DALBERGIA SISSOO + CYMBOPOGON FLEXUOSUS BASED AGRO FORESTRY SYSTEM FOR DEVELOPMENT OF ENTISOLS IN CHHATTISGARH

Sajiwan Kumar*

M. N. Naugraiya**

Abstract

In Chhattisgarh State (India), Red lateritic soil popularly known as Bhata lands (*Entisols*), is very common feature and as an estimate it's to be around 20 per cent of total area in central plains of Chhattisgarh. These Bhata lands have gentle slopes and undulating topography with gravel's and sub-soil layers forming hard and compact lateritic pans at places. Rehabilitation of such type of degraded lands can be done by revegetation with multipurpose trees/woody species/perennial plants. The present investigation was conducted on the Red lateritic wasteland at Dr. Richharia Research and Instructional Farm, Baronda, Department of Forestry, Indira Gandhi Krishi Vishwavidyalaya, Raipur (CG) during two consequent years *i.e.*, 2007-08 and 2008-09. *Cymbopogon flexuosus* was cultivated in rain fed condition as an intercrop under 10 year old *Dalbergia sissoo* and sole crop in open field with an application of 30 kg N, 20 kg P & K comprising eight treatments under split plot design having three replications and production performance of Lemon grass with physical-chemical properties of soil were studied.

The physical and chemical properties of soil were found in higher ranged under sole cropping system with statistically significant variation and there was in order of 5.72 to 6.12 for pH; 33.26 to 46.12 per cent for water holding capacity, 0.61 to 0.78 per cent for organic carbon; 151.89 to 182.97 kg ha^{-1} for available N in soil; 11.82 to 18.52 kg ha^{-1} for available P and 80.02 to 108.04 kg ha^{-1} for available potassium in soil. Nutrients status of open barren land was also recorded which was very poor in fertility level as compared to other cropping systems.

Keywords: Entisols ;Bhata soil;Waste land; Aromatic plants; Fertilizer; Agroforestry; *Dalbergia sissoo; Cymbopogon flexuosus*, etc.

Author correspondence:

Dr. Sajiwan Kumar

SOS in Forestry &Wildlife,

Bastar Vishwavidyalaya, Jagdalpur - 494001

1. Introduction

A multitude of benefits like nutrient re-cycling, minimization of soil water evaporation, provision of food, wood and fertilizer (Green manures) has been attributed through the land use system of agro forestry (Myers,1980). Besides intercropping increase the yield and net profit it also curtails the cost of cultivation. It also helps in reducing the problems of weed, pest and disease management to some extent (Loomis and Whitman, 1983).

Out of the India's total 329 million hectare geographical area, 187.7 m ha (57%) land suffers from various kinds of degradation problems (Paroda, 1998) comes under wastelands. In Chhattisgarh State (India), Red lateritic soil popularly known as Bhata lands (*Entisols*), is very common feature and as an estimate it to be around 20 per cent of total area in central plains of Chhattisgarh (Naugraiya *et al.* 2005). These Bhata lands have gentle slopes and undulating topography (Pofali and Bhattacharjee, 1970) with gravel's and sub-soil layers forming hard and compact lateritic pans at places (Singh and Totey, 1985). Rehabilitation of such type of degraded lands can be done by revegetation with multipurpose trees/woody species/perennial plants (Naugraiya and Puri, 1997). Looking to the above facts and figures, the choice of woody species plays a key role in such degraded land. Hence, suitable species should be grown to produce biomass for community uses and also improvement of the soil health. The importance of tree plantations is already known for their ability to restore soil fertility and for amelioration of microclimatic conditions (Singh *et al.* 2002).

Dalbergia sissoo Roxb. (Leguminosae, subfamily Papilioloideae) a medium to large deciduous tree with a light crown is reproduced by seeds and root suckers (Chaturvedi, 2001). It is an important multipurpose tree and widely used in different agroforestry system of India. However it can also grow in slightly saline soils and it is extensively planted for reclamation

of wasteland. Lemon grass scientifically known as *Cymbopogon flexuosus* belongs to the family Poaceae is a perennial grass about 2 m tall. The essential oil of lemon grass having its chief constitutes Citral is used in perfumaric and flavouring industries as well as in synthesis of vitamin A, and aromatherapy. Hence looking to the importance of *D. sissoo* and *C. flexuosus* as a high value crops the present investigation was under taken to investigate the influences of these two combinitation under agroforestry system on *Entisols*.

