Bio*, 36:409-418.
- Metzker, T., Sposito, T.C., Martins, M.T.F., Horta, M.B. and Garcig, Q.S.** (2011). Forest dynamics and carbon stocks in Rio Doce state park an Atlantic rainforest hotspot. *Current Science*, 100(12):1855-1862.
- Mohanraj, R., Saravanan, J. and Dhanakumar, S.** (2011). Carbon stock in Kolli forests, Eastern Ghat (India) with emphasis on aboveground biomass, litter, woody debris and soil. *Forest Biogeosciences and Forestry*, 4, 61-65.
- Murphy, P.G. and Lugo, A.E.** (1986a). Ecology of tropical dry forest. *Annual Review of Ecology and Systematics*, 17, 67-88.

- Murphy, P.G. and Lugo, A.E.** (1986b). Structure and biomass of a subtropical dry forest in Puerto Rico. *Biotropica*, 18:89-96.
- Mutiso, F.M., Mugo, M.J., Cheboiwo, J., Sang, F. and Tarus, G.K.** (2015). Floristic Composition, Affinities and Plant Formations in Tropical Forests: A Case Study of Mau Forests in Kenya. *Int J Agric For*, 5(2):79-91.
- Naidu, M.T. and Kumar, O.A.** (2016). Tree diversity, stand structure, and community composition of tropical forests in Eastern Ghats of Andhra Pradesh, India. *J Asia Pac Biodivers*, 9:328-334.
- Nascimento, H.E.M. and Laurance, W.F.** (2002). Total aboveground biomass in central Amazonian rainforests: a landscape-scale study. *Forest Ecology and Management*, 168(1/3):311-321.
- Nilroung, S.** (1986). Structural characteristics, Rate of Gap Formation and Turnover Rate in Dry Dipterocarp Forest at Sakaerat. M.Sc. Thesis, Kasetsart University (in Thai).
- Nobel, I.R. and Dirzo, R.** (1997). Forests as human-dominated ecosystems. *Science*, 277:522-525.
- Oraon, P.R., Singh, L. and Jhariya, M.K.** (2014). Variations in Herbaceous Composition of Dry Tropics Following Anthropogenic Disturbed Environment. *Current World Environ*, 9(3):967-979.
- Oraon, P.R., Singh, L. and Jhariya, M.K.** (2015). Shrub Species Diversity in Relation to Anthropogenic Disturbance of Boramdeo Wildlife Sanctuary, Chhattisgarh. *Environment and Ecology*, 33(2A):996-1002.
- Panda, P.C., Mahapatra, A.K., Acharya, P.K. and Debata, A.K.** (2013). Plant diversity in tropical deciduous forests of Eastern Ghats, India: A landscape level assessment. *Int J Biodivers Conserv*, 5(10):625-639.
- Pande, P.K. and Patra, A.K.** (2010). Biomass and productivity in Sal and miscellaneous forests of Satpura plateau (Madhya Pradesh) India. *Advances in Bioscience and Biotechnology*, 1:30-38.
- Pawar, G.V., Singh, L., Jhariya, M.K. and Sahu, K.P.** (2014). Assessment of Diversity along the Disturbance Gradient in Dry Tropics of Chhattisgarh, India. *The Ecoscan*, 8(3-4):225-233.
- Phillips, E.A.** (1959). *Methods of Vegetation Study*. Holt R and Winston, New York USA. 105 p.
- Pimm, S.L. and Raven, P.** (2000). Biodiversity: extinction by numbers. *Nature*, 403:843-845.
- Prasad, R. and Pandey, R.K.** (1992). An observation on plant diversity of Sal and teak forest in relation to intensity of biotic impact of various distances from habitation in Madhya Pradesh, A case study. *Journal of Tropical Forestry*, 8(1):62-83.
- Puyravaud, J.P., Davidar, P. and Laurance, W.F.** (2010). Cryptic loss of India's native forests. *Conserv Lett*, 3(6):390-394.
- Ramirez-Marcial, N., Gonzalez-Espinosa, M. and Williams-Linera, G.** (2001). Anthropogenic disturbance and tree diversity in montane rain forest in Chiapas, Mexico. *For Ecol Manage*, 154:311-326.
- Rawat, V.S.** (2012). Litter fall and soil nutrient returns in community managed forest in Lamgara block of Uttarakhand. *Nature and Science*, 10(12):38-42.
- Richards, P.W.** (1996). *The tropical rainforest*. 2<sup>nd</sup> ed. Cambridge Univ. Press, Cambridge.
- Richards, P.W.** (2002). Composition of primary rain forest (II). In: Chazdon, R.L., Whitmore, T.C. (Eds.) *Foundations of Tropical Forest Biology*. The University of Chicago Press, Chicago and London, pp. 538-544.
- Rodgers, W.A.** (1990). A preliminary ecological survey of Algal spring Sariska Tiger Reserve, Rajasthan. *Journal of Bombay Natural History Society*, 87:201-209.
- Sagar, R. and Singh, J.S.** (1999). Species diversity and its measurement. *The Botanica*, 49:9-16.
- Sagar, R. and Singh, J.S.** (2003). Predominant phenotypic traits of disturbed tropical dry deciduous forest vegetation in northern India. *Community Ecology*, 4:63-71.
- Sahunalu, P., Chamrenpruk, M., Puriyakorn, B., Dhanmanonda, P., Suwannapin, W. and Prachaiya, B.** (1979). Structure of three forest types in the Prom Basin, Chaiyaphum province. *Forest Research Bulletin No. 63*, Faculty of Forestry, Kasetsart University (in Thai).
- Sharma, C.M., Baduni, N.P., Gairola, S., Ghildiyal, S.K. and Suyal, S.** (2010). Tree diversity and carbon stocks of some major forest types of Garhwal Himalaya, India. *Forest Ecology and Management*, 260(12):2170-2179.
- Singh, J.S.** (2002). The biodiversity crisis: a multifaceted review. *Current Science*, 82:638-647.
- Singh, J.S., Saxena, A.K. and Rawat, Y.S.** (1984). India's silent valley and its threatened rain forests ecosystem. *Environmental Conservation*, 11:223-233.
- Singh, L. and Singh, J.S.** (1991). Species structure, dry matter dynamics and carbon flux of a dry tropical forest in India. *Annals of Botany*, 68:263-273.
- Singh, L., Yadav, D.K., Pagare, P., Lekha, G. and Thakur, B.S.** (2009). Impact of land use changes on species structure, biomass and carbon storage in tropical deciduous forest and converted forest. *International Journal of Ecology and Environmental Sciences*, 35(1):113-119.
- Singh, P. and Dash, S.S.** (2014). Plant Discoveries 2013 – New Genera, Species and New Records. Botanical Survey of India, Kolkata.
- Smiet, A.C.** (1992). Forest Ecology on Java: human impact and vegetation of montane forest. *J Trop Ecol*, 8:129-152.
- Sundarapandian, S. and Karoor, P.J.** (2013). Edge effects on plant diversity in tropical forest ecosystems at Periyar Wildlife sanctuary in the Western Ghats of India. *J Forest Res*, 24(3):403-418.

- Swamy, S.L.** (1998). Estimation of net primary productivity (NPP) in an Indian tropical evergreen forest using Remote Sensing data. *Ph.D. Thesis*, Jawaharlal Nehru Technology University, Hyderabad.
- Tang, J.W., Yin, J.X., Qi, J.F., Jepsen, M.R. and Lu, X.T.** (2012). Ecosystem carbon storage of tropical forests over limestone in Xishuangbanna, SW China. *Journal of Tropical Forest Sciences*, 24(3):399-407.
- Thakur, T. and Swamy, S.L.** (2012). Analysis of land use, diversity, biomass, C and nutrient storage of a dry tropical forest ecosystem of India using satellite remote sensing and GIS techniques. In: Proceedings of the 15<sup>th</sup> International Forestry and Environment Symposium, 15:273- 278.
- Thinh, N.V., Mitlohner, R. and Bich, N.V.** (2015). Comparison of floristic composition in four sites of a tropical lowland forest on the North-Central Coast of Vietnam. *J Nat Sci*, 1(8):144.
- Tiwari, A.K.** (1994). Mapping forest biomass through digital processing of IRS-1A data. *International Journal of Remote Sensing*, 15(9):1849-1866.
- Thokchom, A. and Yadava, P.S.** (2013). Biomass and carbon stock assessment in the sub-tropical forests of Manipur, North-East India. *International Journal of Ecology and Environment Science*, 39(2):107-113.
- UNEP** (2001). India: State of the Environment - 2001. United Nations Environment Programme.
- Visaratana, T., Pitprecha, K., Kiratiprayoon, S., Kampan, T. and Higuchi, K.** (1986). Structural characteristics and species composition of dry Dipterocarp forest (*Dipterocarpus tuberculatus* Roxb. Community type) at Salak Phra Wildlife Sanctuary. Technical Paper No. 10 Forest Ecology Section, FRd (in Thai).
- Wu, J.G.** (2013). Key concepts and research topics in landscape ecology revisited: 30 years after the Allerton Park workshop. *Landsc Ecol*, 28:1-11.
- WWF** (2002). Forest management outside protected areas. World Wildlife Fund (WWF), Gland, Switzerland.
- Yadav, D.K. and Jhariya, M.K.** (2017). Tree Community Structure, Regeneration and Patterns of Diversity in Natural and Plantation Forest Ecosystem. *Research in Environment and Life Sciences*, 10(4):383-389.
- Yadav, D.K., Ghosh, L. and Jhariya, M.K.** (2017). *Forest Fragmentation and Stand Structure in Tropics: Stand Structure, Diversity and Biomass*. Lap Lambert Academic Publishing, Heinrich-Bocking-Str. 6-8, 66121, Saarbrücken, Germany. Pp. 116. ISBN: 978-3-330-05287-1.
- Yadav D.K., Jhariya, M.K. and Ghosh, L.** (2019). Vegetation inter-relationship and regeneration status in tropical forest stands of central India. *Journal of Plant Development Sciences*, 11(3):151-159.
- Yadava, P.S.** (2010). Soil and vegetation carbon pool and sequestration in the forest ecosystem of Manipur, NE India. Pages 163-170, In: Qasim SZ, Goel M. (Editors) CO<sub>2</sub> Sequestration Technology for Clean Energy. Daya Publication House, New Delhi.

## PERFORMANCE OF OSMO-PROTECTANTS AND ANTIOXIDANTS IN AMELIORATION OF TERMINAL HEAT STRESS IN WHEAT (*TRITICUM AESTIVUM* L.)

Shabnam\*, Rashpal Singh Sarlach<sup>2</sup> and Rohit Chhabra<sup>1</sup>

<sup>1</sup>Department of Botany, Punjab Agricultural University, Ludhiana, 141004

<sup>2</sup>Department of Plant Breeding & Genetics, Punjab Agricultural University, Ludhiana, 141004

Email: [shabnam-bot@pau.edu](mailto:shabnam-bot@pau.edu)

Received-02.04.2019, Revised-25.04.2019

**Abstract:** Terminal heat stress causes significant yield reduction in wheat (*Triticum aestivum* L.) due to rise in temperature. The present study on the performance of osmo-protectants and antioxidants on three wheat varieties was conducted at the experimental area of Department of Plant Breeding and Genetics, PAU, Ludhiana. Two foliar sprays of osmo-protectants (Salicylic acid, KNO<sub>3</sub> and ZnSO<sub>4</sub>.7H<sub>2</sub>O) and antioxidants (Ascorbic acid and arginine) excluding water were done at anthesis stage and ten days after anthesis stage. The data revealed that concentration of salicylic acid (75 µgml<sup>-1</sup>) had non-significant effect on wheat yield. KNO<sub>3</sub> and salicylic acid gave better yield as compared to all other treatments. Ascorbic acid and arginine proved significant in all the three varieties. It may be interpreted that osmo-protectants and antioxidants can neutralize heat stress. WH 1105 gave 7.7 percent higher yield than PBW 621 and 10.6 percent than PBW 550 in response to osmo-protectants and antioxidants application.

**Keywords:** Antioxidants, Osmo-protectants, Terminal Heat Stress, Yield, Wheat

### INTRODUCTION

Wheat is one of the premier cereal crops having worldwide importance and is grown under a wide range of climatic conditions. It is an important source of carbohydrates, nutrients, dietary fibre and essential amino acids. India is one of the major producers of wheat contributing about 30 per cent to the food basket for our countrymen (Meena *et al.*, 2013). In Punjab, it was grown on 35.38 lac hectares with a production of 16.80 million tonnes during 2013-14 (Anonymous 2014).

Increasing high temperature worldwide presents an alarming threat to wheat in India as late planting of wheat is very common in Punjab. As a result, wheat crop has to face the problem of terminal heat stress. Wheat crop is found to be sensitive to temperature during reproductive phase because it may affect the source – sink relationship and as a result the yield decreases. Accumulation of reactive oxygen species (ROS) as a result of high temperature stress is a major cause of loss of crop productivity worldwide. (Tuteja 2010). The rapid production and accumulation of reactive oxygen species has been induced by high temperature stress (Xu *et al.*, 2008). These high levels of ROS are harmful to all the cellular components and negatively influence cellular metabolic processes (Breusegem *et al.*, 2001). It causes series of morphological, anatomical and biochemical changes which affect plant growth and results in reduced yield. Membrane fluidity is the result of ethylene production and lipid peroxidation which is related to ROS formation (Weckx *et al.*, 1989). In mature wheat plants, increased ethylene has been recorded to shorten the grain filling period,

decreases kernel weight, hasten maturity and trigger premature senescence (Beltrano *et al.*, 1999).

There are various methods to reduce high temperature stress in plants. Several osmo-protectants have been reported for alleviating abiotic stress in wheat. Among them, foliar application of, or pre-sowing seed treatment with low concentrations of inorganic salts, osmo-protectants, PGR's and oxidants (e.g., H<sub>2</sub>O<sub>2</sub>) as well as preconditioning of plants are common approaches (Wahid *et al.*, 2007). Foliar application of salicylic acid at 50µgml<sup>-1</sup> and KNO<sub>3</sub> at 2% recorded the maximum heads per meter square, seeds per head, thousand seed weight, seed yield and seed quality in berseem which were significantly higher than the control (Kumar *et al.*, 2013). Heat stress triggers the production and accumulation of ROS (Almeselmani *et al.*, 2009). Hence their detoxification by antioxidant systems is important for protecting plants against heat stress (Suzuki *et al.*, 2013). Farouk (2011) reported that ascorbic acid and α-tocopherol sprayed plants postponed the leaf senescence by peroxide/ phenolic/ ascorbate system which is involved in scavenging the reactive oxygen species (ROS) (Asthir *et al.*, 2009) produced during leaf senescence. Previous studies are reported that, exogenous applications of abscisic acid (AA) decreased adverse effects of various stress conditions including heat stress in rice, sunflower, bean, mungbean and wheat (Dolatabadian and Jouneghani 2009, Kumar *et al.*, 2011, Shah *et al.* 2011, Dwivedi *et al.*, 2012 and Malik and Ashraf 2012). Hence, the present study was undertaken to focus on osmo-protectants and antioxidants as an effective tool to improve terminal heat stress tolerance in wheat.

\*Corresponding Author

## METHODOLOGY

The present study was conducted at experimental area of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana during *rabi* 2014-15 in loamy soil. The bulk density of soil was 1.6 gm/cubic cm, low in potassium, optimum in phosphorus and moderate in nitrogen. The pH of soil was 7.8. The treatment of three osmo-protectants (Salicylic acid @ 50 µg ml<sup>-1</sup> and 75 µg ml<sup>-1</sup>), (KNO<sub>3</sub> @ 0.5 and 1.0 percent) and (ZnSO<sub>4</sub>.7H<sub>2</sub>O @ 0.5 & 1.0 percent) and two antioxidants (Ascorbic acid @ 100 µg ml<sup>-1</sup> and 200 µg ml<sup>-1</sup>), Arginine (1.0 mM) and Arginine (2.0 mM), excluding control (unsprayed) and water treatment were given to three wheat varieties namely PBW 550, PBW 621 and WH 1105. The crop was sown in a randomized block design with three replications using 100 kg seed rate per hectare at 20.0 cm row spacing. One third nitrogen, full phosphorus and potash were applied to the seed at the time of sowing and were sown by *kerā* (dropping of seed in the open furrow). The seeds were treated with thiram @ 1.0g/kg seed against the seed borne diseases. The weeds were controlled by spraying weedicide and the crop was irrigated five times. Two foliar sprays of osmo-protectants and antioxidants were done when the crop reached at anthesis stage and ten days after anthesis stage. The following yield parameters were recorded viz; Spikelets per spike, Grains per spike, Grain yield (q/ha), Harvest Index were recorded. Leaf area was measured from three leaves per replication of each genotype for given treatments at 60, 90 and 120 DAS by using CI 203 Portable leaf area meter.

### Statistical Analysis

The statistical analysis was carried out with CPCS-1 software using factorial RBD design.

### Agrometeorological data

The meteorological data for the experimental period was attained from School of Agricultural Meteorology, PAU, Ludhiana (Appendix 1).

## RESULTS AND DISCUSSIONS

### Leaf area

Leaf area is one of the most important variables affecting light interception and hence affects photosynthesis and carbohydrate production. Among foliar applications of osmo-protectants, maximum leaf area was recorded in WH 1105 (13.4 cm<sup>2</sup>, 35.5 cm<sup>2</sup> and 38.1 cm<sup>2</sup>) and minimum leaf area was recorded in PBW 621 (11.3 cm<sup>2</sup>, 28.6 cm<sup>2</sup> and 29.6 cm<sup>2</sup>) at 60, 90 and 120 DAS respectively. The spray of KNO<sub>3</sub> (0.5%) gave maximum leaf area (38.0 cm<sup>2</sup>) and significantly more than the rest of the treatments. The minimum leaf area was obtained in control plot (32.3 cm<sup>2</sup>) at 120 DAS. On leaf area at 120 DAS, non-significant interaction between varieties and foliar sprays was recorded (Table 1). The maximum leaf area was recorded in PBW 621 (15.5 cm<sup>2</sup>) at 60

DAS, in PBW 550 (32.4 cm<sup>2</sup>) at 90 DAS and in WH 1105 (36.6 cm<sup>2</sup>) on 120 DAS and minimum leaf area was recorded in PBW 550 (12.4 cm<sup>2</sup>) at 60 DAS, in PBW 621 (28.0 cm<sup>2</sup> and 29.7 cm<sup>2</sup>) at both 90 and 120 DAS.

Among the effect of foliar sprays of antioxidants, the spray of ascorbic acid at 200 µg ml<sup>-1</sup> gave maximum leaf area (35.7 cm<sup>2</sup>) and significantly more than the rest of the treatments. The minimum leaf area was obtained in control plot (33.9 cm<sup>2</sup>) at 120 DAS. On leaf area at 120 DAS, a significant interaction was recorded (Table 2). High temperature during wheat reproductive development hastens the decline in photosynthesis and leaf area, thus affecting water-use efficiency (Kumar *et al* 2011).

### Dry matter accumulation

Manipulation of dry matter accumulation by plant is the outcome of stress conditions. Under foliar application of osmo-protectants, maximum dry matter accumulation was recorded in PBW 621 (6.3 g, 13.5 g and 25.2 g) and minimum dry matter accumulation was recorded in PBW 550 (4.5 g, 12.2 g and 22.3 g) at 60, 90 and 120 DAS respectively (Table 3). Among the effect of foliar sprays of osmo-protectants, the spray of KNO<sub>3</sub> (0.5%) gave maximum dry matter accumulation (27.2 g) and significantly more than the rest of the treatments. The minimum dry matter accumulation was obtained by the application of ZnSO<sub>4</sub>.7H<sub>2</sub>O at 1% (19.1 g) at 120 DAS. On dry matter accumulation at 120 DAS, significant interaction was recorded.

Under foliar applications of antioxidants, maximum dry matter accumulation was recorded in PBW 621 (6.12 g, 13.9 g and 25.3 g) and minimum dry matter accumulation was recorded in PBW 550 (4.4 g, 11.7 g and 22.0 g) at 60, 90 and 120 DAS respectively. The spray of ascorbic acid at 200 µg ml<sup>-1</sup> gave maximum dry matter accumulation (27.2 g) and significantly more than the rest of the treatments. The minimum dry matter accumulation was obtained in control (19.0 g) at 120 DAS. On dry matter accumulation at 120 DAS, a significant interaction was recorded (Table 4). Thus, variation in dry matter accumulation is the outcome of abiotic stress conditions. Our findings are supported by Sarlach *et al* 2013.

### Number of spikelets per spike

Maximum of spikelets per spike were recorded in PBW 621 (18.9) and minimum number of spikelets per spike were recorded in PBW 550 (15.9). Non-significant difference and non-significant interaction was recorded among the treatments between the varieties and foliar sprays. It was observed that foliar sprays of osmo-protectants do not affect number of spikelets per spike much because with heat stress there was no decrease or increase in number of spikelets per spike (Table 5).

For effect of foliar sprays of antioxidants, maximum number of spikelets per spike was recorded in WH 1105 (18.6) and minimum number of spikelets per spike was

recorded in PBW 550 (15.8). Foliar spray of ascorbic acid at  $200 \mu\text{g ml}^{-1}$  showed maximum spikelets per spike (18.5), followed by arginine at 2.0 mM (18.0) and minimum was recorded under unsprayed (control) condition (Table 6). There was a significant interaction observed among varieties and foliar sprays on spikelets per spike. Sarlach *et al* (2013) reported that number of spikelet per spike determines the spike length and if all the spikelets are well filled, it helps in an increase in number of grains per spike.

#### Number of grains per spike

PBW 621 (50.0) gave significantly more number of grains per spike, followed by PBW 550 (41.2) than WH 1105 (36.4). Application of  $\text{KNO}_3$  at both the concentrations 0.5% and 1% produced maximum (48.0 and 46.1 respectively) and minimum was recorded by the application of both the concentrations of  $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$  (Table 5).

Foliar spray of Antioxidants revealed that, PBW 621 (50.1) gave significantly more number of grains per spike, followed by WH 1105 (45.8) than PBW 550 (39.2). Application of ascorbic acid at both the concentrations  $200 \mu\text{g ml}^{-1}$  and  $100 \mu\text{g ml}^{-1}$  produced maximum (50.8 and 48.9 respectively) and minimum (39.6) was recorded under unsprayed (control) condition (Table 6). Number of grains per spike reduced in heat stress environment it may be due to no formation of secondary grains because of heat stress. The grains per spike seemed to have decreased due to the sensitivity of the wheat plants to photoperiod and temperature. As the photoperiod and temperature increased, proper fertilization of the ovule may not have occurred to produce grains (Slafer and Whitechurch 2001). Laghari *et al* (2012) also reported reduction in grains per spike due to high temperature shocks.

#### Grain yield

Among varieties, PBW 621 and WH1105 were found statistically parbut significantly better than PBW 550. It may be attributed on account of duration of varieties. PBW 621 recorded 5.32 percent more yield than WH 1105 and 13.70 per cent than PBW 550. It is thus clear that PBW 621 and WH 1105 are considered suitable with respect to high yield level under timely sown wheat condition of punjab. The response of chemical treatment gave noticeable effect on grain yield. The  $\text{KNO}_3$  and salicylic acid spray gave better yield as compare to all the other treatments. However,  $\text{KNO}_3$  (0.5%) gave maximum grain yield (63.3 q/ha) which was found significantly superior than all other treatments except salicylic acid ( $50 \mu\text{gml}^{-1}$ ). The higher concentration of salicylic acid ( $75 \mu\text{gml}^{-1}$ ) proved not effective in increasing the wheat yield. It is thus clear that lower dose of salicylic acid and both the concentrations of  $\text{KNO}_3$  showed discernible response on wheat crop. The interaction among varieties and chemicals were found non-significant (Table 4.5-a).

Firstly, with the application of antioxidants, PBW 621 and WH 1105 were found statistically parbut

significantly better than PBW 550. WH 1105 gave 7.7 percent more yield than PBW 621 and 10.6 percent than PBW 550 (Table 4.5-b). It is thus clear that PBW 621 and WH 1105 are considered suitable with respect to high yield level under timely sown wheat condition of Punjab. The response of chemical treatment gave noticeable effect on grain yield. The ascorbic acid and arginine sprays gave better yield as compare to all the other treatments. However, Ascorbic acid @  $200 \mu\text{g ml}^{-1}$  gave maximum grain yield (53.8 q/ha) which was found significantly superior than all other treatments. The interaction among varieties and chemicals were found non-significant.

