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Nutrient status of soil and wheat varieties cultivated as intercrop under *Ceiba pentandra* based Agri-silviculture system

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Abstract
Field experiment was conducted to investigate the nutrient status of soil and crop of wheat under *Ceibapentandra* (L) *Gaertn. Agri-silviculture* system. The tree components comprise of *Ceiba pentandra* (L) Gaertn. Ceiba pentandra is a medium sized deciduous tree widely distributed in western-southern part of india. It is commonly known as silk cotton or kapok tree. The Agri-silviculture system was grown on vertisol soil in July 19th 1995. The study were done during rabi season with 40 treatment. These comprises of three spacing (4x4 m; 4x6 m and 4x8m), four varieties of wheat (Sujata (V_1); Lok-1 (V_2); Kanchan (V_3) and GW-174 (V_4)) and three distances from tree base {0.5 to 1.0 m (d_1), 1.5 to 2.0 m (d_2) and 2.5 to 3.0 m (d_3)}, including four control treatment.. The experiment was laid out in factorial randomized block design with five replications.
The result in the present investigation on soil nutrient status revealed that higher available Nitrogen, Phosphorus, Potassium and organic carbon were observed in the soil at 4x4 m tree spacing,while it was minimum in the sole crop. Available nutrient and organic carbon decreased gradually with increasing the soil depth. Perennial woody tree species are important components of Agri-silviculture system. They have extensive root systems and accumulate large quantity of biomass (above and below ground) as compared to annual crops. Litter addition, decomposition and nutrient release, biological nitrogen fixing, nutrient pumping and controlling erosion losses are vital processes for improving soil nutrient status for sustainable farm production.And the nutrients (N, P and K) content in the shoot and root component of wheat crop were found to be maximum in Sujata varieties and were minimum in GW-174 variety. The nutrient content decreased with the growth of crop. The rate of decrease was found to be more repaid in nitrogen followed by potassium and phosphorus. The status of nutrients (N, P and K) in the tall varieties. (Sujata and Lok-1) were found to be high as compared to dwarf varieties (Kanchan and GW-174).

Keywords: investigation, properties, mucin obtained, *Ceibapentandra* (L)

Introduction
Agro forestry system attempts to mimic the natural ecosystem which has withstood the test of evolutionary time as model. Such mimics can be productive, protective and conservative of natural resources. Agri-silviculture is one such system of agroforestry where agriculture crop are grown in association of tree. Due to difference in growth pattern and resource requirement of component (trees/crop), interactive relation is obvious, which could be of various kinds. The advantages of intercropping of crops have been well explored I the last two decades (Willey, 1979, Francis1986, Fukai, 1993) [7, 2, 3] and those of crop sequences and rotations have long been well known (Puckridge and French 1983; Francis1986) [4, 2], but those grown under tree systems have rarely been studied. Currently trees are viewed as having the potentials to increase crop productivity, reduce soil erosion, improve soil fertility and check desertification (Young, 1987) [8]. Agricultural production is mainly dependent on availability of natural recourses. Increasing human and livestock population creates pressure on natural resources, which limits their availability in cropping systems. Increasing crop productivity to meet increasing food requirements with resource conservation in our country is a greater challenge. High fertile soils contribute mostly in country's food production through improving soil productivity. Intensification of agriculture results in depletion of soil fertility through overutilization of recourses. The land use systems comprising of tree and crops play an important role in improving soil fertility and its quality by several ways. Agri-silviculture has a great potential of both restoring and maintaining soil fertility and increasing agricultural production. Perennial woody tree species are the important component of Agri-silviculture systems.

They reduce nutrient losses from the productive system through efficient nutrient cycling. Addition of nutrients through litter decomposition, dead root biomass and N_2fixation increases importance of tree species in soil nutrient status improvement. The present study are recommending Agri-silviculture systems for increasing agricultural production with improving soil as well as crop nutrient status.