2. Research Method

The present study was conducted in 10 years old plantation of *Dalbergia sissoo* Roxb. based agroforesty system in *Entisols* for two years of cropping seasons *i.e.* 2007-08 and 2008-09 at Dr. Richharia Research and Instructional Farm, Baronda, Department of Forestry, IGKV, Raipur (CG). The study site falls under the central region of Chhattisgarh plains agro-climatic zone. The plantation of *D. sissoo* at the spacing of 5 x 5 m was established in the year 1998; however under storey crop of *C. flexuosus* was introduced in July 2007 as an intercrop in interspace. The climate of study site is dry humid sub-tropical with an average annual rainfall of 1250 mm. About 80 percent of the annual rainfall is received from south- west monsoon during June to mid August. The mean monthly maximum temperature varies from 13.2^{0}C in December to 18.3^{0}C in May with maximum temperature goes beyond 45^{0}C in May and minimum below 10^{0}C in December. The relative humidity lies between 70-90 per cent from mid June to March end.

The experiments were carried out on eight different combination of NPK fertilizer @ 0, 20, 30 kg/ha comprised of following 8 treatments - ($\mathbf{N_0P_0K_0}$, $\mathbf{N_{30}P_0K_0}$, $\mathbf{N_0P_{20}K_0}$, $\mathbf{N_0P_0K_{20}}$, $\mathbf{N_{30}P_{20}K_{20}}$, $\mathbf{N_{30}P_0K_{20}}$, $\mathbf{N_0P_{20}K_{20}}$ and $\mathbf{N_{30}P_{20}K_{20}}$) with three replications in split plot design with assigned intercrop and sole crop in the main plot and fertilizers combination in the sub plot. Fertilizers was applied in two split doses during planting *i.e*. July/Aug and followed by 45 days after planting (second dose). The sub plots were treated by fertilizing through Urea, Phosphorus through SSP and Potash at the rate of 30 kg N/ha, 20 kg P/ha, and 20 kg K/ha. Disease free and healthy rooted slips of *C. flexuosus* was transplanted at a distance of one meter spacing in both as intercrops as well as in sole crops and given light irrigation.

Analysis of physical and chemical characteristics of soil, samples were collected from 16 plots comprising eight treatments of fertilizers under *Dalbergia sissoo* based agroforestry system and solo crop (Lemongrass) as well as one open barren field (without any crop) at the depth of 15 to 30 cm, with the help of soil agar. The sample was collected randomly from four points in each plot and bulk of the four samples was used for analysis. The samples were dried in hot air oven at 105^0C. Well crushed soil passed through 2 mm sieve and stored. The soil sample analyzed for their physico-chemical properties by using standard methods (AOAC, 1975) of analysis.

3. Results and Analysis

In the present study, the status of soil nutrients at different intervals mainly before and after harvesting of Lemon grass were compared and analyzed for N, P, K and organic carbon etc. in sole *C. flexuosus*, sole *D. sissoo* and their intercrop under agroforestry system as well as adjacent barren land, for consistently two years of cropping season in 2007-2008 and 2008-09 and data are presented and analyzed in Table No.1 & 2.

Soil characteristics during cropping season 2007-08

Soil samples should be collected during the cropping season 2007-08 of *C. flexuosus* was analyzed for its physical and chemical characteristics as per standard methods and presented in Table (1). Effect of cropping system on soil water holding capacity during the year 2007-08 was found statistically significant. The maximum water holding capacity was observed in *D. sissoo* + *C. flexuosus* agro forestry system (45.62 %) and minimum was observed in sole cropping of *C. flexuosus* (36.13 %). However, the fertilizer effect on water holding capacity was ranged between 30.30 to 52.08 per cent. The maximum water holding capacity of 52.08 per cent was recorded in treatment T_4 ($N_0P_0K_{20}$) and minimum of 30.30 per cent in T_1 ($N_0P_0K_0$) with statistically significant variation ($P<0.05$ %). The water holding capacity in rest of the fertilizers treatment was found in order of T_7 (47.08 %) > T_8 (45.29 %) > T_6 (42.53 %) > T_2 (38.95 %) > T_5 (36.70 %) > T_3 (34.20 %) presented in Table 1. Effect of cropping system on soil pH showed that in sole cropping of *C. flexuosus* low and higher pH *i e.*, 6.12 was observed in *D. sissoo* + *C. flexuosus* based agro forestry. Effect of fertilizer on soil pH showed statistically non significant variation ranged from 5.50 to 6.52. The maximum soil pH of 6.52 was observed in treatment T_5 ($N_{30}P_{20}K_{20}$) and minimum of 5.50 in treatment T_1

($N_0P_0K_0$). The pH in rest of fertilizers treatments was found in order of T_7 (6.42) > T_8 (6.34) > T_6 (6.27) > T_4 (5.92) > T_3 (5.69) > T_2 (5.53) presented in Table No.1.