An increase in grain yield with the application of  $\text{KNO}_3$  might be due to availability of K from  $\text{KNO}_3$ , which has important role in growth and development of plant as it increases enzyme activity and photosynthesis, improve synthesis of protein, carbohydrates and fats and translocation of photosynthates from source to sink, maintenance of turgor and transpiration in cells under environmental stress conditions. The increment of yield under heat stress conditions by foliar application of  $\text{KNO}_3$  was also reported in Egyptian clover by Kumar *et al* (2013). Mandavia *et al* (2010) found that application of 50 and  $100 \mu\text{gml}^{-1}$  of salicylic acid as foliar spray at vegetative (40 days after sowing) and reproductive stage (55 days after sowing) on chickpea had significantly increased the seed yield as compared to control. A decrease in pod and grain yield under salicylic acid at  $100 \mu\text{gml}^{-1}$  in the study might be due to inhibition of foliar protein which leads to breakdown/degradation of chlorophyll (Kumar *et al* 2013). Mahajan *et al* (2012) reported that grain yield can be improved with single spray of 1%  $\text{KNO}_3$  at flowering stage in transplanted rice. Imas and Magen (2007) reported that potassium helps in photosynthesis, carbohydrate distribution and starch synthesis in storage organs which helps in high grain yield.

#### Harvest index

Non-significant difference was recorded among the varieties. Foliar sprays and varieties, non-significantly affected harvest index (Table 7). The results showed that application of different osmo-protectants influenced all yield related parameters under terminal heat stress in wheat. The response of chemical treatment gave noticeable effect on grain yield. The  $\text{KNO}_3$  (0.5 % and 1.0%) and salicylic acid ( $50 \mu\text{gml}^{-1}$ ) spray gave better yield as compare to all the other treatments. However,  $\text{KNO}_3$  (0.5%) gave maximum grain yield (63.33 q/ha) which was found significantly superior than all other treatments except salicylic acid ( $50 \mu\text{gml}^{-1}$ ). The higher concentration of salicylic acid ( $75 \mu\text{gml}^{-1}$ ) proved not effective in increasing the wheat yield. It is thus clear that lower dose of salicylic acid and both the concentrations of  $\text{KNO}_3$  showed discernible response on wheat crop. Foliar sprays and varieties non-significantly affected

harvest index with interaction among them. Our results are in accordance with findings of Sarlach *et al.*, 2013. Non-significant difference was recorded

among the varieties. Foliar sprays and varieties, non-significantly affected harvest index, with no interaction among them (Table 8).

**Table 1.** Influence of different osmo-protectants on leaf area in wheat (*Triticum aestivum* L.)

Treatment	Leaf Area (cm <sup>2</sup> )											
	60 DAS				90 DAS				120 DAS			
	PBW 550	PBW 621	WH 1105	MEAN	PBW 550	PBW 621	WH 1105	MEAN	PBW 550	PBW 621	WH 1105	MEAN
T1:- Salicylic acid (50µg ml <sup>-1</sup> )	12.0	11.0	14.0	<b>12.3</b>	38.0	29.0	38.0	<b>35.0</b>	38.0	30.0	40.0	<b>36.0</b>
T2:- Salicylic acid (75µg ml <sup>-1</sup> )	13.0	10.0	13.0	<b>12.0</b>	36.0	24.0	30.0	<b>30.0</b>	32.0	27.0	39.0	<b>32.7</b>
T3:- KNO <sub>3</sub> (0.5%)	14.0	12.0	14.0	<b>13.3</b>	39.0	31.0	44.0	<b>38.0</b>	38.0	34.0	42.0	<b>38.0</b>
T4:- KNO <sub>3</sub> (1%)	12.0	10.0	14.0	<b>12.0</b>	30.0	36.0	40.0	<b>35.3</b>	36.0	33.0	39.0	<b>36.0</b>
T5:- ZnSO <sub>4</sub> .7H <sub>2</sub> O (0.5%)	12.0	11.0	13.0	<b>12.0</b>	31.0	28.0	29.0	<b>29.3</b>	28.0	28.0	36.0	<b>30.7</b>
T6:- ZnSO <sub>4</sub> .7H <sub>2</sub> O (1%)	12.0	10.0	13.0	<b>11.7</b>	25.0	25.0	32.0	<b>27.3</b>	30.0	26.0	33.0	<b>29.7</b>
T7:- Water sprayed	14.0	13.0	14.0	<b>13.7</b>	34.0	29.0	38.0	<b>33.7</b>	37.0	32.0	39.0	<b>36.0</b>
T8:- Unsprayed (control)	13.0	13.0	12.0	<b>12.7</b>	35.0	27.0	33.0	<b>31.7</b>	33.0	27.0	37.0	<b>32.3</b>
<b>Mean</b>	<b>12.8</b>	<b>11.3</b>	<b>13.4</b>	<b>12.5</b>	<b>33.5</b>	<b>28.6</b>	<b>35.5</b>	<b>32.5</b>	<b>34.0</b>	<b>29.6</b>	<b>38.1</b>	<b>33.9</b>
<b>CD at 5%</b>	Varieties (A) = 0.6 Treatments (B) = NS A x B = 1.7				Varieties (A) = 1.3 Treatments (B) = 2.1 A x B = 3.6				Varieties (A) = 1.9 Treatments (B) = 3.1 A x B = NS			

**Table 2.** Influence of different antioxidants on leaf area in wheat (*Triticum aestivum* L.)

Treatments	Leaf Area (cm <sup>2</sup> )											
	60 DAS				90 DAS				120 DAS			
	PBW 550	PBW 621	WH 1105	Mean	PBW 550	PBW 621	WH 1105	Mean	PBW 550	PBW 621	WH 1105	Mean
T1- (Ascorbic acid 100 µgml <sup>-1</sup> )	13.7	10.8	13.1	<b>12.5</b>	37.8	30.4	27.0	<b>31.7</b>	35.6	29.2	37.1	<b>34.0</b>
T2- (Ascorbic acid 200 µgml <sup>-1</sup> )	11.9	11.8	12.8	<b>12.2</b>	36.2	27.4	31.7	<b>31.8</b>	38.9	30.8	37.5	<b>35.7</b>
T3- (Arginine 1.0 mM)	11.7	9.2	14.4	<b>11.8</b>	30.6	29.0	32.6	<b>30.7</b>	27.8	34.0	40.6	<b>34.1</b>
T4- (Arginine 2.0 mM)	12.4	9.93	14.1	<b>12.1</b>	34.0	29.1	34.1	<b>32.4</b>	30.9	32.9	38.7	<b>34.8</b>
T5- (Water sprayed)	12.0	10.8	13.5	<b>12.1</b>	30.3	26.4	31.9	<b>29.5</b>	33.6	27.6	42.3	<b>34.5</b>
T6- (Unsprayed control)	12.6	40.4	14.6	<b>22.6</b>	25.2	23.8	29.8	<b>26.3</b>	36.8	25.7	39.1	<b>33.9</b>
<b>Mean</b>	<b>12.4</b>	<b>15.5</b>	<b>13.7</b>	<b>13.9</b>	<b>32.4</b>	<b>28.0</b>	<b>33.8</b>	<b>31.4</b>	<b>33.7</b>	<b>29.7</b>	<b>36.6</b>	<b>33.3</b>
<b>CD at 5%</b>	Varieties (A) = 1.1 Treatments (B) = NS A x B = NS				Varieties (A) = 2.4 Treatments (B) = NS A x B = 3.4				Varieties (A) = 1.4 Treatments (B) = 2.0 A x B = 5.9			

**Table 3.** Effect of different concentrations of osmo-protectants on Dry Matter Accumulation (g) in wheat (*Triticum aestivum* L.)

Treatment	Dry Matter Accumulation (g/plant)											
	60 DAS				90 DAS				120 DAS			
	PBW 550	PBW 621	WH 1105	Mean	PBW 550	PBW 621	WH 1105	Mean	PBW 550	PBW 621	WH 1105	Mean
T1:- Salicylic acid (50µg ml <sup>-1</sup> )	4.5	6.4	6.1	<b>5.7</b>	11.2	14.1	14.3	<b>13.2</b>	23.6	27.6	23.3	<b>24.8</b>
T2:- Salicylic acid (75µg ml <sup>-1</sup> )	4.6	6.0	5.3	<b>5.3</b>	11.3	13.5	13.0	<b>12.6</b>	22.7	25.7	22.5	<b>23.6</b>
T3:- KNO <sub>3</sub> (0.5%)	4.6	6.7	5.7	<b>5.7</b>	12.4	15.2	15.1	<b>14.2</b>	27.1	28.1	26.5	<b>27.2</b>
T4:- KNO <sub>3</sub> (1%)	4.5	6.4	5.3	<b>5.4</b>	12.6	14.6	12.8	<b>13.4</b>	24.4	28.4	25.9	<b>26.2</b>
T5:- ZnSO <sub>4</sub> .7H <sub>2</sub> O (0.5%)	4.6	6.4	5.3	<b>5.4</b>	10.7	12.9	11.5	<b>12.3</b>	19.5	21.8	21.8	<b>21.0</b>
T6:- ZnSO <sub>4</sub> .7H <sub>2</sub> O (1%)	4.4	6.1	5.3	<b>5.3</b>	13.9	13.6	10.8	<b>12.7</b>	13.6	23.1	20.7	<b>19.1</b>

T7:- Water sprayed	4.5	6.2	5.3	<b>5.3</b>	15.4	12.8	12.5	<b>13.6</b>	24.8	24.6	24.4	<b>24.6</b>
T8:- Unsprayed (control)	4.6	6.2	5.5	<b>5.4</b>	10.2	11.8	11.4	<b>11.1</b>	22.9	22	22.5	<b>22.4</b>
<b>Mean</b>	<b>4.5</b>	<b>6.3</b>	<b>5.5</b>	<b>5.4</b>	<b>12.2</b>	<b>13.5</b>	<b>12.5</b>	<b>12.8</b>	<b>22.3</b>	<b>25.2</b>	<b>23.4</b>	<b>23.6</b>
<b>CD at 5%</b>	Varieties (A) = 0.2 Treatments (B) = NS 0A x B = NS				Varieties (A) = 0.7 Treatments (B) = NS A x B = NS				Varieties (A) = 1.1 Treatments (B) = 1.8 A x B = 3.0			

**Table 4:** Effect of different concentrations of ascorbic acid and arginine on Dry Matter Accumulation (g) in wheat (*Triticum aestivum* L.)

Treatment	Dry Matter Accumulation (g/plant)											
	60 DAS				90 DAS				120 DAS			
	PBW 550	PBW 621	WH 1105	Mean	PBW 550	PBW 621	WH 1105	Mean	PBW 550	PBW 621	WH 1105	Mean
T1- (Ascorbic acid 100 µgml <sup>-1</sup> )	4.6	6.4	6.2	<b>5.7</b>	12.4	14.1	11.8	<b>12.8</b>	24.8	27.6	25.9	<b>26.1</b>
T2- (Ascorbic acid 200 µgml <sup>-1</sup> )	4.5	6.0	6.2	<b>5.6</b>	12.6	13.5	12.8	<b>13.0</b>	27.1	28.1	26.4	<b>27.2</b>
T3- (Arginine 1.0 mM)	4.6	6.7	6.1	<b>5.8</b>	10.7	15.2	14.3	<b>13.4</b>	22.9	24.6	22.5	<b>23.3</b>
T4- (Arginine 2.0 mM)	4.4	6.4	5.3	<b>5.4</b>	13.8	14.6	13.0	<b>13.8</b>	24.4	25.7	23.3	<b>24.4</b>
T5- (Water sprayed)	4.1	5.6	5.1	<b>5.0</b>	9.8	12.9	12.8	<b>11.8</b>	19.5	24.0	21.8	<b>21.8</b>
T6- (Unsprayed control)	4.2	5.4	5.1	<b>4.9</b>	11.2	12.9	12.5	<b>12.2</b>	13.6	22.0	21.5	<b>19.0</b>
<b>Mean</b>	<b>4.4</b>	<b>6.1</b>	<b>5.7</b>	<b>5.4</b>	<b>11.7</b>	<b>13.9</b>	<b>12.9</b>	<b>12.8</b>	<b>22.0</b>	<b>25.3</b>	<b>23.6</b>	<b>23.6</b>
<b>CD at 5%</b>	Varieties (A) = 0.2 Treatments (B) = 0.3 A x B = NS				Varieties (A) = 0.9 Treatments (B) = 1.3 A x B = NS				Varieties (A) = 1.2 Treatments (B) = 1.7 A x B = 3.0			

**Table 5.** Effect of osmo-protectants on spikelets per spike and grains per spike in wheat (*Triticum aestivum* L.)

Treatments	Number of spikelets per spike				Number of grains per spike			
	PBW 550	PBW 621	WH 1105	Mean	PBW 550	PBW 621	WH 1105	Mean
T1- Salicylic acid (50µg ml <sup>-1</sup> )	15.0	19.0	18.0	<b>17.3</b>	43.7	49.3	36.8	<b>43.3</b>
T2- Salicylic acid (75µg ml <sup>-1</sup> )	16.0	18.0	17.0	<b>17.0</b>	44.3	49.0	36.8	<b>43.4</b>
T3- KNO <sub>3</sub> (0.5%)	16.0	20.0	20.0	<b>18.7</b>	45.7	57.7	40.7	<b>48.0</b>
T4- KNO <sub>3</sub> (1%)	16.0	19.0	19.0	<b>18.0</b>	42.3	57.0	39.1	<b>46.1</b>
T5- ZnSO <sub>4</sub> .7H <sub>2</sub> O (0.5%)	16.0	18.0	18.0	<b>17.3</b>	34.0	48.3	33.2	<b>38.5</b>
T6- ZnSO <sub>4</sub> .7H <sub>2</sub> O (1%)	16.0	19.0	17.0	<b>17.3</b>	35.3	46.0	32.9	<b>38.1</b>
T7- Water sprayed	16.0	19.0	17.0	<b>17.3</b>	43.3	49.0	36.6	<b>43.0</b>
T8- Unsprayed (control)	16.0	19.0	17.0	<b>17.3</b>	41.0	47.3	35.2	<b>41.2</b>
<b>Mean</b>	<b>15.9</b>	<b>18.9</b>	<b>17.9</b>	<b>17.5</b>	<b>41.2</b>	<b>50.5</b>	<b>36.4</b>	<b>42.7</b>
<b>CD 5%</b>	Varieties (A) = 0.6 Treatments (B) = NS A x B = NS				Varieties (A) = 2.3 Treatments (B) = 3.7 A x B = NS			

**Table 6.** Effect of ascorbic acid and arginine on spikelets per spike and grains per spike weight in wheat (*Triticum aestivum* L.)

Treatment	No. of spikelets per spike				No. of grains per spike			
	PBW 550	PBW 621	WH 1105	Mean	PBW 550	PBW 621	WH 1105	Mean
T1- (Ascorbic acid 100 µgml <sup>-1</sup> )	16.1	18.1	19.1	<b>17.8</b>	42.3	57.0	47.3	<b>48.9</b>
T2- (Ascorbic acid 200 µgml <sup>-1</sup> )	16.3	19.1	20.2	<b>18.5</b>	45.7	57.7	49.0	<b>50.8</b>
T3- (Arginine 1.0 mM)	15.7	17.8	18.5	<b>17.3</b>	38.3	49.0	45.7	<b>44.3</b>
T4- (Arginine 2.0 mM)	15.9	18.7	19.5	<b>18.0</b>	39.3	49.3	47.0	<b>45.2</b>
T5- (Water sprayed)	15.4	17.5	17.3	<b>16.8</b>	35.3	45.0	43.8	<b>41.4</b>
T6- (Unsprayed control)	15.2	17.2	17.3	<b>16.6</b>	34.0	42.7	42.2	<b>39.6</b>
<b>Mean</b>	<b>15.8</b>	<b>18.1</b>	<b>18.6</b>	<b>17.5</b>	<b>39.2</b>	<b>50.1</b>	<b>45.8</b>	<b>45.0</b>
<b>CD at 5%</b>	Varieties (A) = 0.4 Treatments (B) = 0.6 A x B = 1.0				Varieties (A) = 2.4 Treatments (B) = 3.4 A x B = 5.8			

**Table 7.** Performance of different osmo-protectants on grain yield and harvest index in wheat (*Triticum aestivum* L.)

Treatments	Grain yield (q/ha)				Harvest index			
	PBW 550	PBW 621	WH 1105	Mean	PBW 550	PBW 621	WH 1105	Mean
T1- Salicylic acid (50µg ml <sup>-1</sup> )	52.0	66.0	59.0	<b>59.0</b>	0.4	0.4	0.4	<b>0.4</b>
T2- Salicylic acid (75µg ml <sup>-1</sup> )	49.0	57.0	51.0	<b>52.3</b>	0.4	0.4	0.3	<b>0.4</b>
T3- KNO <sub>3</sub> (0.5%)	55.0	68.0	67.0	<b>63.3</b>	0.4	0.4	0.4	<b>0.4</b>
T4- KNO <sub>3</sub> (1%)	57.0	61.0	58.0	<b>58.7</b>	0.4	0.4	0.4	<b>0.4</b>
T5- ZnSO <sub>4</sub> .7H <sub>2</sub> O (0.5%)	47.0	47.0	46.0	<b>46.7</b>	0.3	0.3	0.3	<b>0.3</b>
T6- ZnSO <sub>4</sub> .7H <sub>2</sub> O (1%)	40.0	50.0	43.0	<b>44.3</b>	0.3	0.3	0.3	<b>0.3</b>
T7- Water sprayed	50.0	52.0	52.0	<b>51.3</b>	0.4	0.3	0.3	<b>0.3</b>
T8- Unsprayed (control)	51.0	55.0	57.0	<b>54.3</b>	0.3	0.3	0.3	<b>0.3</b>
<b>Mean</b>	<b>50.1</b>	<b>57.0</b>	<b>54.1</b>	<b>53.7</b>	<b>0.4</b>	<b>0.4</b>	<b>0.3</b>	<b>0.3</b>
<b>CD 5%</b>	Varieties (A) = 3.1 Treatments (B) = 5.1 A x B = NS				Varieties (A) = NS Treatments (B) = 0.03 A x B = 0.05			

**Table 8.** Performance of different antioxidants on straw grain yield and harvest index in wheat (*Triticum aestivum* L.)

Treatments	Grain yield (q/ha)				Harvest index			
	PBW 550	PBW 621	WH 1105	Mean	PBW 550	PBW 621	WH 1105	Mean
T1- (Ascorbic acid 100 µgml <sup>-1</sup> )	53.1	51.5	57.4	<b>54.0</b>	0.3	0.3	0.4	<b>0.4</b>
T2- (Ascorbic acid 200 µgml <sup>-1</sup> )	50.9	51.6	57.6	<b>53.8</b>	0.4	0.3	0.4	<b>0.4</b>
T3- (Arginine 1.0 mM)	51.1	53.5	56.6	<b>53.5</b>	0.3	0.4	0.4	<b>0.4</b>
T4- (Arginine 2.0 mM)	50.9	53.9	56.2	<b>53.0</b>	0.3	0.3	0.4	<b>0.3</b>
T5- (Water sprayed)	46.3	51.2	52.3	<b>49.9</b>	0.4	0.4	0.3	<b>0.4</b>
T6- (Unsprayed control)	46.4	45.0	49.0	<b>46.8</b>	0.4	0.3	0.3	<b>0.4</b>
<b>Mean</b>	<b>49.8</b>	<b>51.2</b>	<b>55.1</b>	<b>52.0</b>	<b>0.3</b>	<b>0.3</b>	<b>0.4</b>	<b>0.4</b>
<b>CD at 5%</b>	Varieties (A) = 1.7 Treatments (B) = 2.4 A x B = NS				Varieties (A) = NS Treatments (B) = NS A x B = 0.06			

**Appendix 1.** Meteorological data during experimental period at PAU, Ludhiana

Month	Standard week	Temp (°C)			Normal Temp (°C)			RH (%)	Total rainfall (mm)	No. of rainy days	Pan evaporation (mm)	Sun-shine hours
		Max.	Min.	Mean	Max.	Min.	Mean					
October	44	29.1	14.1	21.6	29.5	12.8	21.2	64	0	0	22.2	7.2
November	45	28.7	14.2	21.4	28.1	11.3	19.7	63	0	0	17.2	5.5
	46	26.1	8.9	17.5	27.1	10.3	18.7	61	0	0	17.6	8.1
	47	25.4	8.3	16.8	25.3	8.8	17.1	63	0	0	14.8	7.7

	48	26.2	9.8	18.0	23.8	7.4	15.6	66	0	0	14.0	7.4
December	49	25.1	7.7	16.4	22.9	6.4	14.7	68	0	0	15.0	7.9
	50	18.6	7.2	12.9	21.6	6.3	14.0	76	42.2	1	11.2	4.0
	51	12.5	6.9	9.7	20.7	5.6	13.2	88	0	0	5.4	1.4
	52	13.3	5.2	9.3	19.1	5.9	12.5	89	0	0	6.2	1.8
January	1	16.2	8.2	12.2	19.1	5.0	12.1	86	0.4	0	7.2	0.9
	2	13.3	7.3	10.3	18.9	5.1	12.0	87	4.6	1	6.1	0.3
	3	17.4	6.2	11.8	19.1	5.0	12.1	83	6.2	1	7.2	5.7
	4	14.7	7.7	11.2	19.8	6.0	12.9	87	14.6	1	6.0	3.1
February	5	18.6	7.1	12.9	19.6	6.0	12.8	77	11.6	1	13.2	5.9
	6	20.9	7.2	14.1	20.9	6.2	13.6	77	0	0	13.6	7.4
	7	23.9	11.2	17.5	21.6	7.9	14.8	77	8.4	1	17.2	5.8
	8	23.5	14.5	19.0	22.3	7.7	15.0	86	19.0	3	15.4	3.7
March	9	20.3	10.6	15.5	23.9	8.8	16.4	80	24.8	2	14.8	8.3
	10	22.5	9.2	15.8	25.4	10.1	17.8	78	8.2	1	16.4	8.2
	11	24.1	12.5	18.3	27	11.2	19.1	78	36.2	3	18.5	6.1
	12	29.0	15.2	22.1	27.4	12.1	19.8	74	0	0	28.2	10.2
April	13	30.2	17.7	23.9	29.4	13.5	21.5	69	15.8	1	34.2	6.8
	14	27.1	17.3	22.2	31.2	14.6	22.9	73	3.4	0	28.0	6.7
	15	32.6	18.1	25.4	33.6	16.2	24.9	64	17.6	1	40.6	9.4
	16	34.7	20.3	27.5	35.1	17.3	26.2	63	8.0	1	50.0	9.0

## CONCLUSION

It may be concluded that grain yield is an important selection criterion for breeding programmes. Grain yield is related with yield components. These yield related traits like number of spikelets per spike, thousand grain weight, straw yield and grain yield per plot etc. The information obtained from these traits during the studies may be used to evolve high yielding varieties which can produce economic yield and help the yield sustainability in those areas where terminal heat stress is a major threat.