Material and Method

Studies were conducted on five year old *Ceiba pentandra* (L.) Geartn based Silvi agriculture system. Trees planted at three different spacing viz, 4x4 m, 4x6 m and 4x8 m. Four wheat varieties (Sujata, Lok-, Kanchan and GW-174) were sown as intercrop. Land was prepared thoroughly by ploughing with tractor grown cultivator and then rotavated with rotavator to pulverize the soil. Weeds and crop resides were removed manually. Plots of the size 64 sq m in 4x4 m, in 4x6 spacing and 64 Sq.m. in 4x8 m spacing were demarcated with and without trees. Wheat varieties were sown in these plots in a factorial randomized block design with five replication. Wheat varieties sown in plots without trees served as control plots. Seed rate of 125 kg per ha was applied by maintaining a distance of 20 cm between the rows. Recommended fertilizer dose of nitrogen (urea) @ 60 kg/ha, phosphorus (SSP) @ 30 kg/ha potassium (MOP @ kg/ha were applied for the two tall varieties viz. Sujata and Lok-1; While nitrogen (urea) @ 120kg/ha, phosphorus (SSP) 60 kg/ha, potassium (MOP) @ 40 kg/ha were applied for the remaining two dwarf varieties viz., Kanchan and GW-174.

Urea was applied in two half as basal dose at the time of sowing and remaining half 30 days after sowing in the form of top dressing. Irrigation was applied at 4 different stages of crop growth. First irrigation was given first after completion of sowing (2 days), second irrigation at crown root initiation stage (21 days); third at tillering stage (40 days); and final irrigation at booting stage (75 days). The crop attained maturity in the last week of March and was manually harvested on 2nd April 2000.

Result and Discussion

Soil Nutrient Status

The soil of experimental area was analyzed for organic carbon, pH available nitrogen, available phosphorus, and available potassium before sowing wheat and after harvesting of wheat crop. Soil sample were collected at a distance of 1 m from the tree base at three depts. i.e. 0-20 cm, 20-40 cm, 40-60 cm.

Table 1: Changes in physico- chemical properties of soil at the time of sowing and after harvesting of wheat crop in an Agri-silviculture system

Treatment	Sowing					Harvesting				
	pH	Organic carbon (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)	pH	Organic carbon (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
Spacing										
4 x 4 m(S_1)	7.6^b	0.69^a	280.9^a	13.6^a	464.8^a	7.6^b	0.69^a	276.4^a	12.3^a	462.7^a
4 x 6 m (S_2)	7.3^c	0.69^a	272.5^b	12.4^b	457.4^b	7.2^c	0.65^b	272.9^b	11.5^b	454.1^b
4 x 8 m (S_3)	7.9^a	0.64^b	265.2^c	11.6^c	449.4^c	7.8^a	0.61^c	265.9^c	11.3^c	446.2^c
Without tree (S_0)	7.2^d	0.56^c	244.6^d	11.1^c	439.8^d	7.2^d	0.57^d	244.7^d	10.4^d	438.2^d
SE (m) ±	0.02	0.005	0.96	0.19	0.19	0.003	0.31	0.31	0.05	0.56
C.D. at 5%	0.06	0.012	2.3	0.48	0.48	0.008	0.77	0.77	0.13	1.36
Depth										
00-20 cm (D_1)	7.2^c	0.78^a	312.8^a	15.3^a	535.6^a	7.1^c	0.75^a	312.0^a	13.5^a	532.2^a
00-20 cm (D_2)	7.5^b	0.63^b	257.9^b	12.3^b	455.9^b	7.4^b	0.63^b	257.5^b	11.7^b	454.9^b
00-20 cm (D_3)	7.9^a	0.53^c	226.1^c	8.9^c	336.6^c	7.8^a	0.51^c	226.7^c	9.0^c	363.7^c
SE (m) ±	0.02	0.004	0.84	0.17	1.22	0.02	0.003	0.27	0.04	0.48
C.D. at 5%	0.05	0.01	2.04	0.42	2.97	0.05	0.007	0.669	0.11	1.18

Note: Figures followed by the same letter do not differ significantly (P<0.5) within a column; NS- Non significant