The availability of organic substances in its bio- degradable forms are found to be responsible to build a rich humus soil. The data with respect to availability of organic carbon under cropping system it revealed that sole cropping of *C. flexuosus* were recorded maximum of 0.61 per cent organic carbon and minimum of 0.55 per cent was determined in *D. sissoo* + *C. flexuosus* based agro forestry system with statistically significant differences (P<0.05 %) (Table1). The fertilizer effect on availability of organic carbon in both the cropping systems was ranged between 0.82 to 0.37 per cent with statistically significant differences. The maximum organic carbon was determined in treatment T_8 ($N_{30}P_{20}K_{20}$) with 0.82 % and minimum under treatment T_1 ($N_0P_0K_0$) with 0.37 %, while in rest of fertilizers treatment, the organic carbon was found in order of T_5 (0.66 %) > T_7 (0.64 %) > T_6 (0.64 %) > T_4 (0.60 %) >T_3 (0.48 %) >T_2 (0.43 %). (Table No.1)

Effect of cropping system on available nitrogen was found maximum 163.57 kg N/ha in soil under sole crop of C. flexuosus and minimum 151.89 kg N/ha was under *D. sissoo* + *C. flexuosus* based agroforestry system with statistically significant variation. Effect of fertilizer on available nitrogen in soil under both the cropping system during 2007-08 was ranged between 181.62 to 123.85 kg N/ha with maximum 181.62 kg N/ha in (T_8) $N_{30}P_{20}K_{20}$ and followed by T_6 (173.88 kg N/ha), T_5 (170.61 kg N/ha), T_2 (163.51 kg N/ha), T_7 (161.76 kg N/ha), T_4 (149.07 kg N/ha), T_3 (137.55 kg N/ha), while the minimum 123.85 kg N/ha was found in $N_0P_0K_0$ (T_1) presented in Table1. Effect of cropping system on available phosphorus in soil revealed that the maximum available phosphorus of 15.81 kg P/ha was observed in sole crop of *C. flexuosus* and minimum of 11.82 kg P/ha was observed in *D. sissoo* + *C. flexuosus* based agroforestry system. The fertilizer effect on availability of phosphorus in soil of both the crop field during the year 2007-08 was ranged between 8.72 to 19.39 kg P/ha. The perusal of data revealed that the maximum level of available phosphorus was observed 19.39 kg P/ha in (T_8) $N_{30}P_{20}K_{20}$ followed by T_7 (19.16 kg P/ha), T_6 (15.47 kg P/ha), T_5 (15.25 kg P/ha), T_3 (12.81 kg P/ha), T_4 (11.12 kg P/ha) and T_2 (8.59 kg P/ha) respectively, while 8.72 kg P/ha was minimum in treatment T_1, ($N_0P_0K_0$). The results on availability of potassium in soil showed that was maximum potassium was determined in sole cropping of *C. flexuosus* (84.02 kg K/ha) and minimum of in *D. sissoo* + *C. flexuosus* based agroforestry system

(80.02 kg K/ha). The effect of fertilizer on availability of potassium in the soil was ranged from 62.36 to 105.17 kg K/ha with statistically significant differences (P<0.05 %).

Soil characteristics during cropping season 2008-09

During cropping season of 2008-09, the data on soil physical and chemical characteristics are presented in Table No. 2. The perusal of the data revealed that the effect of cropping system *i.e., C. flexuosus* in *D. sissoo* based agro forestry system and sole crop on water holding capacity was found statistically significant with maximum water holding capacity under *D. sissoo* + *C. flexuosus* agro forestry system *i.e.,* 46.12 per cent and minimum in sole cropping of *C. flexuosus i.e.,* 33.26 per cent. The effect of fertilizers on water holding capacity was found statistically significant in ranged of 29.23 to 48.88 per cent. The maximum water holding capacity was determined in (T_4) $N_0P_0K_{20}$ followed by T_7 (46.99 %), T_6 (44.88 %), T_8 (42.16 %), T_2 (38.00 %), T_5 (35.00 %) and T_3 (32.38 %) with minimum of 29.23 per cent in T_1 ($N_0P_0K_0$) presented in Table (2). The results on soil pH under cropping system *viz., D. sissoo* + *C. flexuosus* based agroforestry and sole crop of *C. flexuosus* showed that the maximum soil pH of 5.72 was recorded in soil of sole crop of *C. flexuosus* and minimum of 5.61 was observed in *D. sissoo* + *C. flexuosus* based agroforestry which was insignificantly less (P<0.05 %). Effect of fertilizer on soil pH showed statistically insignificant variation in range of 5.30 to 6.00. The maximum soil pH was observed in treatment T_5 ($N_{30}P_{20}K_0$) followed by T_7 (5.88), T_8 (5.77), T_6 (5.72), T_4 (5.66) and T_3 (5.55) with insignificant differences, while minimum was recorded in T_1 ($N_0P_0K_0$) Table No. 2.