## REFERENCES

- Almeselmani, M., Deshmukh, P.S. and Sairam, R.K.** (2009). High temperature stress tolerance in wheat genotypes, role of antioxidant defence enzymes. *Acta Agronomica Hungarica* 57: 1–14.
- Anonymous** (2014). Ministry of Agriculture, Govt. of India. [www.indiastat.com](http://www.indiastat.com).
- Asthir, B., Koundal, A. and Bains, N.S.** (2009). Kinetic and thermodynamic behaviour of wall-bound peroxidase from wheat leaves infected with stripe rust. *Journal of Plant Growth Regulation* 59: 117-124.
- Beltrano, J., Ronco, M.G. and Montaldi, E.R.** (1999). Drought stress syndrome in wheat is provoked by ethylene evolution imbalance and reversed by re-watering, amino-ethoxy-vinyl-glycine and sodium benzoate. *Journal of Plant Growth Regulation* 18: 59–64.
- Breusegem, FVE, Vranova, J.F. and Dat, D.I.** (2001). The role of active oxygen species in plant signal transduction. *Plant Science* 161: 405-414.
- Dadbakhsh, A., Yazdanehpas, A. and Ahmaddizadeh, M.** (2012). Influence of water deficit on yield and some quantitative traits in wheat genotypes. *Current Research Journal of Biological Sciences* 4: 75-81.
- Dolatabadian, A. and Jouneghani, R.S.** (2009). Impact of exogenous ascorbic acid on antioxidant activity and some physiological traits of common Bean subjected to salinity stress. *Notulae Botanicae Horti Agrobotanici Cluj- Napoca* 37(2): 165-172.
- Dwivedi, S.K., Singh, V.P., Singh, G.P. and Arora, A.** (2012). Combined effect of cytokinin, paclobutrazol and ascorbic acid on nitrogen metabolism and yield of wheat (*Triticum aestivum* L.) under water deficit stress condition. *Indian Journal of Plant Physiology*, 17: 259-267.
- Farouk, S.** (2011). Ascorbic Acid and  $\alpha$  tocopherol minimize salt-induced wheat leaf senescence. *Journal of Stress Physiology & Biochemistry* 7: 58-79.
- Imas, P. and Magen, H.** (2007). Management of potassium nutrition in balanced fertilization for soybean yield and quality- Global perspective. In: Proc. of Regional Seminar on Recent Advances in Potassium Nutrition Management for Soybean based Cropping System, 28-29 September, 2007. National Research Centre for Soybean, Indore. pp 1-20.
- Kumar, B., Singh, Y., Ram, H. and Sarlach, R.S.** (2013). Enhancing seed yield and quality of Egyptian clover (*Trifolium alexandrinum* L.) with foliar application of bio-regulators. *Field Crops Research* 146: 25-30.
- Kumar, S., Kaur, R., Kaur, N., Bhandhari, K., Kaushal, N., Gupta, K., Bains, T.S. and Nayyar, H.** (2011). Heat-stress induced inhibition in growth and chlorosis in mungbean (*Phaseolus aureus* Roxb.) is partly mitigated by ascorbic acid application and is related to reduction in oxidative stress. *Acta Physiologica Plantarum* 33: 2091–2101.
- Laghari, K.M., Sial, M.A. and Arain, M.A.** (2012). Effect of high temperature stress on grain yield and yield components of wheat (*Triticum aestivum* L.). *Science Technology & Development* 31: 83-90.
- Mahajan, G., Sarlach, R.S. and Gill, M.S.** (2012). Effect of foliar application of potassium nitrate and urea on performance of transplanted rice. *Ecology Environment and Conservation* 18:533-534.
- Malik, S. and Ashraf, M.** (2012). Exogenous application of ascorbic acid stimulates growth and photosynthesis of wheat (*Triticum aestivum* L.) under drought. *Soil Environment* 31(1):72-77.
- Mandavia, C., Raval, L., Mandavia, M.K. and Khasiya, V.** (2010). Influence of salicylic acid and

brassinolide on biochemical composition and yield of chickpea. *Indian Journal of Agricultural Biochemistry* 23: 32-35.

**Meena, B.L., Singh, A.K., Phogat, B.S. and Sharma, H.B.** (2013). Effects of nutrient management and planting systems on root phenology and grain yield of wheat. *Indian Journal of Agricultural Sciences* 83: 627-632.

**Sarlach, R.S., Sharma, A., Bains, N.S. and Gill, M.S.** (2013). Effect of foliar application of osmo-protectants and ethylene inhibitors to enhance heat tolerance in wheat (*Triticum aestivum* L.). *Vegetos* 26: 266-271.

**Shah, F., Huang, J., Cui, K., Nie, L., Shah, T., Wu, W., Wang, K., Khan, Z.H., Zhu, L. and Chen, C.** (2011). Physiological and biochemical changes in rice associated with high night temperature stress and their amelioration by exogenous application of ascorbic acid (vitamin C). *Australian Journal of Crop Sciences* 5(13): 1810-1816.

**Slafer, G.A. and Whitechurch, E.M.** (2001). Manipulating wheat development to improve adaptation. In Reynolda M P, Ortiz-Monasterio J I

and Mcnab A (ed) *Application of Physiology in Wheat Breeding*. CIMMYT, Mexico, DF.

**Suzuki, N., Miller, G., Sejima, H., Harper, J. and Mittler, R.** (2013). Enhanced seed production under prolonged heat stress conditions in *Arabidopsis thaliana* plants deficient in cytosolic ascorbate peroxidase2. *Journal of Experimental Botany* 64: 253–263.

**Tuteja, N.** (2010). Cold, salt and drought stress in, *Plant Stress Biology, From Genomics towards System Biology*, Wiley-Blackwell, Weinheim, Germany. pp137-159.

**Wahid, A., Gelani, S., Ashraf, M. and Foolad, M.R.** (2007). Heat tolerance in plants, An overview. *Environmental and Experimental Botany* 61: 199-123.

**Weckx, J., Vangronsveld, J. and Vanpoucke, M.** (1989). Effect of paraquat on ethylene biosynthesis by intact green *Phaseolus vulgaris* seedlings. *Physiologia Plantarum* 75: 340-345.

**Xu, P.L., Guo, Y.K., Bai, J.G., Shang, L. and Wang, X.J.** (2008). Effects of long-term chilling on ultra-structure and antioxidant activity in leaves of two cucumber cultivars under low light. *Physiologia Plantarum* 132: 467-478.

## IMPACT OF INTEGRATED NUTRIENT MANAGEMENT ON QUALITY SEEDLING PRODUCTION IN *FLEMINGIA SEMIALATA* ROXB

Kameshwar Kumar Rajak\*, Ravi Hunje and Krishna A.

Department of Forest Biology and Tree Improvement, College of Forestry, Sirsi-581401, University of Agricultural Science, Dharwad-580005, Karnataka, India

Email: [kumar.kameshwar1207@gmail.com](mailto:kumar.kameshwar1207@gmail.com)

Received-01.04.2019, Revised-27.04.2019

**Abstract:** In this experiment thirteen treatments involving different organic, inorganic, bio-fertilizer and their combinations were assessed on seedling growth. Application of Arbuscular mycorrhiza (AM) (10 g) + Phosphate solubilising bacteria (PSB) (5 g) + NPK (Sampurna 19:19:19- 2g/seedling) (T13) to soil media containing red soil, sand and FYM in 2:1:1 ratio increased the plant growth attributes viz., plant height, collar diameter and number of branches and number of leaves by 41.62, 44.09, 44.23 and 39.17 per cent respectively after 150 days of transplanting compared to control. The extent of increase in seedling height due to treatment (T13) in *F. Semialata* was found to be 51.13, 68.14, 78.13, 83.79 and 87.26 per cent over initial plant height at 30, 60, 90, 120 and 150 days after transplanting respectively. The increase in collar diameter due to treatment (T13) in *F. Semialata* was found to be 58.47, 73.36, 80.63, 83.38 and 85.65 per cent over initial collar diameter at 30, 60, 90, 120 and 150 days after transplanting respectively. Higher number of number of leaves per plant noticed in treatment (T13) was 50.98, 60.38, 68.54, 69.40 and 69.62 per cent over initial number of leaves per plant at 30, 60, 90, 120 and 150 days after transplanting respectively. Significantly higher fresh weight and dry weight were obtained in *Flemingia semialata* by application of (T13) AM (10 g) + PSB (5 g) + NPK (Sampurna 19:19:19- 2g/seedling). Overall, the treatment (T13) constituting AM (10 g) + PSB (5 g) + NPK (19:19:19- 2 g/seedling) gave highest growth parameters as compared to other treatments. So it can be recommended as best treatment for integrated nutrient management for quality seedling production.

**Keywords:** Organic, Inorganic, Biofertilizer, Plant height, Weight

### INTRODUCTION

*Flemingia semialata* is commonly called as “Winged-Stalk Flemingia” and in Hindi it is known as “Bara Solpan” and “Ban Chola”. It is perennial, erect, quick growing and put responsive lac host, grows up to height of about 2.5-3.5 m depending upon plant management. It has well-developed root system which comprises taproots and nodulation on the root hairs. Leaves are digitately trifoliate, with 2.5-7.5 cm long narrowly winged stalk (Anon., 2013). Leaflets are up to 15.0 cm long and 5 cm broad, broadly lance shaped, long pointed and minutely gland dotted below the lateral leaflets oblique. Stalks of the leaflets are 5 mm long. Stipules are 1.2 cm long, stem clasping. Flowering starts during August – September. Flowers are borne in often branched racemes, equal to or longer than the leaf stalk, at the end of branches on leaf axils. Bracts are ovate, falling off. Sepal cup is 6-6.5 mm long, densely silky, teeth much longer than the tube. Flowers are purple in colour, 6-6.5 mm long, shaped like pea-flowers. Fruits are 1.2-1.3 cm long, velvety, 2 seeded. Seeds ripen during the months of November-December. The pods are oblong green, tomentose, swollen, sac like structure bearing two seeds. Seeds are round, black with sporadic white spots on the outer skin. One kg seed contains approximately 27,000-30,000 seeds (Kumar and Kumar, 2014). One plant produces approximately 15-20 g of seeds. It has capacity to fix atmospheric nitrogen, thereby enriching soil fertility. In view of being responsive to high coppicing, manageable stature, this plant species is

gaining popularity for production of superior quality winter season kusmi lac under rain fed condition to match pace with growing global demand of lac.

*Flemingia semialata* has emerged recently as one of the most suitable lac host plant which is bushy in nature and quick growing, and more importantly lac cultivation can be started from second year. The practice of lac cultivation on *Flemingia semialata* has been standardized (Jaiswal and Singh 2012) and it has shown potential for intensive lac cultivation in short time and provides very attractive returns. This plant can also be integrated in agriculture, horticulture and forest ecosystems for enhanced income (Singhal *et al.* 2014). Due to good returns through lac as compared to the agricultural crops, introduction of bushy lac host *Flemingia Semialata* in the farmers’ field can improve overall returns. Thus the cultivation of winter season kusmi lac on *Flemingia semialata* with improved technologies will bring better economic empowerment to farmers.

The problem associated with *Flemingia semialata* is hard coat of seed due to which germination gets affected. Use of treatments which are designed to soften the hard coat of seeds has been found to be very effective. The seed treatments have a profound influence in growth aspects of seedlings, as the early germinated seeds show significant growth when compared to other seedling. Treated seeds often showed better growth in terms of height, collar girth, number of branches and number of leaves (Asare and Otsyina, 1980).

\*Corresponding Author

Potting media can influence the quality of seedling to a great extent. Seedling raised in good medium can ensure better establishment and growth when planted out in the main field and show very good succulence to lac host insect. So, production of lac increased in large scale, which is the only resin of animal. The information on the effect of media on growth of seedlings is absolutely essential for large-scale production of healthy seedlings in the nursery (Baiyari., 2003).

## MATERIALS AND METHODS

A comprehensive laboratory study entitled “**Impact of integrated nutrient management on quality seedling production in *Flemingia semialata* Roxb** . was undertaken at Department of Forest Biology and Tree Improvement, College of Forestry, University of Agriculture Sciences, Dharwad during 2014-16. The fresh seeds of *Flemingia semialata* were obtained from the Indian Institute of Natural Resin and Gums (IINRG) Namkum, Ranchi, Jharkhand. To study the nutrient responses on seedling growth and establishment, uniform sized normal healthy seedlings were transplanted in thirteen different nutrient media as per the treatments. The potting mixture which contains two portion of red soil, one portion of sand and one portion of FYM is treated as control. Nutrient treatment combinations are added to the standard potting mixture and other natural practices were carried out. The experiment was laid out at poly house of COF, Sirsi in Complete Randomized Design (CRD) with three replications. After 15 days of transplanting of the seedlings to polybags the nutrient management treatments were imposed as per the treatments. The cultural operations and aftercare like watering and weeding was done regularly as and when required throughout the experimental period the details of the treatments are as under:

### Treatment details:

**T1:** Control [Red soil: Sand: FYM (2:1:1)]

**T2:** Red soil: Sand: FYM (2:1:1) + Vermicompost (10 g.)

**T3:** Red soil: Sand: FYM (2:1:1) + Poultry manure (10 g.)

**T4:** Red soil: sand: FYM (2:1:1) + Arbuscular Mycorrhiza (AM) 10 g.

**T5:** Red soil: sand: FYM (2:1:1) + Phosphate Solubilizing Bacteria (PSB) (5 g.)

**T6:** Red soil: Sand: FYM (2:1:1) + 19:19:19 (NPK) 1 g.

**T7:** Red soil: Sand: FYM (2:1:1) + 19:19:19 (NPK) 2 g.

**T8:** Red soil: sand: FYM (2:1:1) + AM + 19:19:19 (NPK) 1g.

**T9:** Red soil: sand: FYM (2:1:1) + AM + 19:19:19 (NPK) 2 g.

**T10:** Red soil: sand: FYM (2:1:1) + PSB + 19:19:19 (NPK) 1 g.

**T11:** Red soil: sand: FYM (2:1:1) + PSB + 19:19:19 (NPK) 2 g.

**T12:** Red soil: sand: FYM (2:1:1) + AM + PSB +19:19:19 (NPK) 1 g.

**T13:** Red soil: sand: FYM (2:1:1) + AM +PSB + 19:19:19 (NPK) 2 g.

Observation on above ground growth parameters were recorded for six months at monthly interval. Whereas, seedling fresh weight and seedling dry weight were estimated at the end of the experiment

## RESULTS AND DISCUSSION

Integrated Nutrient Management is a practice where all sources of nutrients namely organic, inorganic (chemical fertilizer) and bio-fertilizers can be combined and applied to soils so that plant growth is enhanced. It integrates the objectives of seedling production with least expensive and without harming environment, *ie.* optimum crop nutrition, optimum functioning of soil health and minimum nutrient losses. Integrated Nutrient Management practices are adopted to ensure sustainable productivity, to enhance soil productivity, to prevent degradation of the environment and to reduce expenditure on the cost of chemical fertilizers.

Growth of seedling on virtuous media with optimum quantity of nutrients is essential for production of healthy seedlings and for development of sturdy root system. Inexpensive and nutrient rich medium that produce healthy and vigorous seedlings which ensure early establishment are required in raising plantation where, after care of seedlings are comparatively less. It also reduces the time the seedling should be kept in nursery which intern reduces the cost of production per seedlings. Hence, an experiment with integrated approach for application of manures was tried to find out best combination suitable to obtain high seedling growth. The nutrient combinations significantly influenced all the seedling parameters during all the growth stages.

The significantly higher seedling height 15 cm, 23.01 cm, 34.13 cm, 45.23 cm and 57.57 cm (depicted in Table 5. and Fig. 5) and collar diameter 2.36 mm, 3.68 mm, 5.06 mm, 5.90 mm and 6.83 mm (depicted in Table 6.) was obtained with application Arbuscular Mycorrhiza (AM) (10 g) + Phosphate solubilizing bacteria (PSB) (5 g) +NPK 2 g/plant (T13) at 30 DAT, 60 DAT, 90 DAT, 120 DAT and 150 days after storage respectively (Table- 1 and Fig-1). This was followed by treatment T12 constituting AM (10 g) + PSB (5 g) + NPK 1 g/plant. This may be due to inorganic fertilizers which lead to increase uptake of essential nutrients which in turn enhances the seedling height. Nitrogen plays important role in increasing the plant height as it plays direct role in protein formation while this was supported by mycorrhizae by helping in synthesizing nutrients and making them available in later stages of growth and phosphobacteria has ability to solubilize the bonded phosphate in the soil by secreting organic

acid like formic, acetic, lactic and succinic acids that lower the soil pH and bring about the dissolution of bounded form of phosphate. Phosphorous might have contributed in increasing height by increasing photosynthesis, cell division and cell enlargement in which phosphorus role is well established. The results are in conformation with result obtained by Navale and Channabasappa (2011), revealed that, the use of chemical fertilizer along with the bio-fertilizer significantly influenced the seedling parameters like higher collar diameter (5.64 mm) and higher seedling height (41.53 cm) were obtained at 180 days after transplanting compared to control in *Hydnocarpus pentandra* seedlings.

The increased in plant height *Flemingia semialata* may be due to application of optimum quality of fertilizers and it might have influenced the chlorophyll formation in the plant, which lead to improve photosynthetic activity ultimately resulted in vigorous vegetative growth and development of plant. These results are in line with studies conducted with *Melia azaderachta* where in, maximum seedling height (127.5 cm), collar diameter (7.41 mm) were recorded with 1.0 g NPK at 180 DAP compared to 0.5 g NPK/seedling (Sujatha, 2014). Chaya (2014) reported that, among the inorganic fertilizers, maximum seedling height (85.49 cm), collar diameter (11.20 mm) were recorded with PSB (10 g) + Mycorrhizae (10 g) + NPK 1g/plant in *Lagerstroemia lanceolata* seedlings.

**Table 1.** Effect of integrated nutrient management on seedling height of *Flemingia semialata*

Treatments	Height (cm)					
	Initial	30DAT	60DAT	90DAT	120DAT	150DAT
T1 Control [Red soil: Sand: FYM (2:1:1)]	7.29	9.99	16.82	24.16	31.89	40.65
T2 Vermicompost (10 g.)	7.09	12.70	20.29	30.25	40.94	52.06
T3 Poultry manure (10 g.)	7.42	12.09	19.73	29.83	40.17	51.35
T4 Arbuscular Mycorrhiza (10 g.)	7.21	12.50	20.13	30.05	40.50	51.83
T5 PSB (5 g.)	7.20	11.77	19.55	27.47	39.84	51.07
T6 NP K (19:19:19) 1g/plant	7.58	13.04	20.36	30.62	41.24	52.28
T7 NP K (19:19:19) 2g/plant	7.72	13.21	20.52	30.89	41.64	52.73
T8 AM + NP K (19:19:19) 1g/plant	7.06	14.12	21.83	32.53	43.29	55.36
T9 AM + NP K (19:19:19) 2g/plant	7.81	14.28	22.20	32.77	43.92	55.63
T10 PSB + NP K (19:19:19) 1g/plant	7.24	13.73	21.03	31.53	42.12	53.89
T11 PSB + NP K (19:19:19) 2g/plant	7.33	14.00	21.39	32.09	42.52	54.52
T12 AM+PSB + NP K (19:19:19) 1g/plant	7.94	14.54	22.48	33.32	45.06	56.87
T13 AM +PSB+ NP K (19:19:19) 2g/plant	7.33	15.00	23.01	34.13	45.23	57.57
Mean	7.40	13.15	20.71	30.81	41.41	52.75
SEm±	0.30	0.28	0.26	0.39	0.34	0.30
CD@1%	NS	0.62	0.77	0.86	1.00	0.87

**Table 2.** Effect of integrated nutrient management on collar diameter of *Flemingia semialata*

Treatments	Collar diameter (mm)					
	Initial	30DAT	60DAT	90DAT	120DAT	150DAT
T1 Control [Red soil: Sand: FYM (2:1:1)]	0.96	1.27	1.92	2.95	3.86	4.74
T2 Vermicompost (10 g.)	0.99	1.54	2.57	3.76	4.84	5.28
T3 Poultry manure (10 g.)	0.98	1.54	2.57	3.76	4.84	5.10
T4 Arbuscular Mycorrhiza (10 g.)	0.92	1.48	2.52	3.67	4.76	5.20
T5 PSB (5 g.)	0.95	1.32	2.28	3.34	4.43	5.02
T6 NP K (19:19:19) 1g/plant	0.85	1.60	2.64	3.82	4.92	5.31
T7 NP K (19:19:19) 2g/plant	0.92	1.63	2.73	4.06	5.15	5.44
T8 AM + NP K (19:19:19) 1g/plant	0.99	1.90	2.97	4.48	5.36	6.28
T9 AM + NP K (19:19:19) 2g/plant	0.96	2.07	3.14	4.70	5.60	6.42
T10 PSB + NP K (19:19:19) 1g/plant	0.84	1.79	2.85	4.27	5.12	5.76
T11 PSB + NP K (19:19:19) 2g/plant	0.95	1.87	2.90	4.38	5.32	6.06
T12 AM+PSB + NP K	0.96	2.15	3.31	4.902	5.67	6.74

(19:19:19) 1g/plant						
<b>T13</b> AM +PSB+ NP K (19:19:19) 2g/plant	0.98	2.36	3.68	5.06	5.90	6.83
<b>Mean</b>	0.94	1.72	2.76	4.06	4.97	5.70
<b>SEm±</b>	<b>0.03</b>	<b>0.07</b>	<b>0.29</b>	<b>0.07</b>	<b>0.10</b>	<b>0.02</b>
<b>CD@1%</b>	<b>NS</b>	<b>0.22</b>	<b>0.60</b>	<b>0.22</b>	<b>0.29</b>	<b>0.30</b>

**Table 3.** Effect of integrated nutrient management on no. of leaves of *Flemingia semialata*

Treatments	No. of leaves/ plant					
	Initial	30DAT	60DAT	90DAT	120DAT	150DAT
<b>T1</b> Control [Red soil: Sand: FYM (2:1:1)]	8.00	10.80	14.37	18.40	19.00	19.40
<b>T2</b> Vermicompost (10 g.)	7.80	12.40	16.90	20.50	20.80	21.13
<b>T3</b> Poultry manure (10 g.)	7.90	11.40	15.00	20.00	20.20	20.50
<b>T4</b> Arbuscular Mycorrhiza (10 g.)	8.13	12.00	16.80	20.40	20.60	20.93
<b>T5</b> PSB (5 g.)	7.90	11.80	14.83	19.00	19.20	19.60
<b>T6</b> NP K (19:19:19) 1g/plant	7.00	13.00	17.60	20.83	21.60	22.00
<b>T7</b> NP K (19:19:19) 2g/plant	7.60	13.40	17.80	21.13	21.93	22.20
<b>T8</b> AM + NP K (19:19:19) 1g/plant	7.80	13.97	19.20	22.10	22.80	23.23
<b>T9</b> AM + NP K (19:19:19) 2g/plant	8.26	14.00	19.37	22.40	23.30	23.90
<b>T10</b> PSB + NP K (19:19:19) 1g/plant	7.60	13.60	18.40	21.40	22.10	22.50
<b>T11</b> PSB + NP K (19:19:19) 2g/plant	7.80	13.77	18.80	21.85	23.10	22.80
<b>T12</b> AM+PSB + NP K (19:19:19) 1g/plant	7.60	14.63	19.80	24.13	22.43	25.37
<b>T13</b> AM +PSB+ NP K (19:19:19) 2g/plant	8.20	16.73	20.70	26.07	24.90	27.10
<b>Mean</b>	7.81	13.13	17.65	21.33	26.80	22.35
<b>SEm±</b>	<b>0.36</b>	<b>0.46</b>	<b>0.42</b>	<b>0.44</b>	<b>21.97</b>	<b>0.34</b>
<b>CD@1%</b>	<b>NS</b>	<b>1.36</b>	<b>1.22</b>	<b>1.26</b>	<b>0.43</b>	<b>1.02</b>

**Table 4.** Fresh weight and dry weight (g) of *Flemingia semialata* at 150 DAT after treating with fertilizers

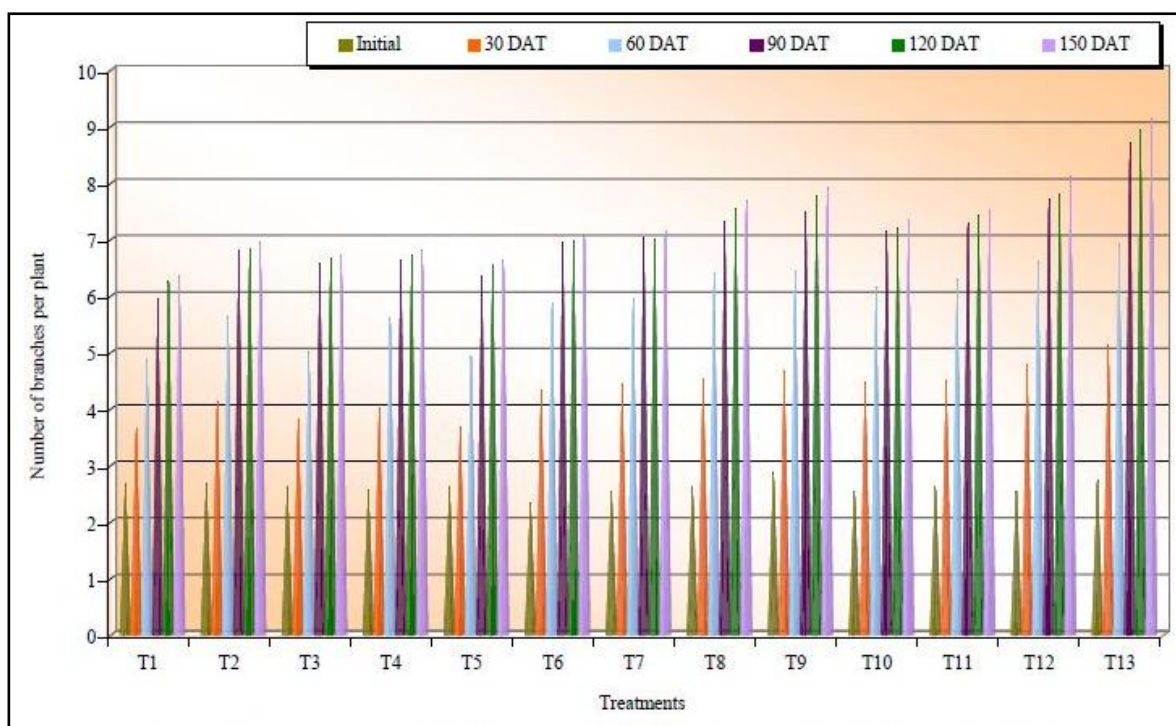
Treatments	Fresh weight (g)	Dry weight (g)
<b>T1</b> Control [Red soil: Sand:FYM (2:1:1)]	56.18	15.83
<b>T2</b> Vermicompost (10 g.)	80.23	<b>27.12</b>
<b>T3</b> Poultry manure (10 g.)	70.14	22.44
<b>T4</b> Arbuscular Mycorrhiza (10 g.)	77.07	24.26
<b>T5</b> PSB (5 g.)	65.20	20.63
<b>T6</b> NP K (19:19:19) 1g/plant	84.23	29.57
<b>T7</b> NP K (19:19:19) 2g/plant	87.54	30.44
<b>T8</b> AM + NP K (19:19:19) 1g/plant	104.36	36.45
<b>T9</b> AM + NP K (19:19:19) 2g/plant	109.14	38.24
<b>T10</b> PSB + NP K (19:19:19) 1g/plant	89.42	32.06
<b>T11</b> PSB + NP K (19:19:19) 2g/plant	96.31	33.32
<b>T12</b> AM+PSB + NP K (19:19:19) 1g/plant	119.58	41.82
<b>T13</b> AM +PSB+ NP K (19:19:19) 2g/plant	125.97	46.31
<b>Mean</b>	<b>89.64</b>	<b>30.65</b>
<b>SEm±</b>	0.92	0.63
<b>CD@1%</b>	2.77	1.90