It is evident from the table1 that the available N, P and K were lowest in the soil of sole crop plot. Maximum nutrient content (280.9kg N/ha, 13.6 kg P/ha and 464.8kg K/ha) were found in the soil of 4x4 m spacing treatment before sowing of the wheat crop. N,P and K decreased by 1.27,9.07 and0.35 percent respectively after harvesting of the wheat crop. Maximum organic carbon of 0.6% was observed in the soil where trees are planted at 4x4 m spacing. An increase of 1.45 %was observed after harvesting of wheat crop. The interaction effect between tree spacing and soil depth showed significant difference for all the studied soil parameters (pH, organic carbon, N,P and K).it is evident that the soil nutrient had significant effect due to presence of tree component. The higher organic matter formed by the litter of *kapok* tree and high rates of its decomposition increased the release of available nutrient in the soil. The activity of soil microbial population will also be higher in the top layer as compared to bottom layer. The decrease in nutrient content with an increase in soil dept is in conformity with many workers (Danso and Morgan, 1993; Lal, 1989, Smucker *et al* 1992) [1, 6]. The higher available N, P and K were observed due to higher N-mineralization, Haggar1991reported as same.

Crop nutrient status

The nutrient content in the shoot and root component of the wheat varieties were investigation at 60, 90 and 120 days after sowing. The results in terms of N, P, K content is evident from the (Table 1 to 4).It is Evident from the Table 1 that N, P, and K content at 60, 90 and 120 DAS in the shoot and root varied significantly in the four varieties of wheat. The nutrients decreased with an increase in crop age. This was found to be more than two times for nitrogen and potassium. This indicates that the nutrient was utilized within the plant system for its growth. All the three nutrients (N, P and K) in the shoot and root were found maximum in Sujata tall variety and minimum in GW-174 dwarf variety.

Table 2: Status of nutrient in the shoot of wheat varieties grown under agri-silviculture system

Treatment	Nitrogen (%)			Phosphorus (%)			Potassium (%)		
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
Wheat variety									
Sujata (V_1)	1.25[a]	0.84[a]	0.52[a]	0.41[a]	0.39[a]	0.37[a]	1.29[a]	0.93	0.66[a]
Lok-1 (V_2)	1.09[c]	0.76[b]	0.42[c]	0.38[b]	0.33[b]	0.23[b]	1.23[b]	0.85[b]	0.63[b]
Kanchan (V_3)	1.14[b]	0.78[b]	0.45[b]	0.38[b]	0.32[b]	0.23[b]	1.21[c]	0.94[ab]	0.66[a]
GW-174 (V_4)	1.03[d]	0.73[c]	0.43[c]	0.38[b]	0.30[c]	0.22[b]	1.24[bs]	0.99[a]	0.62[b]
SE (m) ±	0.005	0.007	0.004	0.005	0.004	0.005	0.005	0.038	0.004
C.D. at 5%	0.014	0.02	0.012	0.014	0.01	0.014	0.014	0.1	0.01
Tree Spacing									
4 x 4 m (S_1)	1.13[c]	0.77[b]	0.42[c]	0.42[a]	0.37[a]	0.30[a]	1.35[a]	1.001	0.65[b]
4 x 6 m (S_2)	1.18[b]	0.85[a]	0.55[a]	0.41[a]	0.35[b]	0.27[b]	1.17[c]	0.92	0.65[b]
4 x 8 m (S_3)	1.23[a]	0.84[a]	0.51[b]	0.39[b]	0.31[c]	0.24[c]	1.33[b]	0.93	0.68[a]
Without tree (S_0)	0.98[d]	0.65[c]	0.33[d]	0.35[c]	0.29[d]	0.23[c]	1.12[d]	0.87	0.58[c]
SE (m) ±	0.005	0.007	0.004	0.005	0.004	0.005	0.005	-	0.003
C.D. at 5%	0.014	0.02	0.012	0.014	0.01	0.014	0.014	NS	0.01

Note: Figures followed by the same letter do not differ significantly (P<0 5) within a column; NS- Nonsignificant