The availability of organic carbon under *D. sissoo* + *C. flexuosus* agro forestry system and sole cropping of *C. flexuosus* was maximum 0.78 per cent in sole cropping of *C. flexuosus* and minimum of 0.68 per cent was determined in *D. sissoo* + *C. flexuosus* based agro forestry system with statistically non significant difference (P<0.05 %). However, the fertilizer effect on availability organic carbon was ranged between 0.55 to 0.96 per cent with statistically significant differences. The maximum organic carbon was determined in treatment T_8 ($N_{30}P_{20}K_{20}$) and minimum in treatment T_1 ($N_0P_0K_0$), while in the rest of fertilizers treatment the organic carbon was found in order of T_6 (0.84 %) > T_7 (0.78 %) > T_4 (0.78 %) > T_5 (0.73 %) > T_3 (0.60 %) > T_2 (0.57 %) Table No. 2.

The available nitrogen in soil under *D. sissoo* + *C. flexuosus* agro forestry and sole cropping of *C. flexuosus* was found maximum of 182.97 kg N/ha in soil under sole crop of *C. flexuosus* while minimum was 155.76 kg N/ha under *D. sissoo* + *C. flexuosus* based agro forestry system with statistically significant variation. Effect of fertilizer on available nitrogen in soil under both the cropping system was ranged between 149.52 to 188.02 kg N/ha. The maximum 188.02 kg N/ha was observed in T_8 ($N_{30}P_{20}K_{20}$) and followed by T_6 (182.00 kg/ha), T_5 (175.03 kg/ha), T_2 (172.65 kg/ha), T_7 (168.67 kg/ha), T_4 (162.75 kg/ha) and T_3 (156.28 kg/ha), while the minimum was 149.52 kg N/ha in $N_0P_0K_0$ (T_1). The available phosphorus in soil data revealed that the maximum available phosphorus of 18.52 kg/ha was observed in soil under sole crop of *C. flexuosus* while minimum of 15.04 kg P/ha was observed in soil under *D. sissoo* + *C. flexuosus* based agro forestry system. The data with respect to fertilizer effect on availability of phosphorus in soil of both the crop field was ranged between 12.05 to 21.11 kg/ha. The perusal of data revealed that the maximum level of available phosphorus was observed 21.11 kg P/ha in T_8 ($N_{30}P_{20}K_{20}$) followed by T_7 (19.96 kg P /ha), T_5 (18.64 kg P /ha), T_6 (17.75 kg P /ha), T_3 (16.36 kg P /ha), T_4 (14.44 kg P /ha) and T_2 (13.95 kg P /ha) respectively, while minimum 12.05 kg P/ha was found in treatment T_1 ($N_0P_0K_0$). The effect of cropping system on availability of potassium in soil was maximum in soil under sole cropping of *C. flexuosus* (108.04 kg K/ha) and minimum in *D. sissoo* + *C. flexuosus* based agro forestry system (100.15 kg K/ha).The data with respect to fertilizer effect on availability of potassium in the soil during the year 2008-09 was ranged from 77.09 to 129.35 kg K/ha. The perusal of data revealed that the maximum available potassium of 129.35 kg K/ha was determined in T_8 ($N_{30}P_{20}K_{20}$) followed by T_7 (119.94 kg/ha), T_6 (116.36 kg/ha), T_4 (107.80 kg/ha), T_5 (101.21 kg/ha), T_3 (97.25 kg/ha) and T_2 (83.78 kg/ha). The minimum available potassium of 77.09 kg K/ha was found in treatment T_1 ($N_0P_0K_0$) presented in Table No. 2.

Soil of any plantation site gets changed over a period according to utilization and deposition of nutrients through litter accumulation by the crops. The utilization of nutrient depends on the resource availability. Similarly deposition of nutrient in the soil also depends on deposition as well as on the decomposition rate of litters, which further governed by microclimate of the site. Tree plantations are universal known to result in many beneficent interactions with the surroundings in which they grow. The soil an important natural

resources, is influenced greatly by tree plantations in many way. Trees bio-rejuvenate the soil by adding organic matter, returning nutrients, promoting microbial activity and improving the soil physical properties by litter decomposition (Zevitkovsky and Newton, 1971; James *et al.*, 1972).

Table No.1 Effect of cropping system and fertilizers on soil physical and chemical status during 1st year (2007-08) of cropping season

Treatment	WHC (%)	pH	Org. C (%)	Available N (Kg/ha)	Available P (Kg/ha)	Available K (Kg/ha)
Cropping system						
Sole crop	36.13	6.12	0.61	163.57	15.81	84.02
AFS (Intercrop)	45.62	5.92	0.55	151.89	11.82	80.02
CD (at 5%)	**2.85**	**NS**	**NS**	**7.43**	**0.80**	**3.53**
Fertilizer						
T_1 - $N_0P_0K_0$	30.30	5.50	0.37	123.85	8.72	62.36
T_2 - $N_{30}P_0K_0$	38.95	5.53	0.43	163.51	8.59	63.48
T_3 - $N_0P_{20}K_0$	34.20	5.69	0.48	137.55	12.81	70.41
T_4 - $N_0P_0K_{20}$	52.08	5.92	0.60	149.07	11.12	85.32
T_5 - $N_{30}P_{20}K_0$	36.70	6.52	0.66	170.61	15.25	77.77
T_6 - $N_{30}P_0K_{20}$	42.53	6.27	0.64	173.88	15.47	92.07
T_7 - $N_0P_{20}K_{20}$	47.08	6.42	0.64	161.76	19.16	99.58
T_8 - $N_{30}P_{20}K_{20}$	45.29	6.34	0.82	181.62	19.39	105.17
CD (at 5%)	**3.91**	**NS**	**0.10**	**5.29**	**2.95**	**3.89**