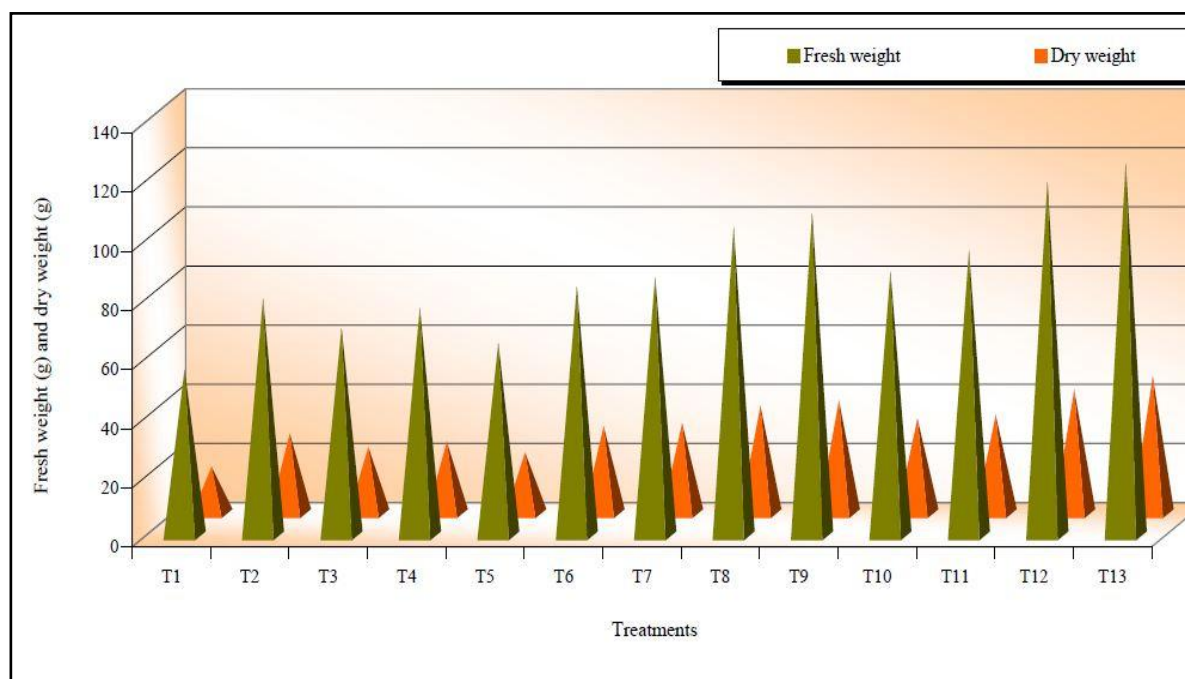
Plate 1. Effect of INM on seedling height of *Flemingia semialata* Roxb.



Plate 2. Seedling growth (whole plant) under integrated nutrient management



**Fig. 1.** Effect of integrated nutrient management on number of branches per plant of *Flemingia semialata*



**Fig. 2.** Fresh weight (g) and dry weight (g) of *Flemingia semialata* at 150 days after transplanting after application of treatments

There was significant increase in number of branches 5.10, 6.90, 8.70, 8.93 and 9.13 (depicted in Table 7. and Fig. 6.) and number of leaves 16.73, 20.70, 26.07, 26.80 and 27.10 (depicted in Table 8.) with application of AM (10 g) + PSB (5 g) + NPK 2 g/plant at 30 DAT, 60 DAT, 90 DAT, 120 DAT and 150 days after storage respectively followed by application of AM (10 g) + PSB (5 g) + NPK 1 g/plant. This may be due to application of optimum quantity of nitrogen in applied

fertilizers might have increased the chlorophyll content in the plants, it also enhanced the photosynthetic activity which resulted in increased synthesis of carbohydrates by the action of bio-fertilizers resulting in vigorous vegetative growth and development of seedling. Banerjee (1973) reported that increased number of branches can be attributed to increased availability of nutrients which might have resulted in increased production of photosynthates and their

translocation into branches and leaves. These results are in conformation with Chaya (2014) who revealed that, among different manures and fertilizers, application of PSB (10 g) + Mycorrhizae (10 g) + NPK (1 g) has significantly increased seedling growth attributed *viz.*, number of branches and number of leaves respectively over control. Lebba (2011) studied the nutrient response of *Melia dubia* and reported that, application of complex fertilizers at 1.0 g/seedling significantly increased the seedling growth attributes *viz.*, number of branches and number of leaves as compared to control (Table- 2,3 and Fig-2).

All the biomass accumulation parameters such as fresh weight and dry weight of seedlings differed significantly after 150 days after transplanting. Maximum fresh weight of seedling (125.97 g) and dry weight of seedling (46.3 g) was recorded in treatment with application of AM (10 g) + PSB (5 g) +NPK 2 g/plant followed by treatment AM (10 g) + PSB (5 g) + NPK 1 g/plant (Table- 4). This may be due to well established fact that Arbuscular mycorrhizae can markedly improve the efficiency of nutrient absorption in plants by increasing the surface area, mobilizing sparingly available nutrient sources and phosphobacteria can solubilizes the available source of phosphate in the soil and make it available to the plant these by enhancing the growth of the plant. These results are in lines with Thriveni *et al.* (2010) and Krishnan *et al.* (2004) and they reported that, vigorous seedlings of *Nothapodytes nimmoniana* and *Simarouba glauca* could be grown economically by applying complex fertilizers at the rate of 0.25 g per plant and phosphobacteria @ 5 g per plant at monthly interval with increased seedling growth and dry biomass when compared to other treatments.

## REFERENCES

- Anonymous** (2013). *Flemingia semialata*. Winged stalk Flemingia. Retrived june 10, 2013 ([http://WWW.flowersofindia.net/catalog/slides/winged-stalk%20 Flemingia.htm](http://WWW.flowersofindia.net/catalog/slides/winged-stalk%20Flemingia.htm))
- Asare, E. O. and Otsyina, R. H. M.** (1980). Theeffect of six pre-sowing treatments on germination of *Flemingiamacrophylla*. *Ghana J. Agri. Sci.*, **13**: 19-22.
- Banerjee, A. K.** (1973). Plantations of *Acacia auriculiformis* (Benn.) A. Cunn. In West Bengal. *Indian For.*, 99 (9):533-540.
- Baiyari, K. P.** (2003). Evaluation of nursery media for seedling emergence and early seedling growth of two tropical tree species. *Moor J. Agric. Res.*, 4(1): 60- 65.
- Chaya, K. B.** (2014). Standardization of nursery techniques in *Lagerstromia lanceolata* Wall. *M. Sc. Thesis*, Univ. Agric. Sci., Dharwad.
- Jaiswal, A. K. and Singh, J. P.** (2012). How to culture lac insect on *Flemingia Semialata*-a bushy lac host. Indian Institute of Natural resins and gums, Ranchi Jharkhand, India. *Bull. Tech.*, 3:1-22.
- Kumar, A. and Kumar, A.** (2014). Prospects of scientific Lac Cultivation in India. Expert publisher, Ranchi, India.
- Krishnan, R. P., Sundersingh, R. J. and Kalai, S. T.** (2004). Influence of inoculation of bio-fertilizers on growth and biomass productivity of *Simarouba glauca* seedlings. *My For.*, 40(2): 197-202
- Lebba, J. J.** (2011). Studies on seed biology, pre-sowing treatments and nutrient response in *Melia dubia* Cav. *M. Sc (For.) Thesis*, Univ. Agric. Sci., Dharwad (India).
- Navale, M. R. and Channabasappa** (2011). Standardization of nursery techniques in *Hydnocarpus pentandra* (Buch-Ham). *M. Sc. Thesis*, Univ. Agric. Sci.,Dharwad.
- Thriveni, H. N., Gunaga, R. P. and Vasudeva, R.** (2010). Influence of inorganic fertilizers on seedling growth and biomass of *Nothapodytes nimmoniana*, an important anti cancer drug yielding tree species of Western Ghats. *Biomed*, 3 (1): 36-41.
- Singhal, V., Meena, S. C., Sharma, K. K. and Ramani, R.** (2014). Lac integrated farming system-a new approach in lac cultivation. Indian Institute of Natural Resins and Gums, Namkum, Ranchi, Jharkhand, India. *Bull. Tech.*, **5**:1-28.
- Sujatha, V. N.** (2014). Standardization of nursery techniques in *Melia azedarach* L. *M.Sc. Thesis*, Univ. Agric. Sci., Dharwad.



## PATTERN OF PRICES AND MARKET INTEGRATION OF MAJOR PULSE CROPS IN GUJARAT

**Ganga Devi\*, K.S. Jadav and Priyanka Changela**

*Department of Agricultural Economics, B. A. College of Agriculture, Anand Agricultural University  
Anand, Gujarat -388110*

*Department of Agricultural Economics, B. A. College of Agriculture, Anand Agriculture University,  
Anand (Gujarat)*

*Email: [gangasaran1982@gmail.com](mailto:gangasaran1982@gmail.com)*

*Received-05.02.2019, Revised-12.04.2019*

**Abstract:** The study has analyzed price and arrivals pattern and market integration of major pulse crops i.e. gram and tur in Gujarat state. The secondary data on monthly wholesale prices and arrivals were collected from the website of [agmarknet.gov.in](http://agmarknet.gov.in) of selected regulated markets for last ten years (2007 to 2016). The study has indicated that the inter-year price analysis shows upward trend of annual price indices and there was a significant increase in the price of gram and tur in all the selected markets with positive and statistically significant compound growth rate during the study period. The intra-year price analysis revealed that the general pattern of seasonal variations in prices were found with increased the prices in off season and decreased in main season all most in all the selected markets in both the crops. The pattern of arrivals shows that the quantity of arrival was more in off season in the selected markets. This may be due to that the stockiest released their stocks with the commencement of new season. The results of market integration exposed that there was positive and significant correlation was found for each market pairs that means the wholesale prices of gram and tur was integrated in all the selected markets. Thus, it can be inferred from the above results that the prices increased in one market, it leads to increase the prices in other markets.

**Keywords:** Gram, Tur, Price behavior, Wholesale prices, Arrivals, Seasonal price indices, Market integration

### INTRODUCTION

Pulses are key source of protein for the rural poor and urban peoples of the country as well as for the vegetarians which comprise major population of the country. These pulses mainly include chickpea, pigeonpea, lentil, mungbean, urdbean and fieldpea. Pulses enrich the soil fertility by fixing atmospheric nitrogen in the root nodules and improve the soil structure. The split grains of pulses called *dal* are excellent source of high-quality protein, essential amino and fatty acids, fibers, minerals and vitamins. India is the largest producer as well as consumer of pulses, and is the largest importer in the world (Singh *et al.*, 2015). This is because the demand for pulses far outweighs their domestic production. Even a liberal import of pulses has not been able to supplement the widening gap between their demand and supply. The skyrocketing prices of pulses since 2008 can be attributed to almost stagnated production leading to a decline in per capita availability. The yields of pulses are often subjected to moderate to severe losses due to recurrent drought situation under rainfed due to low or erratic rainfall. Presently about 24 to 25 million hectares of land is under pulses producing about 19 million tons annually. Even though about 2-3 million tons need to be imported every year to meet the demand. The yield (around 780 kg a hectare) of pulses is less than the global average and the per capita availability ([www.iipr.res.in](http://www.iipr.res.in)). The results from household consumption surveys indicate decline in the

consumption of pulses leading to increase in malnutrition and decline in protein intake, about 15.2 % of people in India are undernourished (Shalendra *et al.*, 2013). Even though India is the largest producer, consumer and importer of the pulses in the world the backdrop of wide mismatch between demand and supply, large scale imports, it is necessary to look at the price movement of pulses. The prices of pulses have shown an upward trend in most of the period in the recent years.

Gujarat state is categorized as one of the minor pulse producing state in India (Srivastava, *et al.*, 2010). In recent time, state is in limelight as agriculture has recorded fastest growth *i.e.* 9.6 per cent during the year 2000 to 2010 among all Indian state. (Gulati *et al.*, 2009). In India, total pulse area and production irrespective of Twelfth Plan was 252.43 lakh hectares and 187.00 lakh tonnes respectively. Out of the total area and production Gujarat have only 2.85 and 3.47 per cent of area and production, respectively, but in case of productivity of pulses Gujarat have 5<sup>th</sup> rank (902 kg per ha). However, 2<sup>nd</sup> and 3<sup>rd</sup> rank for productivity of pigeon pea and chickpea, respectively (DAC&FW, 2016). Looking to the productivity scenario of pulses, Gujarat has great potential and scope to expand the area and meet the gap between demand and supply with enormous extent. Therefore, this study was proposed to glance inter and intra year price movement of major pulses in Gujarat.

\*Corresponding Author

## METHODOLOGY

To achieve the stipulated objective of the study the secondary and time series data for last thirty years (1986-87 to 2015-16) on area, production and productivity of gram and tur were collected from various issues of Directorate of Agriculture, Agriculture & Cooperation Department, Government of Gujarat. The secondary data on monthly wholesale prices and arrivals were collected from the website of [agmarknet.gov.in](http://agmarknet.gov.in) of selected regulated markets for last ten years (2007 to 2016).

The CGR and Instability Index were calculated by using the following methods.

The CGR was calculated by fitting the exponential function given below:

$$Y = a b^t \quad (1)$$

Where, Y = area/production/yield/annual index number of wholesale prices

a = constant

b = regression co-efficient

t = time variable

Thus, natural log on both the sides of eq (1) was taken to convert it in to linear form.

$$\log Y = \log a + t \log b \quad (2) \text{ and,}$$

CGR (%) was work out using following formula:

$$\text{CGR (\%)} = (\text{antilog of } b-1) \times 100$$

The simple co-efficient of variation (CV) often contains the trend component and thus over estimates the level of instability in time series data characterized by long-term trends. To overcome this problem, the Cuddy Della Valle Index was used to correct the CV. Cuddy and Della Valle (1978) and Della Valle (1979).

$$\text{Instability Index (II)} = \text{CV} \times \sqrt{1-R^2}$$

Where, CV = co-efficient of variation and

$R^2$  = co-efficient of determination from a time trend regression adjusted by the number of degrees of freedom.

The significant CGRs were classified in two groups *i.e.* negative and positive CGR.

### Inter-year Price Behaviour

The Inter-year price behavior was studied by using the following methods given below;

To examine the general behavior of wholesale prices the year to year price behavior was ascertained by examining the prices of the crops over the period. The general price behavior of wholesale prices was studied through their price indices.

Annual price index was calculated by the following formula:

$$I_t = P_t/P_0 \times 100$$

Where,

$I_t$  = price index for year t,

$P_t$  = price in period t,

$P_0$  = price in the base year (triennium ending 2007-2009)

To know the trend and rate of increase or decrease in annual wholesale prices the Compound Growth Rate

(CGR) was calculated by using the exponential model as given in equation (1) and (2).

### Intra-year Price Behaviour

The intra-year price behavior was studied by calculating the seasonal price indices of monthly wholesale prices in selected markets.

### Seasonal Price Indices

To know the seasonal pattern of wholesale prices of gram and tur the following multiplicative model of time series analysis was used (Acharya and Agarwal, 1994).

$$O = T \times C \times S \times I$$

Where,

O = Monthly wholesale prices,

T = Trend value,

S = Seasonal variations, and

I = Irregular variations.

The seasonal index numbers were constructed by using the twelve months moving average method. To remove the effects of trend (T) and cyclical variations (C), twelve months moving average were calculated and centered. Further, ratios of original price indices to centered moving average were calculated to obtain the combine effect of S x I. In order to eliminate the effect of irregular component (I), these ratios were averaged and finally adjusted seasonal indices (S) were obtained.

### Market Integration

Market integration shows the extent to which prices in different markets move together (Barret, 2001). It is considered as pre-condition for effective marketing reforms to take place. The high degree of market integration indicates the competitiveness of the markets. The well-integrated market provides the ways for the farmers to specialize according to comparative advantage. Market integration also plays a vital role in determining pattern and pace of diversification towards the high value crops (Sidhu *et al.*, 2010).

To study the market integration three regulated markets on the basis of quantity of arrivals were selected. All the relevant data have been collected from website of [agmarknet.gov.in](http://agmarknet.gov.in). The monthly wholesale prices (for the period 2007-2016) data for selected markets was compiled and analyzed by using Pearson's correlation coefficient to assess the relationship between two markets.

The following formula has been used to calculate the correlation coefficient between the markets;

$$r = \frac{n \sum XY - (\sum X)(\sum Y)}{\sqrt{n \sum X^2 - (\sum X)^2} \sqrt{n \sum Y^2 - (\sum Y)^2}}$$

Where,

r = correlation coefficient;

n = number of observations;

X = monthly average prices of selected crop (Rs/qt) in one market;

Y = monthly average prices of selected crop (Rs/qt) in another market.

The value of correlation coefficient (r) varies from -1 to +1. The positive value indicates that there is a positive relationship among the markets that means increase the prices in one market leads to increase in prices of other market. Degree of relationship is strong when the value is closer to  $\pm 1$ . If the value is exactly  $\pm 1$ , it indicates perfect relationship either positive or negative depending on the sign of the value.

**RESULTS AND DISCUSSION**

Table 1 represents the results of Compound Growth Rate (CGRs) and Instability Index (II) of area, production and yield of gram and tur in Gujarat.

It is evident from the table that the growth rate of area, production and yield of gram was found positive and statistically significant and in case of tur the growth rate of area was found negatively significant. This showed that the area of gram has risen significantly in last thirty years but the area of tur was decreased significantly, whereas, the growth rate of yield was found positive and significant in both the crops. This indicated the increasing trend of yield over the years. Further, the result shows that the variability in production and area was found more as compare to yield in gram and in case of tur area was more stagnant as compared to production and yield.

**Table 1.** Compound Growth Rate (CGR) and Instability Index (II) of Area, Production and Yield

Particular	Gram		Tur	
	CGR	II	CGR	II
Area	3.64**	40.91	-2.04**	10.97
Production	6.35**	53.37	0.20	26.42
Yield	2.55**	24.00	2.29**	21.40

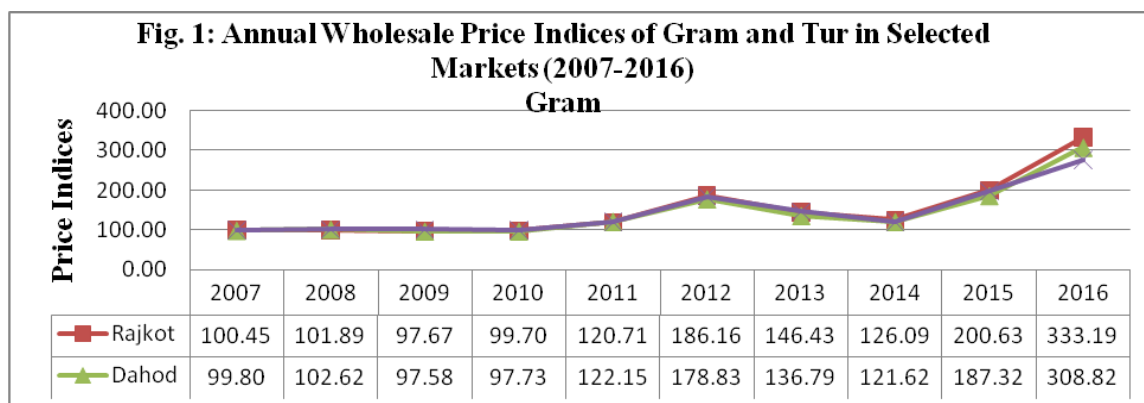
\*\* Significant at 1% level of probability

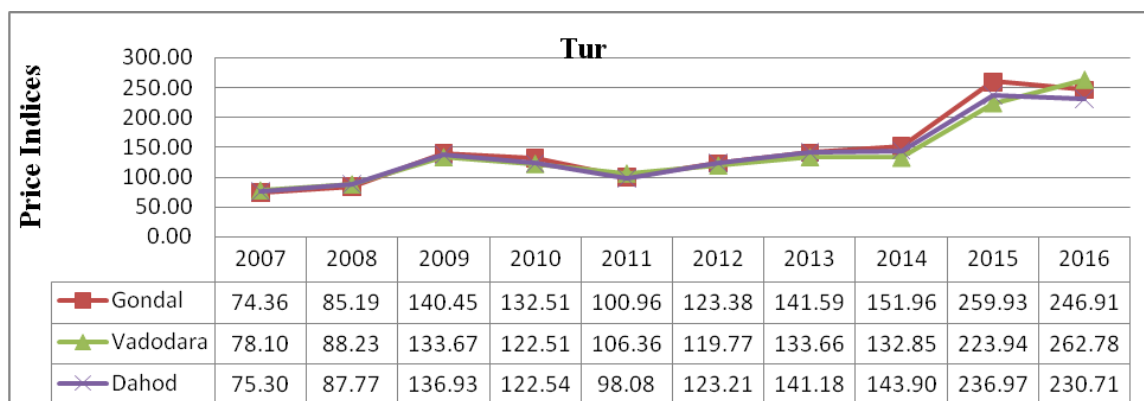
**Inter-Year Price Behaviour**

The inter and intra-year price fluctuations of pulses over the period of time influenced the general price index to a greater extent. The uncertainty in prices affects the farmer’s income and production of crops also.

The annual wholesale price indices of gram and tur during the period 2007-2016 (with base year triennium end 2007-09 =100) were presented in Fig. 1. It can be seen from the figure that the upward trend of annual prices with few exceptions was found in all the selected markets with similar pattern in both the crops. The annual price indices of gram was highest in last two years in all the markets that means the prices of gram was increased in the year 2015 and 2016 as compared to past years. While in case of tur in Gondal and Dahod market the price indices was highest in the year 2015, whereas, in Vadodara the highest prices was recorded in the year 2016.

The estimates of compound annual growth rate of wholesale price of gram and tur were depicted in Table 2. The results disclosed that the compound rate of increase in prices of gram and tur in all the selected markets were statistically significant. This clearly indicates that the price of gram and tur in all the selected markets was significantly increased during last decade.





**Table 2.** Estimates of Compound Growth Rate of Wholesale Price Indices of Gram and Tur in Selected Markets (2007-2016).