Table No. 2: Effect of cropping system and fertilizers on soil physical and chemical status during 2nd year (2008-09) of cropping season

Treatment	WHC (%)	pH	Org. C (%)	Available N (Kg/ha)	Available P (Kg/ha)	Available K (Kg/ha)
Cropping system						
Sole crop	33.26	5.72	0.78	182.97	18.52	108.04
AFS (Intercrop)	46.12	5.61	0.68	155.76	15.04	100.15
CD (at 5%)	**1.43**	**NS**	**NS**	**6.15**	**2.99**	**2.57**
Fertilizer						
T_1 - $N_0P_0K_0$	29.23	5.30	0.55	149.52	12.05	77.09
T_2 - $N_{30}P_0K_0$	38.00	5.42	0.57	172.65	13.95	83.78
T_3 - $N_0P_{20}K_0$	32.38	5.55	0.60	156.28	16.36	97.25
T_4 - $N_0P_0K_{20}$	48.88	5.66	0.78	162.75	14.44	107.80
T_5 - $N_{30}P_{20}K_0$	35.00	6.00	0.73	175.03	18.64	101.21
T_6 - $N_{30}P_0K_{20}$	44.88	5.72	0.84	182.00	17.75	116.36
T_7 - $N_0P_{20}K_{20}$	46.99	5.88	0.78	168.67	19.96	119.94
T_8 - $N_{30}P_{20}K_{20}$	42.16	5.77	0.96	188.02	21.11	129.35
CD (at 5%)	**1.21**	**NS**	**0.05**	**3.36**	**3.10**	**3.57**

Soil pH was ranged 5.27 to 6.12 means it tends to acidic in nature. The pH level in sole crop of *C. flexuosus* was slightly less acidic as compared to agro forestry with statistically non significant in both the year. In sole plantation of *D. sissoo*, soil pH was also recorded higher than sole Lemon grass, adjacent barren land. Thus the pH of soil was found to be influenced by tree canopy but it ranged in limit. The decrease of pH towards neutral point under

agroforestry can be attributed to accumulation and subsequent decomposition of organic matter which releases balancing chemicals responsible for diluting the acidity (Haan, 1977). The results were further supported to many workers Osman *et al.* (2001), Tandel, (2003) and Patel, (2005). Effect of fertilizer on soil pH was found statistically non significant with maximum in combination of $N_{30}P_{20}K_{20}$ and minimum in treatment of without application of any fertilizer or zero fertilizer application in both the year (table 1 & 2). This may be due to the lower doses of NPK supplementation to the soil utilized by the plant species with very less residue in upper surface, which on decomposition released organic acids (Gupta & Sharma, 2009) and thereby reduced soil pH, but the reduction in pH toward neutral side was less on application of individual dose of NPK than combined dose of NK, PK, NP or NPK. The similar results were also reported by Chandashekharaiah, (1986), Singal and Panwar (1991).

Water holding capacity in soil was found statistically significant with the maximum (45.62 and 46.12 %) under agroforestry system, and minimum in sole of *C. flexuosus*, sole plantation of *D. sissoo* and soil from adjacent barren land were also reported. The water holding capacity was higher in sole plantation site in comparison to barren site. In the agro forestry system and sole of *D. sissoo* has maximum water holding capacity and moisture percentage due to finer texture and high organic carbon content of soils (Semwal, *et. al.* 2009). In general maximum water holding capacity decreased down the soil profile under vegetation as well as in barren land (Raina & Gupta, 2009). Favorable influence of soil organic matter on water holding capacity was also been reported by Greenland, (1981). Effect of fertilizer on soil water holding capacity was found statistically significant. It was apparently seen that the presence of potassium in different combination of NPK doses was found to be responsible for higher water holding capacity in the observation both year. The potassium played an important role for mobilization water and nutrients from soil to plants (Beech, 1977). This may be due to higher of accumulation of leaf litter and residue in upper surface, which on decomposition released organic acids and thereby increased water holding capacity (Gupta & Sharma, 2009).

Organic carbon in soil was found statistically non significant with the maximum (0.61 and 0.78 %) under sole of *C. flexuosus* and minimum in agroforestry system (table 1 & 2). The

organic carbon in the soil of sole *D. sissoo* was also reported which was higher than that soil from adjacent barren land, thus the organic carbon in the soil was found to be influenced by the density of vegetation particularly perennial species Gupta and Sharma, (2008).The concomitant rise of organic carbon in the soil under agroforestry and decline in the soil of open space or barren land (Dutta *et al.* 2004). Organic matter is the most capable and potent substance greatly influence the soil composition due to humus deposition in manmade forest (Verma *et al.*, 1982). The availability of organic carbon in soil is found to be associated with organic matter means higher organic matter, higher organic carbon, nutrients, water holding capacity and bulk density etc (Kononova, 1996). Organic carbon plays an important role in improving the physical, chemical and biological health of soil; increase in organic carbon content therefore is an index of improvement of soil fertility.

The available NPK nutrients in soil showed the utilization and accumulation pattern under different cropping system. The results were found statistically significant with maximum availability of NPK under sole crop of *C. flexuosus* and minimum in agro forestry system in both the cropping year (Table 1 & 2). The soil of sole plantation of *D. sissoo* showed the higher level of nutrient availability as compare to soil of adjacent barren land. The pattern of nutrient distribution in different land utilization system was found in similar pattern of study by Sharma *et al.* (2007) and Arunchalam *et al.* (1994), with the remark that high vegetation site had decomposed humus content which further added more nutrient to the soil to maintain mineral richness and fertility as compared to disturbed or less vegetation sites because the accumulated litter underwent decomposition at faster rate.

Effect of fertilizer on availability of nutrients (NPK) in soil was also found statistically significant, and these were found maximum in $N_{30}P_{20}K_{20}$ plots of application and minimum in without application of fertilizer in both the year. The results further showed that the presence of potassium in either applied dose of NPK gave higher accumulation all three nutrients (NPK) in the soil as compare to rest of doses of NPK fertilizers. Thus might be due to higher availability of nutrient in to plant growth and accumulation of leaf litter and residue in upper surface. Enrichment of soil with nutrients in agroforestry system indicates improvement in soil fertility due to presence of *D. sissoo* which is also nitrogen fixing trees as compared to sole cropping of *C. flexuosus*. The availability of nutrients (NPK) depends to

large extent upon the amount and properties of organic matter (Haan, 1977). Highest available nutrients (NPK) content were found in plant where$N_{30}P_{20}K_{20}$ dose fertilizer had been applied, this might be due to the fact that there was an appropriate availability of nutrients (NPK) to enhance the biomass and ultimately accumulation of leaf litter higher organic matter with high microbial activities causing high rate of decomposition and mineralization. These results are well supported by Faiz *et al.* (1996) for N in their study nutrient cycling of Poplar plantation; Singhal and Pawar (1991) for P in their study cropping pattern of Poplar based Agro forestry system and Singh (1999) for NPK in their study impact of various land use on soil properties. Therefore, the available nitrogen content followed the similar trend as that of organic carbon.

Figures: 1. Impact of cropping system on nutrient pool during study periods under experimental areas

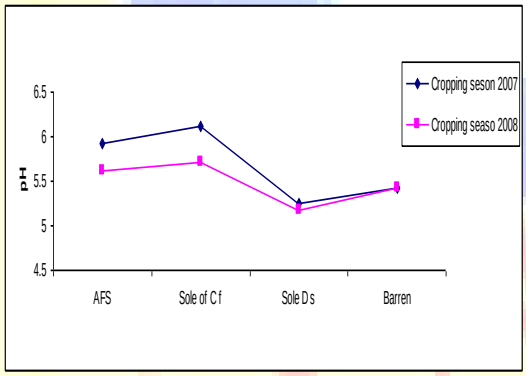

Fig.1 Impact of cropping system on soil pH

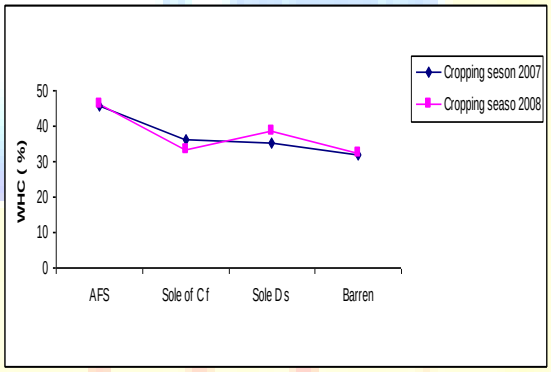

Fig.2 Impact of cropping system on soil WHC (%)