Gram					
Markets	Intercept (a)	Estimates of Coefficient (b)	Compound Growth Rate (CGR) in %	R <sup>2</sup>	Adjusted R <sup>2</sup>
Rajkot	1.88	0.05	11.79**	0.71	0.67
Dahod	1.89	0.04	10.76**	0.68	0.63
Jetpur	1.89	0.04	10.56**	0.71	0.67
Tur					
Gondal	1.85	0.05	12.47**	0.77	0.74
Vadodara	1.88	0.06	14.36*	0.32	0.23
Dahod	1.86	0.05	11.48**	0.78	0.75

\*significant at 5 per cent and \*\* Significant at 1 per cent probability level

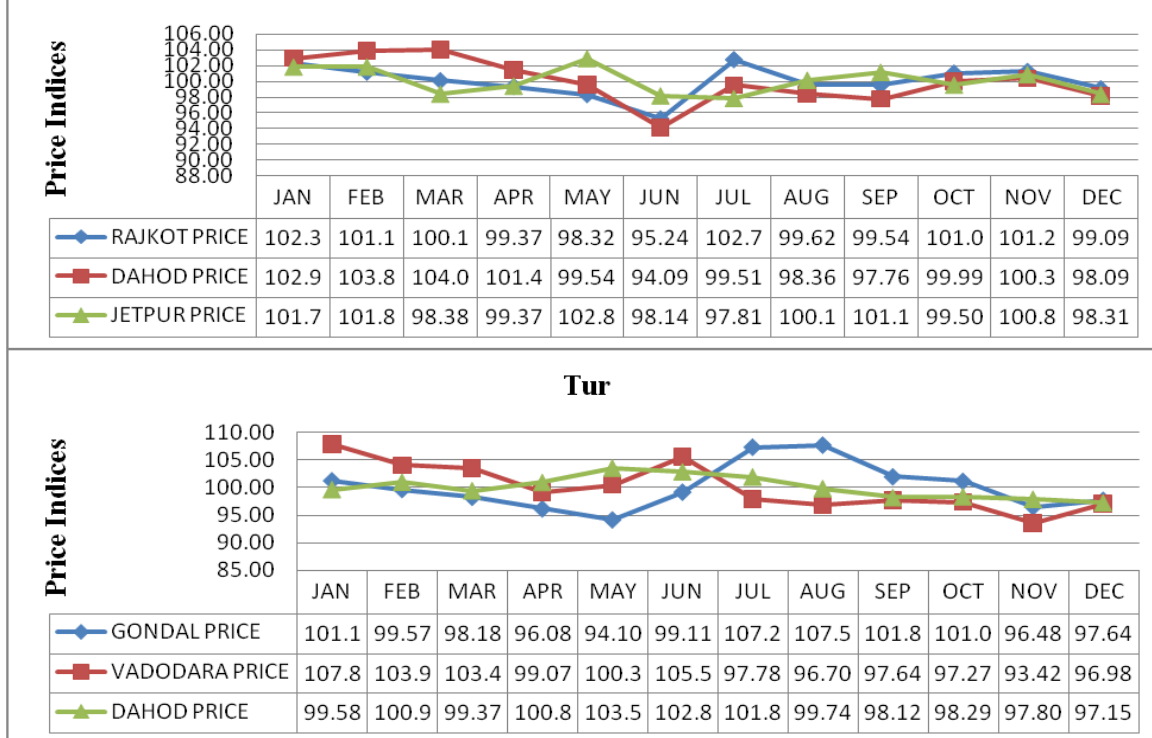
**Intra-Year Price Behaviour**

The estimated monthly seasonal price indices of gram and tur in the selected markets are furnished in Fig. 2. It could be seen from the figure that the intra-year seasonal price indices of gram is all most stable in all the selected markets and it was highest in the month of July (102.79) and lowest in the month of June (95.24) in Rajkot. In case of Dahod market highest in March (104.04) and lowest in June (94.09), whereas, in Jetpur market reached its maximum level in the month of May (102.85) and minimum in July (97.81) month. It can be concluded that the price of gram was decreased in post-harvest season and increased in pre-harvesting period due to advancement of the season all most in all the three selected markets. Further, the results indicated that the intra-year seasonal price indices of tur were showing some ups and downs in all the selected markets. In Gondal market the highest indices was reached in the month of July, August (107.20, 107.56), respectively and lowest in May (94.10), whereas, in Vadodara the highest price indices was found in the month of January (107.83) and lowest in November (93.42). In case of Dahod market the seasonal indices was found highest in the month of May (103.50) and lowest in the month of December (97.15). Overall it can be concluded that the price of tur was increased in off season and decreased in peak season with the expectation of more arrival in the market.

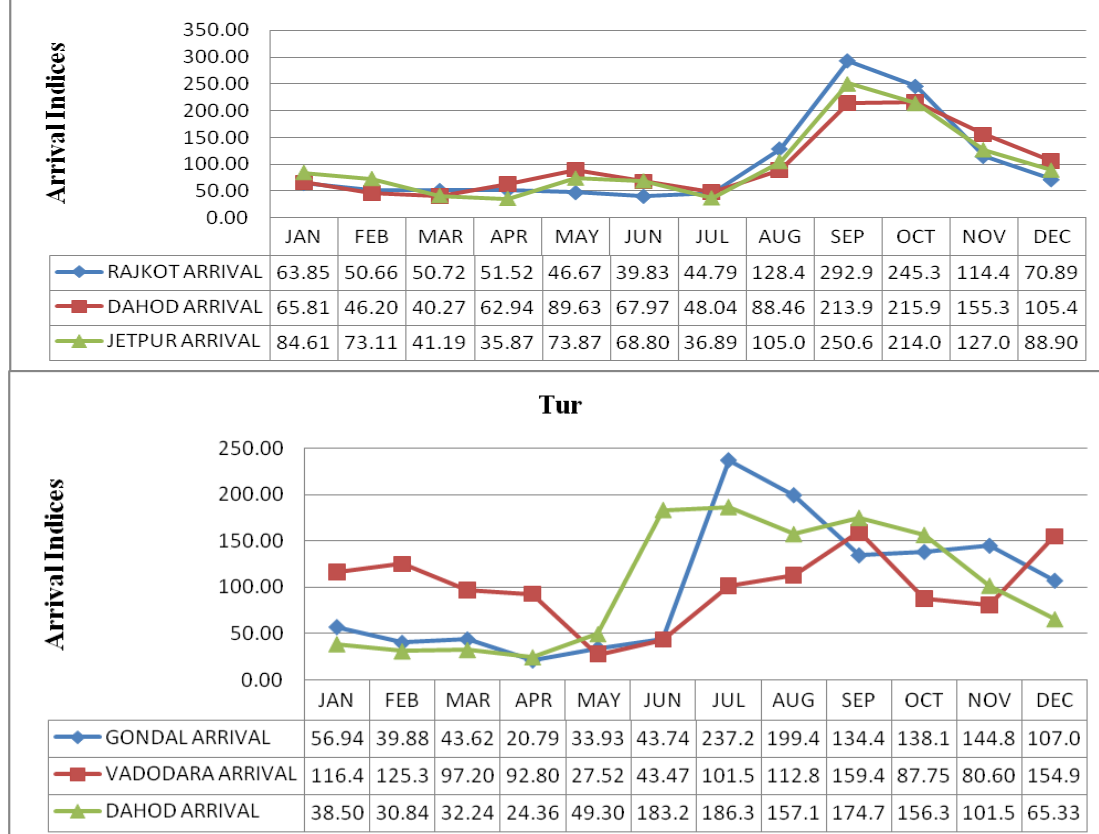
The Monthly patterns of arrivals of gram and tur in selected markets are shown in fig. 3. It is revealed from the figure that maximum arrival of gram in Rajkot market was found in the month of September (292.90) and minimum in the month of June (39.83). In Dahod market the maximum arrivals was found in the month of October (215.90) and minimum in the month of March (40.20), whereas, in case of Jetpur market the arrival reached at highest level in the month of September (250.60) and minimum level in the month of April (35.87). It can be concluded that arrival of gram in all the selected markets was increased in off season continuously from the month of July to October. This may be due to that the millers or traders purchase the commodity from the farmers at the time of harvesting and sale in the market in off season with the expectation of high prices in market in lean season.

Further, it could be seen from the figure that the arrival of tur in Gondal and Dahod market was recorded highest in the month of July (237.20, 186.37), respectively and lowest in the month of April (20.79, 24.36), respectively. Whereas, in Vadodara market the arrival pattern was slightly different from these two markets with highest arrival in the month of September (159.42) and lowest in the month of May (27.52). This may be due to that the stockiest purchased from the farmers in peak season and released the stock in off season with expectation of high prices.

**Fig. 2: Seasonal Indices of Wholesale Price of Gram and Tur in Selected Markets (2007-2016)**



**Fig. 3: Monthly Pattern of Arrivals of Gram and Tur in Selected Markets (2007-2016)**



### Market Integration

The correlation co-efficient of wholesale prices of gram and tur in different market pairs was calculated to determine the degree of market integration between two markets. The results are furnished in Table 3. The results indicated that, the value of correlation co-efficient between two market pairs of gram and tur like Rajkot-Dahod, Rajkot-Jetpur and

Dahod-Jetpur and Gondal-Vadodara , Gondal-Dahod and Vadodara-Dahod, respectively was found positive and highly significant that means the wholesale prices of gram and tur was interlinked in all the selected regulated markets, if the prices increased in one market it leads to increased the prices in other markets, that is showing the positive correlation between the markets in terms of prices.

**Table 3.** Correlation Co-efficient of Wholesale Prices of Gram and Tur in Selected Market Pairs

Gram		
Sr. No.	Market Pairs	Correlation Coefficient
1.	Rajkot-Dahod	0.999 <sup>**</sup>
2.	Rajkot-Jetpur	0.990 <sup>**</sup>
3.	Dahod-Jetpur	0.989 <sup>**</sup>
Tur		
1.	Gondal-Vadodara	0.973 <sup>**</sup>
2.	Gondal-Dahod	0.998 <sup>**</sup>
3.	Vadodara-Dahod	0.976 <sup>**</sup>

<sup>\*\*</sup> Significant at 1 per cent probability level

### CONCLUSION

The findings revealed that the area and production of gram has risen significantly in last thirty years but the area of tur was decreased significantly. In case of yield the positive and significant growth rate was found for both the crops. This shows that the yield of both the pulse crops was increased significantly over the years in Gujarat. The results of instability index showed that the variability in production and area was found more as compare to yield.

The inter-year price analysis shows upward trend of annual price indices and there was a significant increase in the price of gram and tur in all the selected markets with positive and statistically significant compound growth rate during the study period. The intra-year price analysis revealed that the general pattern of seasonal variations in prices were found with increased the prices in off season and decreased in main season all most in all the selected markets. The pattern of arrivals of gram and tur shows that the quantity of arrival was more in off season in the selected markets. This may be due to that the stockiest released their stocks with the commencement of new season.

The results of market integration revealed that there was positive and significant correlation was found for each market pairs in both crops that indicated the wholesale prices of gram and tur was integrated in all the selected markets. Thus, it can be inferred from the above results that the prices increased in one market, it leads to increased the prices in other

markets, and it showed the positive market integration among the markets in terms of prices.

### POLICY IMPLICATIONS

Looking to the demand of pulse crops and significantly increasing the yield there is a need to increase the area of pulse crops with special reference to tur crop because the area of tur was decreased significantly over the years. The intra-year price analysis inferred that the general pattern of seasonal variations in prices was found with increase the prices in off season and decreased in main season in all the selected markets. So farmer should store the product when the prices are goes down and release in the market when prices are goes up. The results of market integration showed that the selected market pairs was integrated to each other in all the selected crops so it suggested that farmer should sale the product in regulated market instead of local market.

### REFERENCES

- Acharya, S. S. and Agarwal, N. L.** (1994). Agricultural prices- analysis and policy, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
- Barrett, C. B.** (2001). Measuring integration and efficiency in international agricultural markets. *Review of Agricultural Economics*, **23**(1): 19-32.
- Cuddy, J. A. and Della Valle, P. A.** (1978). Oxford Bulletin of Economics and Statistics, **40**(1): 79-85.
- Della Valle, P. A.** (1979). Oxford Bulletin of Economics and Statistics, **41**(3): 247-248.
- Gulati, A., Shah, T. and Ganga, S.** (2009). *Agriculture Performance in Gujarat since 2000: Can*

*it be a Divadandi for other State?* New Delhi: International Food Policy Research Institute.

**Shalendra, Gummagolmath, K. C., Sharma, P. and Patil, S. M.** (2013). Role of pulses in the food and nutritional security in India. *Journal of Food Legumes*, **26**: 124–129.

**Sidhu, R. S., Kumar, S., Vatta, K. and Singh, P.** (2010). Supply chain analysis of onion and cauliflower in Punjab. *Agricultural Economics Research Review*, **23**: 445-453.

**Singh, A. K., Singh, S. S., Prakash, V., Kumar, S. and Dwivedi, S. K.** (2015). Pulses production in India: Present Status, Bottleneck and Way Forward. *Journal of AgriSearch*, **2**(2): 75-83.

**Srivastava, S. K., Sivaramane, N. and Mathur, V. C.** (2010). Diagnosis of pulses performance of India. *Agricultural Economics Research Review*, **23**(1): 137-148.

Vision 2050, Indian Institute of Pulse Research, (Indian Council Agricultural Research) Kanpur.

Website: [www.iipr.res.in](http://www.iipr.res.in).



## DIVERGENCE STUDIES IN INDIAN CLUSTER BEAN (*CYAMOPSIS TETRAGONOLOBA* L. TAUB.) FOR DEVELOPING VARIETY FOR VEGETABLE PURPOSE

Smaranika Mishra\*, T.S. Aghora and R. Venugopalan

ICAR-Indian Institute of Horticultural Research  
Bangalore 560 089 (Karnataka)  
Email: [smaranika.mishra@icar.gov.in](mailto:smaranika.mishra@icar.gov.in)

Received-06.04.2019, Revised-27.04.2019

**Abstract:** In a quest for developing improved vegetable type guar, the available germplasm at ICAR- Indian Institute of Horticultural Research, Bangalore collected from different parts of the country were evaluated. Narrow genetic base of the crop due to its self-pollinated nature is a hindrance in getting variability in natural pollination. But, hybridization based on genetic distance is a potential tool to get transgressive segregants. Therefore, this study was formulated to estimate the divergence present in the population and based on their genetic distance the genotypes were classified into 4 different clusters. Inter cluster distance was found maximum between cluster II and IV followed by between cluster I and III and cluster I and II. As the objective is to develop vegetable guar, hybridization between genotypes of cluster I (vegetable guar) and distant genotypes with the desirable trait from different cluster will be advantageous. Direct selection for traits like yield per plant and plant height in cluster I was done to identify the potential parents due to their maximum contribution toward divergence. Based on their genetic distance with desirable genotypes of other clusters which have the supplementary traits missing in cluster I, 11 crosses has been identified which has the potential to bring worthwhile improvement in vegetable guar.

**Keywords:** Cluster bean, Divergence, Diversity, SAS, Vegetable guar

### INTRODUCTION

In India, cluster bean/ guar (*Cyamopsis tetragonoloba* L. Taub.) is considered as a highly nutritious vegetable of family *Leguminosae*. Apart from its tender nutritious pods, it also acts as an excellent green manure crop for its nitrogen fixing ability. Being a hardy crop, it requires a low input and amenable to high density planting. Therefore, suitable for small and marginal farmers. In recent past, this crop has got visibility for its galactomannan gum content which has a high export value and many new varieties have been developed in India with high gum recovery. Mainly, north Indian arid and semi-arid states are cultivating guar for gum purpose. India shares 80% of total world production (Boghara *et al.*, 2010). However, its use as a vegetable is still under-exploited. In South Indian states, it is grown as a vegetable unlimited scale and in north Karnataka districts it is grown year round. But breeding for gum type and vegetable type varieties are entirely different hence, varieties developed for gum cannot be best fitted as vegetable. In India, cultivars (vegetable type) available in public domain are developed long time ago and do not match the productivity level of commercial varieties. Therefore, an intensive breeding programme for vegetable type guar was initiated which can improve the genetic gain under low input conditions.

In self-pollinated crops like guar, germplasm is available in the form of an array of homozygous lines which can be directly released as genetically improved cultivars after selection but creation of

variation is not possible this way. However, for a long-term crop improvement programme, diversity is the pre-requisite which can be achieved through hybridization and subsequent selection for quantitatively inherited traits (Singh *et al.*, 2005). For broadening the genetic base of cultivars, the genetic diversity present in cultivated and wild relatives must be explored (Mishra *et al.*, 2010). Therefore, a study was under taken to determine the variation present in the germplasm and then grouping the genotypes into different clusters based on their genetic distance. Based on which choice of parents for bi-parental mating can be done particularly for getting transgressive segregants for quantitative traits (Arunachalam *et al.*, 1984).

### MATERIALS AND METHODS

The study was conducted during Kharif, 2018 at ICAR- Indian Institute of Horticultural Research, Bangalore, Karnataka, India (Latitude: 13° 7' N and Longitude: 77° 29' E ; altitude 890 MSL). A total of 38 genotypes of guar collected from different regions of India were evaluated in Randomized Block Design (RBD) with three replications. Bunds of size 2 x 1 m. were made and the row to plant spacing was maintained at 60 x 20 cm. The crop was raised as per the recommended package of practices for guar in Karnataka, India. Observations were recorded on 5 randomly selected plants per replication for each genotype for various characters namely days to 1<sup>st</sup> flowering (DF), number of pods per plant (NPP), yield per plant (YP), pod length (PL), pod breadth

\*Corresponding Author

(PB), single pod weight (PW), number of clusters per plant (NCP), number of pods per cluster (PC), plant height (PH) and number of seeds per pod (SP). PROC GLM sub routine of Statistical Analysis System (SAS V 9.3, 2012) was utilized to build up programming codes to evaluate the significant difference ( $p < 0.05$ ) among the genotypes individually for all the traits. Least significant Difference (LSD) was computed as a Post-hoc test (Cochran and Cox, 1957). Using quantitative traits the genetic distance among the populations is calculated using  $D^2$  statistics (Rencher, 1995) on the basis of multiple characters. PROC CLUSTER sub routine of Statistical Analysis System (SAS V 9.3, 2012) was utilized to build up programming codes to study the genetic divergence based on Euclidean distance following Ward's method for clustering (Ward, 1963). Ward's minimum variance method was used to generate a dendrogram. Contribution of traits for divergence was also estimated and presented graphically for ease of understanding.

## RESULTS

The result of analysis of variance (ANOVA) (Online Supplementary Table S1) in the present investigation revealed significant differences (at  $p < 0.05$ ) among the genotypes for all the traits. The dendrogram generated by Ward's minimum variance method classified the genotypes into 2 broad groups (Fig. 1). First group includes the slower seed development types with longer pods and 2<sup>nd</sup> group includes the faster seed development types. 2<sup>nd</sup> group was further classified into 3 sub group viz., i.) bold seeded with more parchment tissues and small pods, ii.) bold seeded but fleshy, small to medium pods and iii.) bold seeded, fleshy medium long pods. All together it was grouped into 4 clusters, as justified by the screen plot presented beneath the dendrogram. Cluster II got maximum (19) genotypes followed by cluster I (11), cluster III (7) and cluster IV got minimum (1) genotype (Table 1). Cluster wise mean performance for each trait was estimated (Table 2). It is observed that Cluster I is superior in terms of DF (29.57), YP (153.22), PL (11.92), PB (1.00), PW (2.83), PH (130.89), SP (7.58) and it includes all the vegetable podded type non branched genotypes. Cluster II showed maximum NPP (137.85) and PC (12.24). But it was of medium height plant with branching and late flowering type with smaller and shorter pods. It includes mostly the genotypes suitable for dual purpose (both for pod and seeds). Cluster III includes dwarf plants (33.34) with medium to small pods (7.07) and more NPP (102.54), hairy pods with bold seeds (Table 2). These are the varieties grown for seeds. Whereas, Cluster IV has only one genotype IIHRCB 30 which is a private variety developed by Sarpan Hybrid seeds company and it is an improved dual purpose variety developed having more NCP (26.9) (Table 2). Intra

cluster distance is maximum in cluster III (3.4114). Minimum inter cluster distance was observed between cluster II and III (3.3262) and maximum inter cluster distance was observed between cluster II and IV (6.5112) followed by between cluster I and III (5.7682); I and II (5.7081); cluster III and IV (5.5378) and cluster I and IV (5.407) (Table 3). Out of 10 characters, as elucidated by the pie-chart (Fig. 2) YP contributed to maximum diversity of 15% followed by PH (12%). Based on that, IIHRCB 01, IIHRCB 04, IIHRCB 05 and IIHRCB 23 were selected from cluster I to be used as first parent in hybridization programme. To identify the source for the traits like NPP, NPC and NCP, the genotype showing higher mean values were identified. For NPP plant genotypes identified are IIHRCB 31 (170.1), IIHRCB 38 (169.0) and IIHRCB 11 (155.0); for NCP genotypes identified are IIHRCB 30 (26.9) and IIHRCB 27 (26.3); for PC, IIHRCB 31 (18.6), IIHRCB 34 (16.35), IIHRCB 18 (15.55) and IIHRCB 38 (15.45) respectively (Table 4). Based on their genetic distance with identified genotypes from cluster I, crosses were identified (Online supplementary Table S2). It was noted that genetic distance is higher between the genotypes compared to their inter cluster distance except in case of IIHRCB 23 x IIHRCB 30, IIHRCB 01 x IIHRCB 27, IIHRCB 04 x IIHRCB 27, IIHRCB 05 x IIHRCB 27 and IIHRCB 23 x IIHRCB 27. Total 23 crosses (IIHRCB 01 x IIHRCB 31, IIHRCB 01 x IIHRCB 38, IIHRCB 01 x IIHRCB 11, IIHRCB 01 x IIHRCB 30, IIHRCB 01 x IIHRCB 34 and IIHRCB 01 x IIHRCB 18, IIHRCB 04 x IIHRCB 31, IIHRCB 04 x IIHRCB 38, IIHRCB 04 x IIHRCB 11, IIHRCB 04 x IIHRCB 30, IIHRCB 04 x IIHRCB 34, IIHRCB 04 x IIHRCB 18, IIHRCB 05 x IIHRCB 31, IIHRCB 05 x IIHRCB 38, IIHRCB 05 x IIHRCB 11, IIHRCB 05 x IIHRCB 30, IIHRCB 05 x IIHRCB 34, IIHRCB 05 x IIHRCB 18, IIHRCB 23 x IIHRCB 31, IIHRCB 23 x IIHRCB 38, IIHRCB 23 x IIHRCB 11, IIHRCB 23 x IIHRCB 34 and IIHRCB 23 x IIHRCB 18) were identified to give improvement in vegetable type guar in terms of NPP, NPC and NCP. As the genotypes IIHRCB 31 and IIHRCB 38 have the potential for simultaneous improvement of NPP and PC, The number of crosses were narrowed down to 11 (Table 4) namely, IIHRCB 01 x IIHRCB 31, IIHRCB 01 x IIHRCB 38, IIHRCB 04 x IIHRCB 31, IIHRCB 04 x IIHRCB 38, IIHRCB 05 x IIHRCB 31, IIHRCB 05 x IIHRCB 38, IIHRCB 23 x IIHRCB 31 and IIHRCB 23 x IIHRCB 38, IIHRCB 01 x IIHRCB 30, IIHRCB 04 x IIHRCB 30 and IIHRCB 05 x IIHRCB 30.

## DISCUSSION

Above study on genetic divergence, classified the genotypes into different clusters based on their domestication since introduction. History suggests that, it is a crop of African origin and was

introduced to India as a fodder crop between 9<sup>th</sup> to 13<sup>th</sup> century AD during Arab-Indian trade. Domestication happened around 1000 years ago in dry region of North-West Indo-Pakistan subcontinent (Hymowitz, 1972). Gopal Krishnan *et al.* (2011) confirmed the presence of a linking species between the wild and cultivated one known as Adak guar in the arid region of north-west India where it is grown mainly for the gum content and fodder purpose. Important traits of domestication syndrome observed in cultivated guar includes compact growth habit, indehiscence of pods, loss of seed dormancy, edible pods, large seed size and cylindrical seed shape (Gopal Krishnan *et al.*, 2011). Currently, India has the maximum diversity in cluster bean owing to its different uses such as gum, fodder, vegetable and green manure etc. In the present investigation, we found inter cluster distances are always higher than intra cluster distance but, higher intra cluster distance in cluster III indicated a lot of scope for exchange of genetic materials among genotypes within these cluster. Minimum inter cluster distance between cluster II and III indicated that one group has little improvement over the other for few traits only. The objective here is to develop vegetable type varieties

and all of them are included in Cluster I with few defects namely, less NPP, less NCP and PC. Hybridization with distant parent is an alternative to improve them. Further, the characters contributing the most towards divergence is responsive towards effective selection and the choice of parents for hybridization. So, direct selection for tall plants with more YP will be useful in improvement of vegetable guar. Choudhury and Kumhar (2010) also had similar observations while studying diversity in cluster bean. Based on that, genotypes from cluster I were selected to be used as first parent in hybridization programme. To supplement the traits like NPP, PC and NCP in them second parents were also identified from other clusters based on their higher mean performance. Genetic distance between the parents were referred to identify the crosses with potential of giving desirable recombinants. Because higher the genetic distance, more is the chance of getting transgressive segregants. Here genotypes showing more genetic distance than their corresponding inter cluster distance were selected as second parents. Based on which 8 potential crosses were identified.