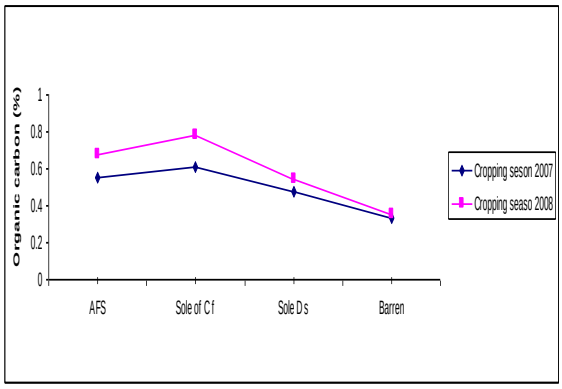

Fig.3: Impact of cropping system on soil OC (%)

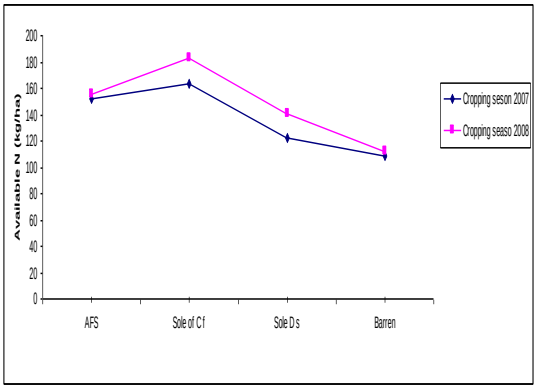

Fig. 4: Impact of cropping system on N (kg/ha)

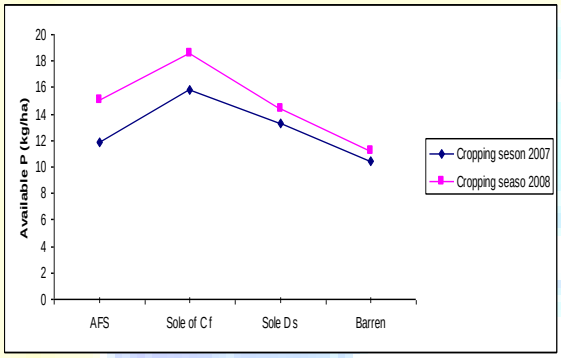

Fig.5: Impact of cropping system on P (kg/ha)

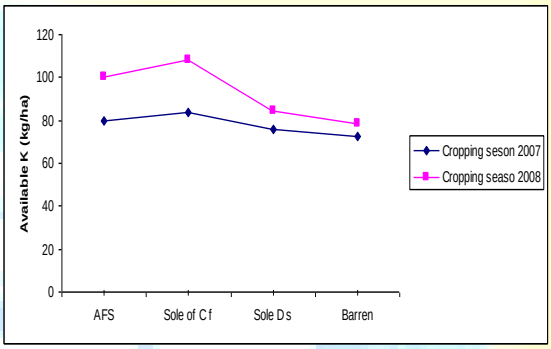

Fig.6: Impact of cropping system on K (kg/ha) in

4. Conclusion

The study indicated that the agro forestry system was proved as most reliable tools for utilization and development of wasteland comprises of tangible and intangible benefits to community and environments. The Chhattisgarh plains have 20 per cent red lateritic wasteland with poor structure, texture, nutrients status such as organic carbon, nitrogen, phosphorus and potash and other micro nutrients. The increasing biotic interferences are further found to be responsible for degrading this productivity as and when used as upland farming. The several studies recommends for adopting the agroforestry models to utilize and conserve such immature soil. It is concluded that practice of alternative land management through Silvi-agriculture, Agri-silviculture and Silvi-pasture practices in such marginal and degraded and lands noted to be established with appropriate need based models developed by consistent research studies. These strategies will help in reducing the biotic pressure and also restoring and conserving the fragile *Entisols* of Chhattisgarh and other part of the country.

References

AOAC (1975). *Methods of analysis*: Association of Official Analytical Chemist, Washington, DC, 1015p.

Arunachalam A, Boral L and Maithani K (1994). Effects of ground fire on nutrients in soil and litter in sub-tropical forest of Meghalaya. *J. Hill Res.*, 7: 13-16.

Beech DF (1977). Growth and oil production of Lemon grass (*Cymbopogon citratus*) in the Ord irrigation area, Western Australia. *Aus. J. Arg.*, 17: 301-307.

Chandrashekharaiah AM (1986). *Investigation on Agroforestry systems in black soil of traditional tracts of Kamatuke*. M.Sc. thesis University Agric. Science, Banglore, 135 p.

Chaturvedi OP (2001). Effect of the thickness and planting orientation on sprouting, rooting, survival and growth of root cutting of *Dalbargia sissoo* Roxb. *Journal of Tropical Forestry*. 17 (3): 52-58.

Dutta M, Dhiman KR and Singh NP (2004). *Soil potassium dynamics through tree leaf manure*. ICAR Research complex for NEH region, Tripura.

Faiz M, Singh PR, Singh K, and Mohsin F (1996). Growth and biomass production by *populus deloides* under agroforestry in Tarai of Kumaun Region, U.P. *Indian Forester*, 122 (7): 631-636.