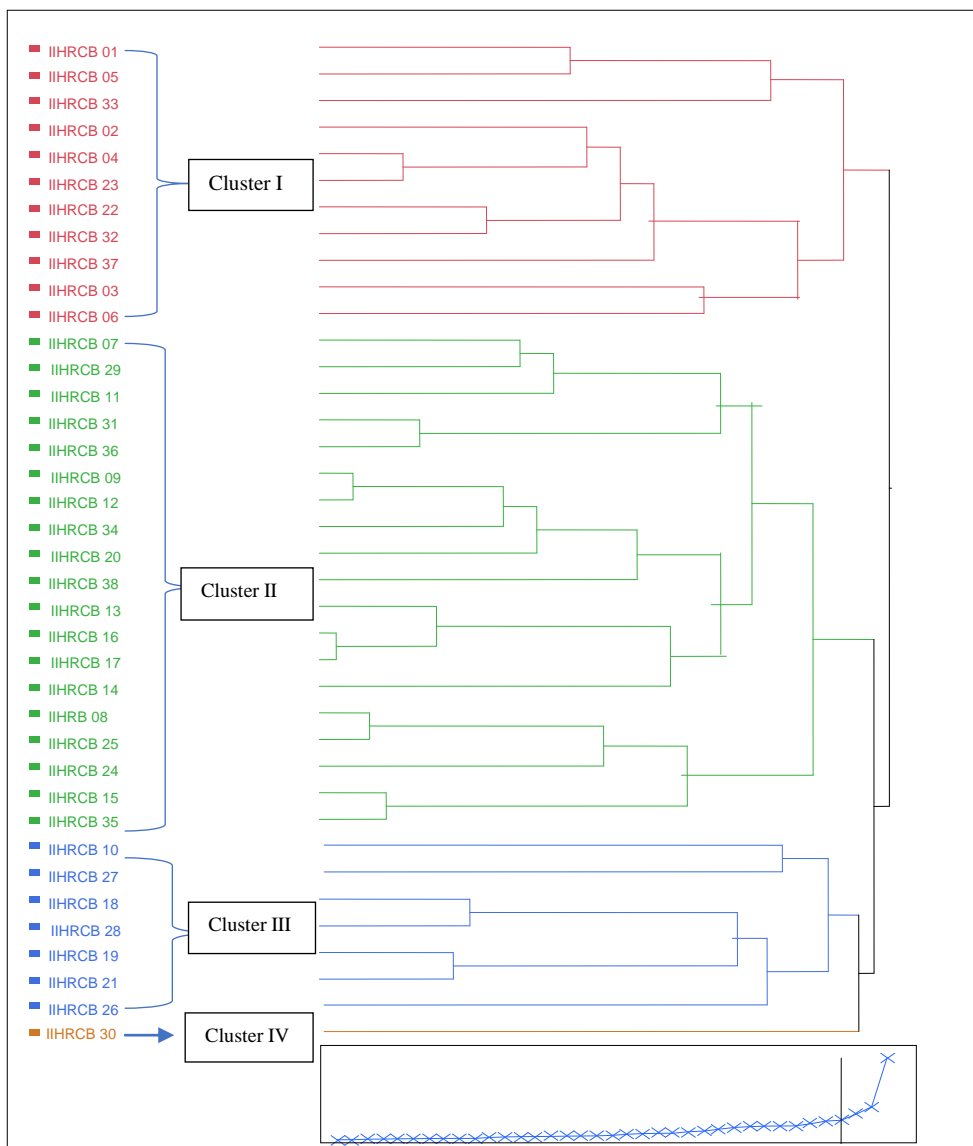
**Table 1.** Analysis of variance (mean sum of squares) for 10 characters in cluster bean

	DF	NPP	YP	PL	PD	PW	PH	NCP	PC	SP
Replication (df=1)	2.22	525.74	517.55	0.16	0.01	0.02	63.41	0.05	0.26	0.01
<b>Genotype (df=37)</b>	27.79*	3499.46*	2069.08*	14.1*	0.5*	1.73*	3220.13*	60.4*	57.51*	2.82*
<b>Error (df=37)</b>	0.65	130.32	206.57	0.16	0.01	0.02	62.5	4.24	5.05	0.07

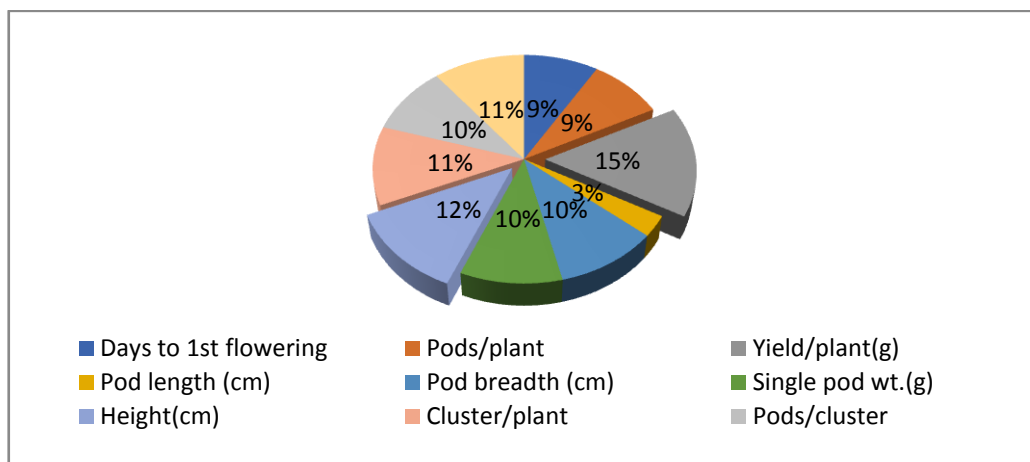
\*significant at  $p < 0.05$  level, DF: Days to flowering, NPP: Number of pods per plant, YP: Yield per plant (g), PL: Pod length (cm), PD: Pod breadth (cm), PW: single pod weight (g), PH: Plant height (cm), NCP: Number of clusters per plant, PC: Pods per cluster, SP: seeds per pod

**Table 2.** Clustering pattern of 38 genotypes of cluster bean based on Euclidean distance following Ward's method and the member present in each respective cluster

Cluster	Number of genotypes	Genotype
I	11	IIHRCB 01, IIHRCB 05, IIHRCB 33, IIHRCB 02, IIHRCB 04, IIHRCB 23, IIHRCB 22, IIHRCB 32, IIHRCB 37, IIHRCB 03, IIHRCB 06
II	19	IIHRCB 07, IIHRCB 29, IIHRCB 11, IIHRCB 31, IIHRCB 36, IIHRCB 09, IIHRCB 12, IIHRCB 34, IIHRCB 20, IIHRCB 38, IIHRCB 13, IIHRCB 16, IIHRCB 17, IIHRCB 08, IIHRCB 14, IIHRCB 25, IIHRCB 24, IIHRCB 15, IIHRCB 35
III	7	IIHRCB 10, IIHRCB 27, IIHRCB 18, IIHRCB 28, IIHRCB 19, IIHRCB 21, IIHRCB 26
IV	1	IIHRCB 30



**Figure 1:** Dendrogram showing cluster bean genotypes in different clusters



**Figure 2:** Contribution of various traits for cluster bean diversity

**Table 3.** Cluster wise mean performance for 10 different quantitative traits

	DF	NPP	YP	PL	PD	PW	PH	NCP	PC	SP
Cluster I	29.57	55.26	153.22	11.92	1.00	2.83	130.89	19.61	2.99	7.58
Cluster II	36.28	137.85	138.47	6.38	0.70	1.01	70.88	11.94	12.24	6.88
Cluster III	33.63	102.54	113.21	7.07	0.75	1.16	33.34	12.57	10.04	5.50
Cluster IV	35.80	31.30	71.60	11.30	0.90	2.30	102.50	26.90	1.20	3.20

DF: Days to flowering, NPP: Number of pods per plant, YP: Yield per plant, PL: Pod length, PD: Pod breadth, PW: single pod wt., PH: Plant height, NCP: Number of clusters per plant, PC: Pods per cluster, SP: seeds per pod

**Table 4.** Average inter and intra cluster distance among the four clusters of cluster bean

Average intra and inter cluster D <sup>2</sup> values				
Cluster	I	II	III	IV
I	<b>2.6671</b>	5.7081	5.7682	5.4047
II		<b>2.1256</b>	3.3262	6.5112
III			<b>3.4114</b>	5.5378
IV				<b>0.0000</b>

\*Values in bold fonts indicate intra cluster distance

**Table 5.** Best genotypes identified for traits like number of pods per plant, number of clusters per plant and pods per cluster along with their values

Trait	Genotype	Cluster
Number of pods per plant	IIHRCB 31(170.1) IIHRCB 38 (169.0) IIHRCB 11 (155.0)	II II II
Number of clusters per plant	IIHRCB 30 (26.9) IIHRCB 27 (26.3)	IV III
Pods per cluster	IIHRCB 31 (18.6) IIHRCB 34 (16.35) IIHRCB 18 (15.55) IIHRCB 38 (15.45)	II II III II

**Table 6.** Genetic distance between genotypes of cluster I and the best genotypes identified to be used as parent

	IIHRCB 31	IIHRCB 38	IIHRCB 11	IIHRCB 30	IIHRCB 27	IIHRCB 34	IIHRCB 18
IIHRCB 01	7.09*	6.02*	5.75*	6.73*	5.00	6.27*	7.41*
IIHRCB 04	7.51*	6.55*	6.12*	6.10*	5.29	6.56*	7.33*
IIHRCB 05	7.70*	6.60*	6.45*	6.66*	5.33	6.90*	7.89*
IIHRCB 23	7.15*	6.34*	5.70*	5.19	4.79	6.42*	6.95*

\*indicates genotypes having higher genetic distance than their respective inter cluster distance

**Table 7.** Parents predicted to give desirable recombinants

P1	P2	Trait to be improved
IIHRCB 01 x	IIHRCB 31 IIHRCB 38 IIHRCB 30	NPP, PC NPP, PC NCP

IIHRCB 04 x	IIHRCB 31 IIHRCB 38 IIHRCB 30	NPP, PC NPP, PC NCP
IIHRCB 05 x	IIHRCB 31 IIHRCB 38 IIHRCB 30	NPP, PC NPP, PC NCP
IIHRCB 23 x	IIHRCB 31 IIHRCB 38	NPP, PC NPP, PC

NPC: Number of pods per plant, NCP: number of clusters per plant and PC: pods per cluster

## CONCLUSION

Production and productivity level of vegetable guar has reached a plateau because of continuous selection within the same vegetable type germplasm. To create variation and to get transgressive segregants, hybridization between divergent parents from different cluster is a potential option. From the above investigations, we identified 3 genotypes (IIHR 31, IIHR 38 and IIHR 30) with the potential to bring improvement in terms of NPP, PC and NCP. Using them, 11 crosses have been identified to give worthwhile improvement. Further evaluation of the hybrids and their subsequent generations is required to identify the improved vegetable type and to prove the robustness of genetic divergence study in crop improvement.

## ACKNOWLEDGEMENTS

The authors express their gratitude to Director, ICAR-IIHR for extending all necessary facilities by granting permission to carry out the research work and SSCNARS, IASRI for providing SAS V 9.2 software to the nodal centre ICAR-IIHR under NAIP project.

## REFERENCES

**Arunachalam, V., Bandyopadhyay, A., Nigam, S.M. and Gibbons, R.W.** (1984). Heterosis in relation to genetic divergence and specific combining ability in groundnut (*Arachis hypogaea* L.). *Euphytica* 33: 33-39.

**Boghara, M.C., Dhaduk, H.L., Kumar, S., Parekh, Mithil, Patel, J., Nilesh, J. and Sharma,**

**Ramavtar** (2016). Genetic divergence, path analysis and molecular diversity analysis in cluster bean (*Cyamopsis tetragonoloba* L. Taub.) *Industrial Crops and products* 89: 468-477.

**Choudhary, B.R. and Kumhar, S.R.** (2010). Diversity Analysis in Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.]. *Annals of Arid Zone* 49(2): 145-147.

**Cochran, W.G. and Cox, G.M.** (1957). *Experimental Design*. 2nd Edition, John Wiley and Sons, New York, 615 p.

**Gopala, K., Dwivedi, N.K. and Singh, J.P.** (2011). Primitive weedy forms of guar, adak guar: possible missing link in the domestication of guar [*Cyamopsis tetragonoloba* (L.) Taub.]. *Genetic Resources and Crop Evolution* 58: 961-966.

**Hymowitz, T.** (1972). The trans-domestication concept as applied to guar. *Economic Botany* 26: 49-60.

**Rencher, A.C.** (1995). *Methods of Multivariate Analysis*, John Wiley and Sons.

**Mishra, S., Sharma, M.K., Singh, Mand and Yadav, S.K.** (2010). Genetic diversity of French bean (bush type) genotypes in North-West Himalayas. *Indian Journal of Plant Genetic Resources* 23(3): 285-287.

**SAS V 9.3** (2012). *Statistical Analysis System*, V 9.3, SAS Institute Inc., Cary NC

**Singh, R.V., Chaudhary, S.P.S., Singh, J. and Singh, N.P.** (2005). Genetic divergence analysis in clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.]. *Journal of Arid Legumes* 2: 102-105.

**Ward, J.H.** (1963). Hierarchical grouping to optimize an objective function. *Journal of American Statistical Association* 58: 236-244.

## PRICE BEHAVIOUR AND CO-INTEGRATION OF GREEN GRAM IN GUJARAT

Ganga Devi\*, K.S. Jadav, Pooja Gamit and Priyanka Changela

Department of Agricultural Economics, B. A. College of Agriculture, Anand Agricultural University,  
Anand - 388 110, Gujarat, India

Email: [gangasaran1982@gmail.com](mailto:gangasaran1982@gmail.com)

Received-22.02.2019, Revised-17.04.2019

**Abstract:** The secondary and time series data on monthly wholesale prices and arrivals of green gram were collected from the website of [agmarknet.gov.in](http://agmarknet.gov.in) of selected regulated markets for last ten years (2007 to 2016). The results evident that the inter-year price analysis shows upward trend of annual price indices and there was a significant increase in the price of green gram in all the selected markets with positive and statistically significant compound growth rate during the study period. The intra-year price analysis revealed that the general pattern of seasonal variations in prices were found with increased the prices in off season and decreased in main season all most in all the selected markets. By using Augmented Dickey Fuller Test, Johansen test and causality test was examined. The results of the study indicated that therefore ADF test at the first difference were significant so the null hypothesis was rejected about the presence of unit root. Thus three series were integrated of the order (I). The price series of all markets were stationary at their levels themselves. Trace statistic and maximum Eigen value test revealed that Gujarat Green Gram markets were found to be integrated with 3 co-integrating equations. All the market pairs exhibited bi-directional causality and prices were transmitted vice versa i.e., mutual influence was exerted by the market on each other.

**Keywords:** Green gram, Price behaviour, Wholesale prices, Causality test

## INTRODUCTION

Pulses are an important source of protein in our daily diet and they have great potential to improve human health, conserve our soils, protect the environment and contribute to global food security. The United Nations, declared 2016 as “International Year of Pulses” (IYP) to heighten public awareness of the nutritional benefits of pulses as part of sustainable food production aimed at food security and nutrition. Pulses are main source of high quality protein, essential amino acids, fibers, minerals, vitamins and fatty acids for the poor as well as for the vegetarians which constitute major population of the country. The major pulses grown in India are chickpea, pigeonpea, lentil, mungbean, urdbean and fieldpea and they are important for sustainable environment and agriculture (Asthana and Chaturvedi, 1999).

India is the largest producer with around 25 per cent of global production as well as consumer about 27 per cent of world consumption and is the largest importer with 14 per cent in the world (Mohanty and Satyasai, 2015). This is because the demand for pulses far outweighs their domestic production. Even a liberal import of pulses has not been able to supplement the widening gap between their demand and supply. The skyrocketing prices of pulses since 2008 can be attributed to almost stagnated production leading to a decline in per capita availability. The yields of pulses are often subjected to moderate to severe losses due to recurrent drought situation under rainfed due to low or erratic rainfall. Presently about 24 to 25 million hectares of land is under pulses producing about 19 million tons annually. Even though about 2-3 million tons need to be imported

every year to meet the demand. The yield (around 780 kg a hectare) of pulses is less than the global average and the per capita availability ([www.iipr.res.in](http://www.iipr.res.in)). Therefore, due to the backdrop of wide mismatch between demand and supply it is necessary to look at the price movement of pulses.

## MATERIALS AND METHODS

To achieve the stipulated objective of the study the secondary and time series data for last thirty years (1986-87 to 2015-16) on area, production and productivity of Green gram was collected from various issues of Directorate of Agriculture, Agriculture & Cooperation Department, Government of Gujarat. The data pertaining to area, production and yield for the year 2013-14 and 2014-15 was used provisional or estimated data. The secondary data on monthly wholesale prices and arrivals were collected from the website of [agmarknet.gov.in](http://agmarknet.gov.in) of selected regulated markets for last ten years (2007 to 2016). The CGR and Instability Index were calculated by using the following methods.

The CGR was calculated by fitting the exponential function given below:

$$Y = a b^t \quad (1)$$

Where, Y = area/production/yield/annual index number of wholesale prices

a = constant

b = regression co-efficient

t = time variable

Thus, natural log on both the sides of eq (1) was taken to convert it in to linear form.

$$\log Y = \log a + t \log b \quad (2)$$

CGR (%) was work out using following formula:

$$\text{CGR (\%)} = (\text{antilog of } b - 1) \times 100$$

\*Corresponding Author

The simple co-efficient of variation (CV) often contains the trend component and thus over estimates the level of instability in time series data characterized by long-term trends. To overcome this problem, the Cuddy Della Valle Index was used to correct the CV.

$$\text{Instability Index (II)} = \text{CV} \times \sqrt{(1-R^2)}$$

Where, CV = co-efficient of variation and  $R^2$  = co-efficient of determination from a time trend regression adjusted by the number of degrees of freedom.

The significant CGRs were classified in two groups *i.e.* negative and positive CGR.

#### Inter-year Price Behaviour

To examine the general behavior of wholesale prices the year to year price behavior was ascertained by examining the prices of the crop over the period. The general price behavior of wholesale prices was studied through their price indices.

Annual price index was calculated by the following formula:

$$I_t = P_t/P_0 \times 100$$

Where,

$I_t$  = price index for year t,

$P_t$  = price in period t,

$P_0$  = price in the base year (triennium ending 2007-2009)

To know the trend and rate of increase or decrease in annual wholesale prices the Compound Growth Rate (CGR) was calculated by using the exponential model as given in equation (1) and (2).

#### Intra-year Price Behaviour

The intra-year price behavior was studied by calculating the seasonal price indices of monthly wholesale prices of green gram in selected markets.

#### Seasonal Price Indices

The multiplicative model of time series analysis was used to know the seasonal pattern of wholesale prices of green gram.

$$O = T \times C \times S \times I$$

where,

O = Monthly wholesale prices,

T = Trend value,

S = Seasonal variations, and

I = Irregular variations.

The seasonal index numbers were constructed by using the twelve months moving average method. To remove the effects of trend (T) and cyclical variations (C), twelve months moving average were calculated and centered. Further, ratios of original price indices to centered moving average were calculated to obtain the combine effect of S x I. In order to eliminate the effect of irregular component (I), these ratios were averaged and finally adjusted seasonal indices (S) were obtained.

#### Market Integration

Augmented Dickey- fuller test involve testing for stationary of the variables. The Augmented Dickey- fuller (ADF) test considers the null hypothesis that

given series has a unit- root, *i.e.* it is non- stationary. The autoregressive formulation of the ADF test with a drift term is given by equation (1).

$$\Delta p_{it} = a_0 + \gamma P_{it-1} + \sum_{i=2}^n \beta_i \Delta p_{i-j+1} + \epsilon_t \quad (1)$$

Where  $P_{it}$  is the price in market i at the time t,  $\Delta P_{it} = (P_{it} - P_{it-1})$  and is the intercept or drift term. The joint hypothesis to check the presence of unit root is  $H_0: Y = a_0 = 0$  using  $\phi_1$  statistics. Failure of the rejection of null hypothesis means that the series non- stationary.

#### Johansen's Multiple Co-integration Analysis

For co-integration analysis, the Johansen (1988) maximum likelihood estimator was chosen over the Engle and Granger (1987) two steps procedure. The Johansen procedure is a multivariate generalization of the Dickey Fuller test and formulation is as follows:

$$p_{it} = A_1 p_{it-1} + \epsilon_t \quad (2)$$

So that,

$$\Delta P_{it} = A_1 p_{it-1} - p_{it-1} + \epsilon_t \quad (3)$$

$$\Delta p_{it} = (A_1 - I) P_{it-1} + \epsilon_t \quad (4)$$

$$\Delta p_{it} = \lambda P_{it-1} + \epsilon_t \quad (5)$$

Where, and are  $(n \times 1)$  vectors;  $\lambda$  is an  $(n \times n)$  matrix of parameters; I is an  $(n \times n)$  identity matrix and n is the matrix.

Trace test was used to determine the presence of co-integration relationship between the prices –series, using the estimates of the characteristics roots, the test for the number of characteristic roots that are insignificantly different from unity was conducted using the following statistics:

$$\lambda_{\text{trace}}(r) = -T \sum_{j=r+1}^n h(1 + \lambda_j^{\wedge}) \quad (6)$$

Where,  $\lambda$  denotes the estimated values of the characteristics roots (eigen value) obtained from the estimated matrix ; and T is the number of usable observations. The Eigen values representing the strength of the correlation between the first difference and error – correction.

#### Granger Causality Test

When a co-integration relationship is present for variables, Granger Causality test (Granger, 1969) can be used to analyze the direction of this co- movement relationship. Whether market  $p_1$ Granger causes market  $p_2$  or vice versa was checked using equation (7).

$$p_{it} = c + \sum_j^n \phi P_{it-j} + S_j p_{2t-j} + \epsilon_t \quad (7)$$

A simple test of the joint significance was used to check the Granger causality, *i.e.*

$$H_0: S_1 = S_2 = S_n = 0$$

## RESULTS AND DISCUSSION

Table 1 represents the results of Compound Growth Rate (CGRs) and Instability Index (II) of area, production and yield of green gram in Gujarat. It is revealed from the table that the growth rate of area was found positive but statistically non-significant, whereas the CGR of production (3.22 per cent) and productivity (3.01 per cent) was found positive and statistically significant. This clearly indicates that the

production and productivity of green gram in Gujarat was increased significantly in last thirty years. Further, the result shows that the instability index of production was found high (41.47) as compare to

area (25.43) and yield (29.68). This showed that the variability in production was found more as compared to area and yield. This may be due to the fluctuations in market prices in last years.