Greenland DJ (1981). Characterization of soil in relation to their classification and Management for crop production: example from some areas of the Humid Tropics. Clarendon Press, Oxford. *Indian J. of forestry,* **19** (4): 302-310.

Gupta MK and Sharma SD (2008). Effect of tree plantation on soil properties, profile morphology and productivity index. I. Poplar in Uttarakhand *Ann. For*. 16 (2):209-224.

Gupta MK and Sharma SD (2009). Effect of tree plantation on soil properties, profiles morphology and productivity index- II. Poplar in Yamunanager district of Haryana. *Ann. For.*, 17 (1): 43-70.

Hann S De (1977). Humus, its formation, its relation with the mineral part of the soil and its significance for the soil productivity. *Soil Organic Matter Studies*, IAEA Vienna, 1: 21-30.

James RG, Likens GE and Boremann FH (1972). Nutrient content of litterfall on the Hoppard Borood experimental forest, New Hampshire. *Ecology*, 53: 769-784.

Kanonova MM (1996). *Soil organic matter, its nature, role in soil formation and in soil fertility*. (Translated by T. Z. Nawankoski and G. A. Greenwood), Pergamon Press, New York. 450 p.

Loomis RS and Whitman CE (1983). *System analysis in production ecology*. In Huxley, P. A. (Ed.). Plant Research and Agroforestry, ICRAF, Kenya: 209-220.

Mayers N (1980). The conservation of tropical forest. *Environment*, 22: 6.13

Naugraiya MN and Puri S (1997). Fuel wood production in an energy plantation on red lateritic soils. *Journal of Tree Sciences*. 16 (2): 81-86.

Naugraiya MN, Puri S and Sisodia AS (2005). Performance of MPTs under high density plantation in red lateritic wastlands of Chhattisgarh plains. In: Tiwari, U. P. and Shrivastava, R. L. (Eds) Multipurpose Trees in the Tropics: Management and Improvement Strategies Proceding of IUFRO. *International Conference*. Pub. AFRI, Jodhpur, 78-87 p.

Osman KT, Rahman MM and Barua P (2001). Effect of some soil properties in Chittagaon University Campus, Bangladesh. *Indian Forester*, 127 (4): 431-441.

Paroda RS (1998). Natural resources management for sustainable agriculture: A new paradigram. *Plenary lecture in First international Agronomy Congress*. November, 23- 27, New Delhi.

Patel, R. M. 2005. The effect of *Casuarina equisetifolia* L. raised at different spacements on Physico-chemical properties of soil in south Gujrat condition. M.sc. (Forestry) thesis, Navsari Agricultural University, Navsari, 194 p.

Pofali RM and Bhattacharjee JC (1970). Terrain analysis of Amnernasin. *Journal of Indian Society of Soil Science.* 18: 279-287.

Raina AK and Gupta MK (2009). Soil and vegetation studies in relation to parent material of Garhwal Himalayas, Uttarakhand, *India. Ann. For., 17 (1): 71-82.*

Semwal DP, Uniyal PL, Bahuguna YM and Bhatt AB (2009). Soil nutrient storage under different forest types in a Part of Central Himalayas, India. *Ann. For.*, 17 (1): 43-52.

Sharma S D, Sitaula B and Singh B R (2007). Soil properties and quality index in relation to land cover in Arnigad wasteland of Garhwal Himalayas, India, *Intl. J. Ecol. Envir. Sci.*, 33 (2-3): 159-169.

Singh AK and Totey NG (1985). Physico-chemical properties of Bhata soils of Raipur (C.G.) as affected by plantation of different tree species. *Journal of Tropical Forestry* 1: 61-69.

Singh KA (1999). Impact of various landuses on soil properties of sloping hills in Sikkim, Eastern Himalaya. *Indian Journal of Soil Conservation.* 27(1): 70-73.

Singh M, Baskarn K, Kulkarni RN and Ramesh R (2002). Comparative performance of Lemon grass (*Cymbopogon flexuosus*) varieties at different levels of nitrogen. *Medicinal and Aromatic J. Plant Sciences*. 24: 50-52.

Singhal RM and Pawar BPS (1991). A study of cropping pattern of poplar based Agroforestry system in North-western U. P. *Van Vigyan*, 29 (3): 187-191.

Tandel MB (2003). Influence of tree cover and litter fall on Physico-chemical properties of soil and availability of nutrients. M.Sc. (Forestry) thesis Navasari Agricultural University, Navsari.

Verma SC, Jain RK, Rao MV, Misra PN and Murty AS (1982). Influence of canopy on soil composition of man-made forest in alkali soil of Banthra (Lucknow). *Indian Forester*, 108: 431-437.

Zavitkovski J and Newton M (1971). Litterfall and litter accumulation in red alder stands in Western Oregon. *Plant and Soil*, **35**: 257- 268.