**Table 1.** Compound Growth Rate (CGR) and Instability Index (II) of Area, Production and Yield of Green Gram in Gujarat

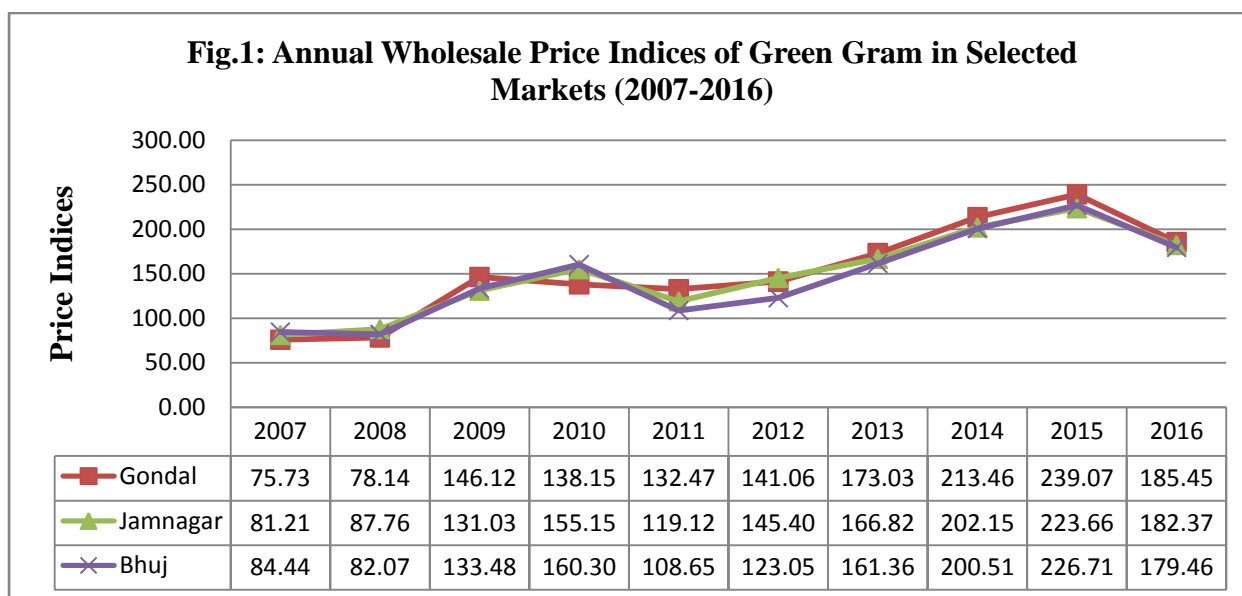
Particulars	Compound Growth Rate (CGR) in Percentage	Instability Index
Area	0.19	25.43
Production	3.22*	41.47
Yield	3.01**	29.68

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

**Inter-Year Price Behaviour**

The annual wholesale price indices of green gram during the period 2007-2016 (with base year triennium end 2007-09 =100) were presented in Fig. 1. It can be seen from the figure that the upward trend of annual prices with few exceptions was found in all the selected markets with similar pattern. The

annual price indices was continuously increased from the year 2011 to 2015 and slightly decreased in the year 2016, that means the prices of green gram was decreased in the year 2016 as compared to past two years. This may be due to the significantly increased in production and yield of green gram over the years.



The estimates of compound annual growth rate of wholesale price of green gram were presented in Table 2. The results revealed that the compound rate of increase in prices of green gram in all the selected markets were statistically significant at one per cent level of probability during study period. The prices

of green gram in Gondal, Jamnagar and Bhuj markets increased at the rate of 11.87, 10.46 and 10.23 per cent per annum, respectively. This clearly indicates that the price of green gram was significantly increased in last one decade in all the selected markets.

**Table 2.** Estimates of Compound Growth Rate of Wholesale Price Indices of Gram in Selected Markets (2007-2016).

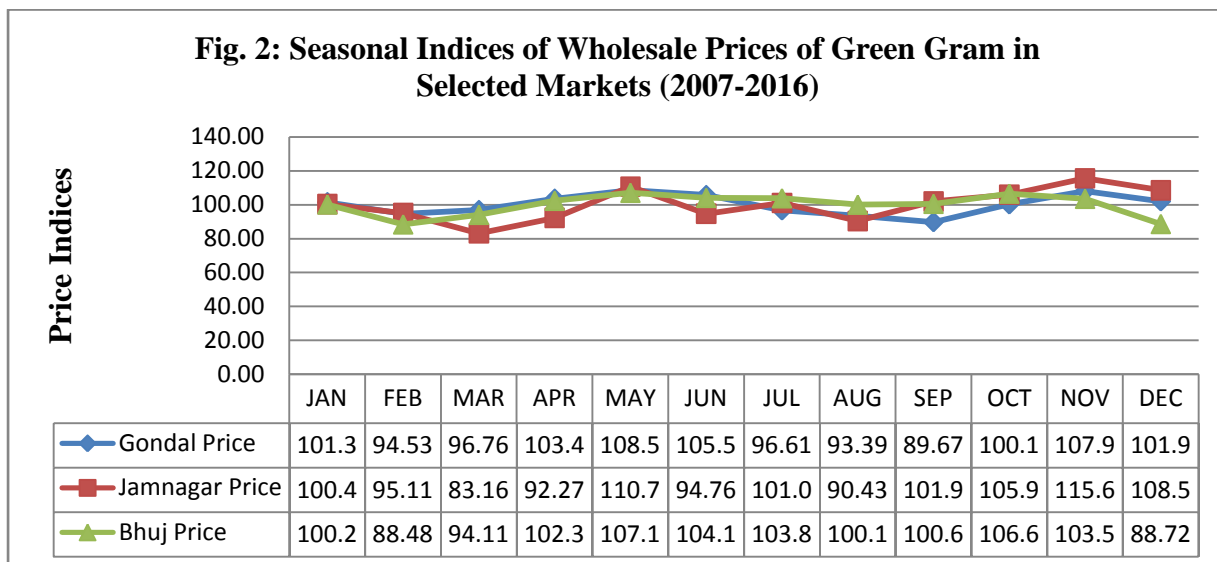
Markets	Intercept (a)	Estimates of Coefficient (b)	Compound Growth Rate (CGR) in %	R <sup>2</sup>	Adjusted R <sup>2</sup>
Gondal	1.89	0.05	11.87**	0.80	0.77
Jamnagar	1.92	0.04	10.46**	0.81	0.78
Bhuj	1.91	0.04	10.23**	0.72	0.68

\*\* Significant at 1 per cent probability level

**Intra-Year Price Behaviour**

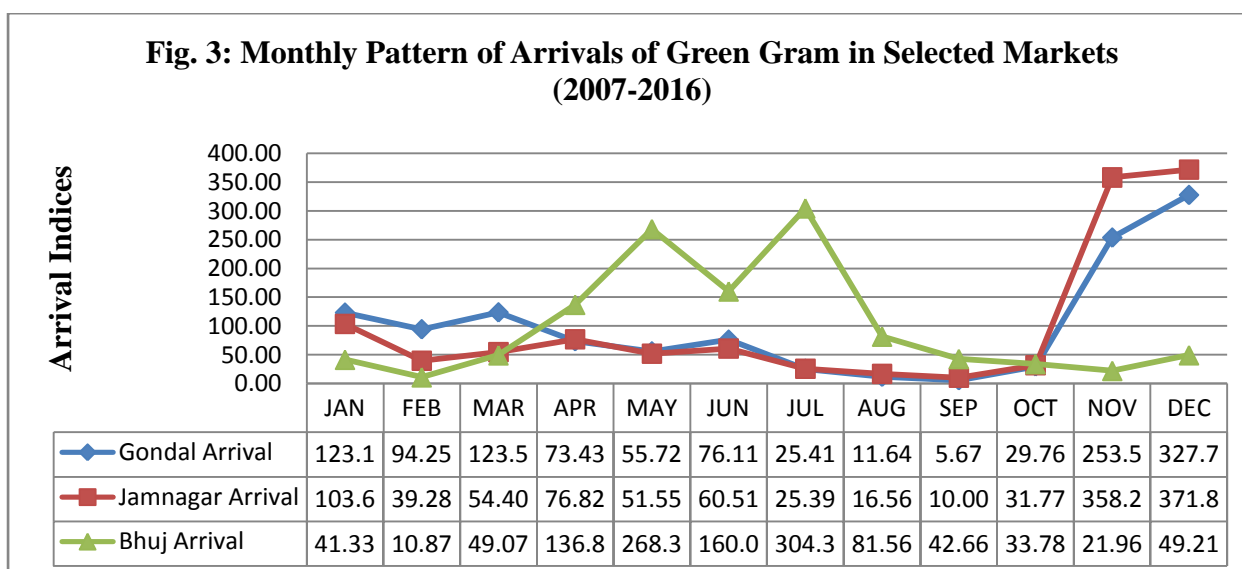
The monthly seasonal price indices of green gram in the selected markets (Gondal, Jamnagar and Bhuj) are presented in Fig. 2. The results put forth that the intra-year seasonal price indices of green gram was all most stable and showing the similar trend in all the selected markets and it varies from 86.67

(September) to 108.50 (May) in Gondal, 83.16 (March) to 115.60 (November) in Jamnagar and 88.48 (February) to 107.13 (May) in Bhuj market. It can be concluded that the price of green gram was slightly decreased in peak season and increased in off season.



The Monthly pattern of arrivals of green gram in Gondal and Jamnagar market was showing the similar pattern with highest arrival in the month of December (327.70, 371.80) and lowest in the month of September (5.67, 10.00), respectively. Whereas, in Bhuj market the arrival pattern was slightly different from these two markets with highest arrival in the

month of July (304.30) and lowest in the month of February (10.87) (Fig. 3). This may be due to the summer arrival in the Bhuj market, this clearly indicated that the arrivals of green gram were highest in peak season in all the selected markets because the farmers immediately sale the crop after harvesting period.



**Market Integration**

**Augmented Dickey Fuller Test**

The Dickey- Fuller test for stationarity of price series for green gram in selected markets of Gujarat is presented in Table 1. The t statistic value for the

ADF test at the level price for the Gondal, Jamnagar and Bhuj markets were found to be -2.011, -1.95 and -1.76 respectively which were less than the critical value hence it was insignificant and so the null hypothesis about the presence of unit root could not

be rejected. The t statistic value for the ADF test at the first difference were found to be -5.19, -3.09 and -13.53 respectively for Gondal, Jamnagar and Bhuj, since the absolute values of t statistic were more than the critical value i.e.  $5.19 > 3.85$ ,  $3.09 > 3.85$  and

$13.53 > 3.85$ , therefore the results of ADF at the first difference were significant so the null hypothesis was rejected about the presence of unit root. Thus three series were integrated of the order (I).

**Table 3.** Augmented Dickey Fuller test for stationarity of the price series

Markets	At Level	Stationary	At First difference	Stationary	Critical values (at 1% level)
Gondal	-2.011664	Non- stationary	-5.193857	stationary	-3.85
Jamnagar	-1.953845	-do-	-3.099397	-do-	
Bhuj	-1.764947	-do-	-13.53137	-do-	

**Johansen’s Co-integration Test**

After having confirmed that the price series are in fact, first difference stationarity, the next step is to examine the number of co-integration vectors. Since there were two price series (n) therefore maximum number of co-integrating vectors (n-1) was one.

The trace test rejected the null hypothesis of zero co-integrating vectors since the p value is 0 per cent which is less than 5 per cent and also the value of corresponding trace statistic is  $67.28 > 29.79$ ,  $18.99 > 15.49$  and  $3.88 > 3.84$ , it means trace statistics is higher than the corresponding critical value at 5% significance level. The null Hypothesis of three co-integrating vector was accepted because the corresponding trace statistic is higher than the corresponding critical value (Table 4).

Eigen value Test also gave the similar result. Since the probability is 0 per cent and the Maximum Eigen

Value (48.2871), (15.1186) and (3.87798) is more than the corresponding critical value (21.1316), (14.2646) and (3.84146) at 5% significance level, therefore the null hypothesis of zero co-integrating equation was rejected. Here also same result came up; the null hypothesis of three co-integrating vector was accepted because the corresponding Maximum Eigen statistic is higher than the corresponding critical value. Therefore there is three error terms in long run (Table 5).

Having confirmed that trace test procedure indicated that green gram markets were integrated with three co-integrating equations. At the same time, co-integration between the markets was confirmed with Maximum Eigen value test also 3 co-integrating equations. The existence of co- integration between markets confirmed that there was a long – run relationship among markets.

**Table 4.** Results of Unrestricted Co- integration Rank Test (Trace)

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	Prob.**
None*	67.28376	29.79707	0.0000
At most 1 *	18.99667	15.49471	0.0142
At most 2 *	3.877985	3.841466	0.0489

**Table 5.** Results of Unrestricted Co- integration Rank Test (Maximum- Eigen value)

Hypothesized No. of CE(s)	Maximum-Eigen Statistic	0.05 Critical Value	Prob.**
None*	48.2871	21.1316	0.0000
At most 1 *	15.1186	14.2646	0.0366
At most 2 *	3.87798	3.84146	0.0489

**Causality in Different Markets**

The causal relationship between the price series in Green Gram markets was approached through Granger Causality technique. The causal relationship between the price series in Green Gram markets was approached through Granger Causality technique. The findings revealed that no co-integration was existing within three pair of market (Gondal- Jamnagar, Jamnagar- Bhuj, Bhuj- Gondal). In order to know the direction of causation between selected green gram markets, Granger causality test was employed. When a co-integration relationship is present for two

variables, the Granger causality test can be used to analyze the influence of price of each market on all other markets.

Gondal market prices influence the prices at Jamnagar market and not vice-versa. Bhuj market prices influence the prices at Jamnagar market and not vice-versa. Gondal market prices influence the prices at Bhuj market and not vice-versa.

From Table 4, it could be inferred that all the market pairs exhibited bi-directional causality and prices were transmitted vice versa i.e., mutual influence was exerted by the market on each other.

**Table 6.** Results of Pair – Wise Granger Causality Test

Null Hypothesis	Obs	F- Statistics	Prob
GONDAL does not Granger Cause JAMNAGAR JAMNAGAR does not Granger Cause GONDAL	119	31.6447 1.06844	<b>1.E-07</b> 0.3034
JAMNAGAR does not Granger Cause BHUJ BHUJ does not Granger Cause JAMNAGAR	119	3.01445 58.1321	0.0852 <b>7.E-12</b>
BHUJ does not Granger Cause GONDAL GONDAL does not Granger Cause BHUJ	119	0.19971 11.5899	0.6558 <b>0.0009</b>

## CONCLUSION

The results observed that the production and yield of green gram was increased significantly in last thirty years. This shows that the production and yield of green gram was increased significantly over the years in Gujarat. The inter-year price analysis shows upward trend of annual price indices and there was a significant increase in the price of green gram was found in all the selected markets with positive and statistically significant compound growth rate during the study period. The intra-year price analysis revealed that the general pattern of seasonal variations in prices were found with increased the prices in off season and decreased in main season all most in all the selected markets. Among the three selected markets only two markets were co integrated at 5 % level of significance. The study indicated that therefore the results of ADF test at the first difference were significant so the null hypothesis was rejected about the presence of unit root. Thus three series were integrated of the order (I). The price series of all markets were stationary at their levels themselves. Trace statistic and maximum Eigen value test revealed that Gujarat Green Gram markets were found to be integrated with 3 co- integrating equations. All the market pairs exhibited bi-directional causality and prices were transmitted vice versa *i.e.*, mutual influence was exerted by the market on each other.

## REFERENCES

- Asthana, A. N. and Chaturvedi, S. K.** (1999). A little impetus needed. *The Hindu, Survey Indian Agril.*, Pp. 61-65.
- Bhardwaj, S. P., Paul, R. and Singh, K. N.** (2015). Price forecast : An instrument for improvement in agricultural production and marketing in Rajasthan – A case study of rape & mustard seeds, *Indian journal of Agricultural Marketing*. **29**(2), 164-171.
- Biswas, A., Singh, R., Gangwar, A., Zalkuwi, J. and Singh, H.P.** (2015). Inter- state market integration in rapessed and mustard in India, *Indian journal of Agricultural Marketing*. **29**(2), 92-99.
- Engle, R. F. and Granger, C. W. J.** (1987). Cointegration and Error correction: Representing estimation and testing, *Econometrica: Journal of Econometrica Society*, **55**, 251-276.
- Granger Clive, W. J.** (1969). Developments in the study of cointegrated Economic variable, *Oxford Bulletin of Economics and Statistics*, **48**, 213-228. <http://www.agmarknet.nic.in>.
- Johansen, S.** (1988). A Statistical Analysis of co integration vectors, *Journal of Economic Dynamic and Control*. **12**, 231-254.
- Kaur, J. P. and Sekhon, M. K.** (2016). Price integration in Green Gram markets of Gujarat, *Indian journal of Agricultural Marketing*. **30**(2), 11-21.
- Mohanty, S. and Styasai, K. J.** (2015). Feeling the pulse, Indian pulses sector. NABARD Rural Pulse, E book issue X July-August. [www.iipr.rcs.in](http://www.iipr.rcs.in)

# INVESTIGATION ON QUALITY OF COIR WASTES BIOCHAR FOR SOIL AMENDMENT AND SOIL CARBON SEQUESTRATION APPLICATIONS

Shalini Ramesh\* and Pugalendhi Sundararaju<sup>1</sup>

*Ph.D Scholar, Department of Bioenergy, AEC & RI, Tamil Nadu Agricultural University, Coimbatore- 641 003, Tamil Nadu, India*

<sup>1</sup>*Professor, Department of Bioenergy, AEC & RI, Tamil Nadu Agricultural University, Coimbatore- 641 003, Tamil Nadu, India*

*Received-12.03.2019, Revised-15.04.2019*

**Abstract:** In this paper, coir wastes biochar was prepared from coirwaste biomass at low temperatures (400-450°C) and the quality of the biochar was tested with reference to the International Biochar Initiative (IBI) criteria for soil amendment and soil carbon sequestration applications. The coir wastes biochar had mass yield (20.02%), H/C<sub>org</sub> (0.48), O/C (0.59), pH (7.28) and EC (0.09 dS cm<sup>-1</sup>). Carbon (%) of the coir waste biochar was found to be increased from 34.52% to 44.98%. The nitrogen (%) and sulphur (%) was found to be low in the coirwastes biochar compared to the raw biomass, indicating that it would produce less NO<sub>x</sub> and SO<sub>x</sub> emissions during combustion. The total organic carbon (%) was notably increased from 18% to 52% and follows class 2 biochars (≥30<60%) based on the criteria given by IBI. It is observed from the results that the thermo-chemically converted coir wastes biochar had greater potential and stability to sequester organic carbon in the soil because H/C<sub>org</sub> of the biochar was found to be <0.70 and all other characteristics were in the threshold criteria as declared by IBI.

**Keywords:** Coir wastes biomass, Biochar, Organic carbon, Stability, IBI criteria

## INTRODUCTION

The world's environment is being severely polluted and global temperature level has been rising up due to the continuous burning of fossil fuels for energy generation, manmade activities inefficient method of wastes disposal and changes in land use pattern resulting in enormous release of harmful green house gas (GHG) emissions to the atmosphere. The concentration of CO<sub>2</sub> in the atmosphere has increased from 277 ppm in 1750 (Le Quere *et al.*, 2016) to 413.52 ppm in 2019 (CO<sub>2</sub> now.org). Due to the changes in land use pattern, global carbon emissions were accounted for about 9% i.e. 0.9 (Gt C) with the release of 3.303 Gt CO<sub>2</sub> in the year 2014 (Butler and Montzka, 2015). From 2005 to 2014, about 44% of CO<sub>2</sub> emissions accumulated in the atmosphere, 26% in the ocean and 30% on land. From 1870 to 2014, cumulative carbon emissions totalled about 545 Gt C. Emissions were partitioned among the atmosphere (230 Gt C or 42%), ocean (155 Gt C or 28%) and the land (160 Gt C or 29%). In 2013, the largest national contributions to the net growth in total global emissions were China (58%), USA (20%) followed by India (17%). Fossil fuel emissions were 0.6% (9.735 Gt C) and 60% more than the emissions in 2013 and 1990 respectively (www.CO<sub>2</sub>.earth accessed on May 2019).

In order to reduce the consumption of fossil fuels, to lower the greenhouse emissions produced from fossil fuels and to balance the uneven distribution of energy resources in the energy portfolio, a shift to renewable energy sources is being made mandatory to ensure long term energy supplies (Unrean *et al.*, 2018).

Among all the different types of renewable energy sources, lignocellulosic biomass feedstocks are the most promising sources to produce carbon rich materials since they are the only carbon neutral sources which are abundantly available in nature, cheaper in costs and locally available for efficient fuel conversion (Iaquaniello *et al.*, 2017). The majority of the wood wastes are produced from agricultural, forestry and energy-based industries (Burgert *et al.*, 2015). In India, the annual biomass production is about 550 MT with a surplus of about 120-150 MT per annum covering agricultural and forestry residues with the energy potential of 18,000 MW ([www.mnre.gov.in](http://www.mnre.gov.in) accessed on Jan 2019). When the biomass or biomass derived fuel is burnt, it gives net zero / lower carbon dioxide emission and promotes carbon dioxide emission reduction and also helps to minimize waste disposal (Nizami *et al.*, 2017).

Recently, carbonization technology receives greater interest and it is considered as one of the most important processes since it converts the biomass into carbon rich solid product called biochar or pyrochar and releases the volatile matter in the form of gaseous product through slow pyrolysis process (Correa *et al.* 2019). This study mainly focuses on the synthesis of biochar derived from coir wastes biomass and to compare the effect of basic utility properties of coir waste biochar with reference to guidelines (Version 2.0) suggested by International Biochar Initiative (IBI, 2015) for soil amendment and soil carbon sequestration applications.

\*Corresponding Author

## MATERIALS AND METHODS

Coir wastes biomass was collected from a coirpith industry located at Pollachi, Coimbatore, Tamil Nadu, India (Latitude: 10.65°N and 77.01°E). The coir wastes was initially dried in the solar tunnel drier until it reaches the optimum moisture content (<10%). The dried coir wastes biomass was stored in the airtight zip lock covers for further characterization and biochar production.

The designed slow pyrolyzer consists of combustion zone in the lower part with grate system to collect the ash and pyrolysis zone in the upper part extended with chimney set up for the release of volatiles during pyrolysis process. According to the bulk density of the biomass and volume of the slow pyrolyzer, about 150 g of dried coirpith biomass was loaded in the pyrolytic zone. Likewise, in the combustion zone, charcoal was filled and used as a combustion fuel. The pyrolysis process was initiated by igniting the combustion fuel and the reactor was sealed immediately. After 30 min the biomass was completely converted to biochar emitting the volatile substances and enhancing the non-volatile carbon at the temperature of above 400-450°C (Prabha et al., 2015). The reactor was allowed to cool and the biochar was collected, sieved down to <2 mm and stored in the zip lock covers for further analysis.

### Characterization of biochar

The coir waste biochars was tested for category A-Basic utility properties since the test is mandatory for all biochars with reference to the standard methods developed by International Biochar Initiative (IBI) (2015) (IBI STD. version 2.1), USA. The physical

properties such as moisture content (%) were calculated by ASTM D1762-84 and particle size (nm) was determined by standard procedure. Total Carbon (%) and other elements such as Hydrogen (%), Nitrogen (%), S (Sulphur) and Oxygen (%) was determined by dry combustion method in the elemental analyzer and O is calculated by the difference of other elements from 100%. Total inorganic carbon (%) was determined by ASTM D4373. Total Organic Carbon ( $C_{org}$ ) was calculated from the difference of Total Carbon and Inorganic Carbon. The molar ratios such as H: Corg (Carbon stability) and O: C is calculated from elemental composition of the biochars. The pH, EC and liming ability of the biochars were determined as per TMECC (2001) and Rayment and Higginson (1992). The total ash (%) present in the biochar sample was determined as per the ASTM D1762-84.

## RESULTS AND DISCUSSION

The summary of the results including a comparison to the criteria set by the IBI for the coir wastes biochar are furnished in table 1. Coir wastes biochar was found to be in the threshold criterion set suggested by IBI. The moisture content (%) and particle size distribution (nm) of the coir wastes biochars were found to be 8.80% and <0.05mm.

Carbon (%) of the coir waste biochar was found to be increased from 34.52% to 44.98% with the decrease of hydrogen(%) from 3.92% to 2.12%, nitrogen(%) from 0.57% to 0.29%, sulphur(%) from 0.44% to 0% and oxygen(%) from 53.56% to 35.62% after pyrolysis.

**Table 1.** Basic utility properties for coir wastes biochar

S.No	Test Category A-Basic Utility Properties	Coir waste biomass	Coir waste biochar	IBI criteria
(a) Physical properties				
1.	Moisture content (% db)	8.97	8.80	Declaration
2.	Particle size distribution (mm)	0.0014	0.0016	Declaration if <0.5
(b) Elemental composition (% db)				
1.	Carbon (%)	34.52	44.98	NR
2.	Hydrogen (%)	3.92	2.12	NR
3.	Nitrogen (%)	0.57	0.29	Declaration
4.	Sulphur (%)	0.44	0.00**	NR
5.	Oxygen (%)	53.56	35.62	NR
(c) Organic Carbon ( $C_{org}$ ) (%)				
1.	Total Organic Carbon (%)	18.00	52.00	Class 2 : $\geq 30 < 60$ biochars
2.	Total Inorganic Carbon (%)	0.30	1.80	Declaration
3.	Total ash (% db)	7.00	17.00	Declaration
(d) Molar ratio				
1.	H: $C_{org}$	2.61	0.48	Declaration if $\geq 0.7$
2.	O:C	1.12	0.59	NR
(e) Electrochemical properties				
1.	pH	5.48	7.28	Declaration
2.	Electrical Conductivity ( $dS\ cm^{-1}$ )	0.40	0.09	Declaration
3.	Liming ability (% $CaCO_3 - eq$ )*	NA	0.30	Declaration if pH >7
(f) Proximate composition (% db)				
1.	Volatile matter (%)	62.00	33.00	NR
2.	Fixed carbon (%)	31.00	50.00	NR

3.	Higher Heating Value (MJ kg <sup>-1</sup> )	20.57	22.69	NR
4.	Biochar mass yield (%)	NA	20.02	NR

\*Liming equivalence, NR – Not Required, (% db) - % on dry basis

\*\* In trace amount not detected by the instrument

The nitrogen (%) and sulphur (%) was low in the biochar compared to the raw biomass, indicating that it would produce less NO<sub>x</sub> and SO<sub>x</sub> emissions during combustion (Neves et al., 2011). The total organic carbon (%) was notably increased 18% to 52% and which falls in the class 2 biochars (≥30<60%) based on the criteria given by IBI. The inorganic carbon (%) was increased from 0.30% to 1.80% since the ash content (%) increased from 7% to 17% when compared to parent initial biomass.

The H:C<sub>org</sub> and O:C molar ratios was found to be decreased from 2.61 to 0.48 and 1.12 to 0.59 in coir wastes biochar. The molar ratios was significantly dropped from biomass state to coal state and confirms that the pyrolysis process effectively contributed in increasing the carbon (%) in the biochar, similar results were observed by Ahmad and Subawi (2013). The use of biochar as a soil amendment is often considered as a mechanism to sequester organic carbon (C<sub>org</sub>) which remains in the soil for centuries depending on the degree of aromaticity, chemical complexity (O/C) and carbon stability (H/C<sub>org</sub>) of the biochars (Spokas, 2010). The molar ratios of the thermo chemically converted coirwaste biochar was below 0.7 (H/C<sub>org</sub> <0.7) and declared with the criteria given by IBI.

The pH of the coir wastes biomass was acidic (5.48) than the coir wastes biochar (7.28). Most of the biochars had alkaline pH. The EC (dS cm<sup>-1</sup>) of the coirwaste biochar was found to be decreased. The pH and EC of the biochars were observed to increase at higher temperatures (600-800°C) and decrease at lower temperatures (400-500°C), and the results were aligned with Al-Wabel et al. (2013). The volatile matter(%) of the biochar was found to be decreased from 62% to 33% due to the release of volatiles into the atmosphere during pyrolysis process with increase in fixed carbon(%) from 31% to 50% with increased HHV(MJ kg<sup>-1</sup>) from 20.57-22.69 MJ kg<sup>-1</sup> compared to raw biomass. A reduction percentage of 53.22% volatile matter was observed before and after pyrolysis indicating that gaseous fuels present in the coir wastes biomass was released to the atmosphere. The average yield of the coir wastes biochar was varied from raw biomass and found to be 20.02%. When the temperature increased from 200-500°C, the biochar yield decreases from 99.3% to 26.8% in wheat straw biochar and 98% to 35.8% in pig manure biochar (Liu et al., 2015). Combination of biochars with high ash content and low volatile matter could give increased biochar mass yield (%) as per the results given by Djousse Kanouo et al., (2017) for eucalyptus tree bark biochar (68%) and corncob biochars (33%). The proximate composition results were consistent with the oak and green house

woody biomass derived biochars which had fixed carbon (>50%), volatile matter (<30%) and ash content (<20%) (Weidemann et al., 2018).

## CONCLUSION

The quality of the coir wastes biochar was tested and found that coir waste biomass is one of the potential lignocellulosic feedstocks for soil amendment and soil carbon sequestration applications. The coir wastes biochar prepared at low temperatures would be more reactive in soil and exhibits higher molar ratios that implies more diversified organic molecules with more O-containing functional groups which are easily bio-degradable and also has larger ion-exchange capacity than the biochars prepared at higher temperatures.

## ACKNOWLEDGEMENT

The authors sincerely thank the Department of Bioenergy, TNAU, Coimbatore for providing advanced lab facilities and the DST-INSPIRE Scheme, New Delhi, India for financially supporting to conduct research by providing research grants.

## REFERENCES

- Ahmad, M. and Subawi, H.** (2013). New Van Krevelen diagram and its relation with the heating value of biomass. *Res.J.Agric.Environ. Manag*, 2, 295-301.
- Al-Wabel, M.I., Al-Omran, A., El-Naggar, A.H., Nadeem, M. and Usman, A.R.A** (2013). Pyrolysis temperature induced changes in characteristics and chemical composition of biochar produced from conocarpus wastes. *Bioresour. Technol.*, 131, 374-379.
- ASTM D1762-84.** 1990. Standard method for chemical analysis of wood charcoal.
- Butler, J.H. and Montzka, S.A** (2015). The NOAA Annual Greenhouse Gas Index (AGGI). Published online <http://www.esrl.noaa.gov/gmd/aggi/aggi.html>.
- Correa, C. R., Hehr, T., Rauscher, Y., Alhnidi, M. J and Kruse, A.** (2019). Biomass Carbonization - An experimental comparison between pyrolysis and hydrothermal carbonization. *Journal of Analytical and Applied Pyrolysis*. doi:10.1016/j.jaap.2019.03.007.
- Djousse Kanouo, B. M., Allaire, S. E. and Munson, A. D** (2017). Quality of biochars made from eucalyptus tree bark and corncob using a pilot-scale retort kiln. *Waste and biomass valorization*, 9(6), 899–909. doi:10.1007/s12649-017-9884-2

- Iaquaniello, G., Centi, G., Salladini, A., Palo, E., Perathoner, S and Spadaccini, L.** (2017). Waste-to-methanol: process and economics assessment. *Bioresour. technol.* 243, 611-619.
- IBI.** (2015). Standardized product definition and product testing guidelines for biochar that is used in soil. IBI biochar standards. (Version 2.1).
- Le Quere, C., Andrew, R. M., Canadell, J. G., Sitch, S., Korsbakken, J. I., Peters, G. P., Manning, A. C., Boden, T. A., Tans, P. P., Houghton, R. A., Keeling, R. F., Alin, S., Andrews, O. D., Anthoni, P., Barbero, L., Bopp, L., Chevallier, F., Chini, L. P., Ciais, P., Currie, K., Delire, C., Doney, S. C., Friedlingstein, P., Gkritzalis, T., Harris, I., Hauck, J., Haverd, V., Hoppema, M., Klein Goldewijk, K., Jain, A. K., Kato, E., Körtzinger, A., Landschützer, P., Lefèvre, N., Lenton, A., Lienert, S., Lombardozzi, D., Melton, J. R., Metzl, N., Millero, F., Monteiro, P. M. S., Munro, D. R., Nabel, J. E. M. S., Nakaoka, S.-I., O'Brien, K., Olsen, A., Omar, A. M., Ono, T., Pierrot, D., Poulter, B., Rödenbeck, C., Salisbury, J., Schuster, U., Schwinger, J., Séférian, R., Skjelvan, I., Stocker, B. D., Sutton, A. J., Takahashi, T., Tian, H., Tilbrook, B., van der Laan-Luijkx, I. T., van der Werf, G. R., Viovy, N., Walker, A. P., Wiltshire, A. J. and Zehle, S.** (2016). Global Carbon Budget. *Earth Syst. Sci. Data*, 8, 605-649, <https://doi.org/10.5194/essd-8-605-2016>.
- Liu, W.J, Jaing, H and Yu, H.Q** (2015). Development of biochar based functional materials toward a sustainable platform carbon material. *Chem.Rev.*115(2), 12251-12285. American chemical society.
- Neves, D., Thunman, H., Matos, A., Tarelho, L. and Gomez Barea, A.** (2011). Characterization and prediction of biomass pyrolysis products. *Prg. Energy Combust.Sci.*37, 611-630.
- Nizami, A. S., Rehan, M., Waqas, M., Naqvi, M., Ouda, O. K. M., Shahzad, K., Miandad, R., Khan, M.Z., Syamsiro, M., Ismail, I.M.I and Pant, D.** (2017). Waste biorefineries: enabling circular economies in developing countries. *Bioresour. technol.* 241, 1101-1117.
- Prabha, B., Pugalendhi, S. and Subramanian, P.** (2015). Design and development of semi-indirect non-electric pyrolytic reactor for biochar production from farm waste (Vol. 85). *Indian Journal of Agricultural Sciences* 85(4):585-591.
- Rayment, G.E. and Higginson, F.R.** (1992). *Australian Laboratory Handbook of Soil and Water Chemical Methods*. Reed International Books, Australia/ Inkata Press, Port Melbourne.
- Spokas, K.A.** (2010). Review of the stability of biochar in soils: predictability of O:C molar ratios. *Carbon Manag.* 2010, 1, 289-303.
- Unrean, P., Lai Fui, B.C., Rainawati, E. and Acda, M** (2018). Comparative techno-economic assessment and environmental impacts of rice husk-to-fuel conversion technologies. *Energy*. doi:10.1016/j.energy.2018.03.112.
- US Composting Council and US Department of Agriculture** (2001). Test methods for the examination of composting and compost. (TMECC) Thompson W.H. (ed.) <http://compostingcouncil.org/tmecc/> (Accessed January 2012).
- Weidemann, E., Buss, W., Edo, M., Masek, O and Jansson, S.** (2017). Influence of pyrolysis temperature and production unit on formation of selected PAHs, oxy-PAHs, N-PACs, PCDDs, and PCDFs in biochar—a screening study. *Environmental Science and Pollution Research*, 25(4), 3933–3940. doi:10.1007/s11356-017-0612-z.

## PHYSICAL CHARACTERISTICS AND CHEMICAL CONSTITUENTS IN CRUDE PLANTS METHANOLIC EXTRACT OF SELECTED MEDICINAL PLANTS BASED ON LITERATURE AND TRADITIONAL KNOWLEDGE

V.P.S. Bhadauria\*, and Varsha Gupta<sup>1</sup>

*Department of Chemistry, St. John's College, Agra-282002, India*

<sup>1</sup>*Agronomy, RVSKVV, Gwalior*

*Chapter at Foundation for Innovative Research, Sustainable Technologies and Intellectual Property*

*(FIRSTIP) [www.firstip.org](http://www.firstip.org)*

*Email: [yps.chem@gmail.com](mailto:yps.chem@gmail.com)*

*Received-06.04.2019, Revised-26.04.2019*

**Abstract:** Eucalyptus globules yielded highest in case of leaves extract, while in case of fruit extract Annona squamosa yield highest and in case of seed extract Butea frondosa yield was highest. Phytochemical evaluation showed that Ailanthus excels (leaves) extract was positive for alkaloids, flavonoids, tannins, phenolic compounds and triterpenoids, while in Calotropis procera (leaves) methanolic extract alkaloids, flavonoids and tannins were identified and in case of Chenopodium album (seeds) alkaloids, saponins, glycosides, fixed oils and tannins were present.

**Keywords:** Phytochemical, Medicinal plants, Alkaloids, Flavonoids, Tannins, Phenolic compounds, Triterpenoids

### INTRODUCTION

Indigenous medicine in the root of nearly all traditional and modern system of medicines in the world. Early accounts of medicinal use of plant can be found in ancient Vedic text, the Rigveda (4500 BC – 1600 BC) and detailed account of instructions and information to be used for prevention and treatment of diseases is found in Ayurveda (2500 – 6000 BC). “Shusrutha Samhita” and “Charak Samhita” followed Ayurveda. Later it made a considerable progress in knowledge of medicinal plants during Buddhist period. Its influence infiltrated even to Egypt, Greece and Rome. The hidden treasures, which are still lying in the indigenous system of Indian Medicine used for curing many diseases in the past, still hold good for their remedial quality.

Plants are the miracle laboratories of nature to provide various kinds of drugs and medicines for maintenance of optimum health and vitality. So far, more than 100,000 biologically active secondary plant compounds have been isolated from higher plants, with most of these diverse structures falling into four main chemical classes, the phenolics (phenols, flavonoids, quinines, tannins and lignins), terpenoids (monoterpenes, sesquiterpene lactones, diterpenes, saponins and others), sulphur compounds (glucosinlates, disulphide and acetylenic thiophenes) and nitrogen compounds (alkaloids, amines, non-protein amino acids and cynogenic glycosides) (Chung AC 1995). India is known for its biodiversity as of today about 1.26 lakhs plants species have been catalogued (Chopra & Chopra 1955).

Indigenous medicines continue to have strong roots amongst local community and to some extent

\*Corresponding Author

privilege in urban locality. Zoopharmacognosy (the study of animal research of certain herbs to treat diseases) has revealed that instinct consistently provides certain animals with therapeutic information allowing them to use this natural system of medicine themselves. This system of medicines is of specific value in developing countries where precious allopathic veterinary medicines are often beyond the reach of livestock producers and still more than 80 percent of livestock population is deprived of modern and systemic approach of high tech allopathic treatment (Mc. Corkle CM 1982). Compare costs and benefits of choosing indigenous medicine in India where the commercial exploitation of herbal medicine has started at a long level, again showing their positive affect in the therapeutic regimen. At the same time, increased use of herbal medicine draws attention of scientific community towards over exploitation of plant resources.

Superiority of these drugs in term of “safe Drug” with parallel efficacy having without or least side effect over high tech allopathic drugs can force more attention and personal to research, development and extension of this system as scarcity of systemic literature.

However, several modern researchers elaborated the use of natural medicinal plant drugs, being safer than synthetic chemicals because there is no side effect, less cost, no incidence of resistance and easily available at the door of farmers (Misri et.al. 2002, Malairajanet.al. 2006 & Kosalge and Fursule 2009). Moreover, Synergistic effect of their active ingredients and presence of minerals and salts are also beneficial in the treatment of *Haemonchus contortus* infestation in animals.

## MATERIALS AND METHODS

### Selection of experimental plants:

Plants were selected on the basis of literature and indigenous traditional knowledge. The selected plants were *Aegle marmelos*, *Ailanthus excelsa*, *Annona squamosa*, *Bauhinia variegata*, *Butea frondosa*, *Calotropis gigantean*, *Calotropis procera*, *Chenopodium album*, *Chrysanthemum indicum*, *Cuscutta reflexa*, *Datura stramonium*, *Euphorbia hirta*, *Eucalyptus globules* and *Ficus religiosa*. All the information regarding taxonomy and action are collected from the book "Encyclopedia of Indian Medicinal Plants" written by Dr. C.P. Khare.

### Collection and processing of raw plant material:

The selected plant material were collected from the Botanical garden of school of Life Sciences, Khandari, Agra (U.P) during March – April 2013 and some of them were purchased from the local market. Plant materials were authenticated by taxonomic characteristics and consultation with experts. The selected plant materials were washed with clean water and allowed to shade dry for about 2-3 weeks. The dried materials were crushed in an electric grinder to coarse powder.

### Preparation of crude plant extracts:

Crude plant extract was prepared by Soxhlet extraction method. About 100 gm of powder material was uniformly packed in to a thimble and run in Soxhlet extractor. It was exhaustively extracted with methanol for the period of about 48 hours or 22 cycles or till the solvent in the siphon tube of an extractor become colorless. After the extracts were filtered with the help of filter paper and solvent evaporated in rotator and vacuum evaporator (Heidolph) to get the syrupy consistency. The residue was dried over anhydrous sodium sulphate to remove trace of alcohol. Then extract kept in refrigerator at 4°C for qualitative phytochemical analysis. The percent yield of different extracts was calculated.

### Determination of extraction yield (% yield):

The yield (% w/w) from all the dried extracts was calculated as :

$$\text{Yield (\%)} = (W1 \times 100) / W2$$

Where W1 is the weight of the extract obtained after drying of solvent and W2 is the weight of the plant powder.

### Phytochemical analysis of different crude extract

Extracts in different solvents were tested for the presence of active principle such as steroids, Carbohydrates, fixed oils, tannins and phenolic, flavonoids, saponins, alkaloids, glycosides, triterpenoids and proteins. Standard procedures (Debelo A 2002).

were used for phytochemical analysis.

## RESULT AND DISCUSSION

### Yield of crude methanolic extract

In present study total of seventeen crude methanolic extracts were prepared from using different plant parts. *Eucalyptus globules* (Leaves) Yield highest (28.42%), while *Bauhinia variegata* (leaves) yield was lowest (18.67%). In case of fruit extract highest yield (33.40%) was in *Annona squamosa* followed by *Aegle marmelosa* (32.23%) and in case of seed extract *Butea frondosa* yielded highest (30.67%) while *Chenopodium album* yielded lowest (18.45%). Difference of percent yield of extraction product among different extraction might be due to the solubility of various ingredients and method and type of extraction used (Paech & Tracy 1955). The details of all extract about percent yield and physical characteristics are given in Table 1.

### Phytochemical analysis

Phytochemical analysis of different extracts were conducted by different tests to know the presence of active constituents like alkaloids, flavonoids, saponins, steroids, carbohydrate, glycosides, tannins, phenolic compounds, protein and triterpenoids.

Phytochemical analysis of methanolic extracts of *Ailanthus excels* (leaves) showed presence of alkaloids, flavonoids, tannins and phenolic compounds and triterpenoids while in case of methanolic extract of *Annona squamosa* (leaves) flavonoids, tannins and triterpenoids were present, methanolic extract of *Annona squamosa* (seeds) showed alkaloids, carbohydrates, tannins and fixed oils.

Methanolic extract of *Aegle marmelos* (leaves) showed the presence of alkaloids, flavonoids and triterpenoids during analysis while methanolic extract of *Butea frondosa* (seeds) alkaloids, tannins, and fixed oils were present, *Bauhinia variegata* (leaves) showed presence of alkaloids, flavonoids and tannins.

In case of methanolic extract of *Calotropis procera* and *Calotropis gigantean* (leaves) alkaloids, flavonoids and tannins were present in both the extracts while in methanolic extract *Cuscutta reflexa* (whole plant) only alkaloids and triterpenoids were present. In the extract of *Chrysanthemum indicum* (leaves) three compounds alkaloids, flavonoids and triterpenoids were present, while in seed of *Chenopodium album* alkaloids, saponins, glycosides, fixed oils and tannins were present, methanolic extract of *Datura stramonium* (leaves) showed the presence of alkaloids, flavonoids and tannins.

Methanolic extract of *Euphorbia hirta* (leaves) contains alkaloids, flavonoids, and tannins where as in methanolic extract of *Eucalyptus globules* (leaves) alkaloids, flavonoids, tannins and triterpenoids were present. *Ficus religiosa* (bark) contains alkaloids, carbohydrates and tannins. Results are portrayed in Table 2.

**Table 1.** Physical characteristics and percent yield of crude methanolic extract of various plants

S.No.	Extracts with common name	Botanical Name	Nature	Color	Odour	% yield
1.	Ardu leaves	<i>Ailenthus excelsa</i>	Non sticky	Drak green	Aromatic	24.42
2.	Sharifa leaves	<i>Annona squamosa</i>	Oily	Solid green	Aromatic	21.50
3.	Sharifa fruit	<i>Annona squamosa</i>	Sticky	Yellowish brown	Peculiar	33.40
4.	Bel leaves	<i>Aegel marmelos</i>	Sticky	Brownish	Peculiar	32.23
5.	Palas seeds	<i>Butea frondosa</i>	Sticky	Yellowish brown	Aromatic	30.67
6.	Kachnar leaves	<i>Bauhinia varigata</i>	Non sticky	Balckish green	Aromatic	18.67
7.	Aak leaves	<i>Calotropis procera</i>	Non sticky	Dark green	Aromatic	21.50
8.	Aak leaves	<i>Calotropis gogantea</i>	Non sticky	Balckish green	Aromatic	19.10
9.	Amar bel whole plant	<i>Cuscutta reflexa</i>	Sticky	Brownish	Peculiar	22.38
10.	Guldaudi leaves	<i>Chrysanthemum indicum</i>	Sticky	Balckish green	Aromatic	24.32
11.	Bathua seeds	<i>Chenopodium album</i>	Sticky	Brownish	Aromatic	18.45
12.	Dhatura	<i>Datura stramonium</i>	Non sticky	Blackish green	Aromatic	22.87
13.	Dudhi leaves	<i>Euphorbia hirta</i>	Non sticky	Brownish	Peculiar	24.72
14.	Peepal leaves	<i>Ficus religiosa</i>	Non sticky	black	Aromatic	27.23
15.	Eucalyptus leaves	<i>Eucalyptus globulus</i>	Non sticky	Yellowish brown	Peculiar	28.42

**Table 2.** Chemical constituents in different crude plants methanolic extract

S.No.	Plant extract	Plant constituents									
		Alkaloids	Flavonoids	Saponins	Carbohydrates	Steroids	Glycosides	Fixed Oils	Tannins & Phenolic	Protein & A.Acid	Triterpenoids
1.	<i>Ailenthus excels</i> (leaves)	+	+	-	-	-	-	-	+	-	+
2.	<i>Annona squamosa</i> (leaves)	+-	+	-	-	-	-	-	+	-	+
3.	<i>Annona squamosa</i> (seeds)	+	-	-	+	-	-	+	+	-	-
4.	<i>Aegel marmelos</i> (leaves)	+	+	-	-	-	-	-	+	-	-
5.	<i>Butea frondosa</i> (seeds)	-	+	-	-	-	-	+	+	-	-
6.	<i>Bauhinia varigata</i> (leaves)	+	+	-	-	-	-	-	+	-	-
7.	<i>Calotropis procera</i> (leaves)	+	+	-	-	-	-	-	+	-	+
8.	<i>Calotropis gogantea</i> (leaves)	+	+	-	-	-	-	-	+	-	+
9.	<i>Cuscutta reflexa</i> (whole plant)	+	-	-	+	-	-	-	-	-	+
10.	<i>Chrysanthemum indicum</i> (leaves)	+	+	-	-	-	-	-	-	-	+
11.	<i>Chenopodium album</i> (seeds)	+	-	+	-	-	+	+	+	-	-
12.	<i>Datura stramonium</i> (leaves)	+	+	-	-	-	-	-	+	-	-
13.	<i>Euphorbia hirta</i> (leaves)	+	+	-	-	-	-	-	+	-	-
14.	<i>Ficus religiosa</i> (bark)	+	-	-	+	-	-	-	+	-	+
15.	<i>Eucalyptus globules</i> (leaves)	+	+	-	-	-	-	-	+	-	+

It was observed from the above observations that the presence of the alkaloids, flavonoids and tannins were necessary for anthelmintic activity. It was interesting to know that the absence of amines in the methanolic extract of all the plants which indicates towards the safety of feeding, because amines are usually toxic substance and this observation was

further supported by (Thanabhorn et.al. 2006, Rajesh and Latha 2004 & Gupta and Mishra 2006).

## REFERENCES

**Chung, A.C.** (1995). Antimicrobial Agents. *Chemother.*, **39**: 2235-2238

- Chopra, R.N. and Chopra, I.C.** (1955). A review of work on Indian medicinal plants. I.C.M.R. special reports series, pp 102
- Mc. Corkle, C.M.** (1982). Management of animal health and disease in an indigenous anderson community SRC RSP Technical report No. 4 Department of Rural Sociology, University of Missouri, Columbia, Missouri, USA pp 106.
- Misri, J., Vihan, V.S., Kumar, A. and Sharma, D.K.** (2002). Evaluation of anthelmintic properties of *M. azedarach* (Bakain) on experimental *H. contortus* infection in goats. Indian J. Vet. Med., **22** (2), 4-6
- Malairajan, P., Gopalakrishnan., Geetha., Narasimhan, S., Jessi., Kala and Ven. K.** (2006). Analgesic activity of some Indian medicinal plants. J. Ethnopharmacol., **106**(3): 425-428.
- Kosalge, S.B. and Fursule, R.A.** (2009). Investigation of ethnomedicinal claims of some plants used by Tribals of Satpuda Hills in India. J. Ethnopharmacol., **121**(3): 456-461.
- Debela, A.** (2002). Manual of Phytochemical screening of medicinal plants. Ethiopian Health and Nutrition Research Institute, Addis Ababa, Ethiopia, 35-47
- Paech, K. and Tracy, M.V.** (1955). Modern methods of plant analysis. III.
- Thanabhorn, S., Jenjoy, K., Thamaree, S., Ingkaninan, K. and Panthong, A.** (2006). Acute and subacute toxicity study of the ethanol extract from *Lonicera japonica*. J. Ethnopharmacol., **107**: 370-373
- Rajesh, M.G. and Latha, M.S.** (2004). Preliminary evaluation of the antihepatotoxic activity of Kamilari, a ployherbal formulation. J. Ethnopharmacol., **91**: 99-104.
- Gupta, A.K. and Mishra, N.** (2006). Hepatoprotective activity of aqueous ethanolic extract of *Chamomile capitula* in paracetamol intoxicated albino rats. Am. J. Pharmacol. Toxicol., **1**: 17-20.