The result in the present investigation on nitrogen content in the shoot and root revealed that maximum N content (%) was recorded in Sujata tall variety at 60 DAS as compared to 90 and 120 DAS. This is related to the crop growth as it was maximum upto 60 DAS Therafter it declined this shows that maximum growth had taken place upto 60 DAS and during this period the metabolic activity of the plant was also highest. As maximum vegetative growth was noticed under Sujata (V_1) and Lok1 (V_2) varieties. Severe attack of windstorms and heavy rainfall produced lodging in taller varieties due to which shed of panicles occurred which drastically affected the yield. As maximum vegetative growth and nutrient status was noticed under Sujata and Lok-1 varieties and lodging was prominent in these varieties, thus the reproductive growth and the yield attributing characters were adversely affected. This resulted in low grain yield production in taller varieties. On the contrarary, higher grain yield of 36.9q/ha was recorded in Kanchan variety followed by 31.6 q/ha, 30.4 q/ha and 24.2 q/ha in GW-174, Lok-1 and Sujata varieties.

Table 3: Status of nutrient in the root of wheat varieties grown under Agri-silviculture system

Treatment	Nitrogen (%)			Phosphorus (%)			Potassium (%)		
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS
Wheat variety									
Sujata (V_1)	0.51[a]	0.37[a]	0.27[a]	0.36[a]	0.30[a]	0.25[a]	0.67[a]	0.46[a]	0.27[a]
Lok-1 (V_2)	0.48[b]	0.37[a]	0.24[b]	0.30[b]	0.24[b]	0.20[b]	0.63[c]	0.43[b]	0.24[b]
Kanchan (V_3)	0.46[c]	0.35[b]	0.25[b]	0.23[d]	0.21[c]	0.17[d]	0.65[b]	0.46[a]	0.25[ab]
GW-174 (V_4)	0.44[d]	0.33[c]	0.22[c]	0.25[c]	0.21[c]	0.18[c]	0.64[c]	0.43[b]	0.22[c]
SE (m) ±	0.003	0.003	0.004	0.006	0.004	0.003	0.005	0.004	0.006
C.D. at 5%	0.008	0.008	0.01	0.02	0.01	0.008	0.013	0.01	0.02
Tree Spacing									
4 x 4 m (S_1)	0.44[c]	0.35[c]	0.24[b]	0.32[a]	0.24[b]	0.17[c]	0.65[b]	0.45[b]	0.25[a]
4 x 6 m (S_2)	0.56[a]	0.39[a]	0.25[b]	0.28[b]	0.25[ab]	0.19[b]	0.65[b]	0.45[b]	0.25[a]
4 x 8 m (S_3)	0.50[b]	0.38[b]	0.26[a]	0.29[b]	0.25[ab]	0.24[a]	0.68[a]	0.47[a]	0.26[a]
Without tree (S_0)	0.38[d]	0.30[d]	0.23[b]	0.26[c]	0.23[c]	0.20[b]	0.61[c]	0.42[c]	0.21[b]
SE (m) ±	0.003	0.003	0.004	0.006	0.004	0.003	0.005	0.004	0.006
C.D. at 5%	0.008	0.008	0.01	0.02	0.01	0.008	0.013	0.01	0.02

Note: Figures followed by the same letter do not differ significantly (P<0 5) within a column; NS- Non significant

Conclusion

Agri-silviculture is a traditional practice followed in Chhattisgarh plains. In case of Agri-silviculture practices are followed in a scientific way, the productivity of land can be increased The present studies enumerate this fact. The nutrient (N, P and K) content in the shoot and root component were found to be maximum in Sujata and minimum in GW-174 variety. On the contrary grain yield was found to maximum in Kanchan Variety due to sever attack of windstorm and heavy rainfall produce lodging in tall varieties. Nutrient (N, P and K) availability were found to be maximum in the soil of 4x4 m tree spacing. Organic Carbon, available nitrogen (280.9 Kg/ha), Phophorus (13.56kg/ha) and Potassium (464.3 Kg /ha) were found maximum in 4x4 m tree spacing. The top soil layer (0-20) had higher available nutrient (N, P and K) and was rich in organic carbon (0.69 %). From the present investigation it can be concluded that kapok and Kanchan variety of wheat based agroforestry system have capacity to improve soil nutrient status as well as crop nutrient status in Chhattisgarh region.

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Authors contribution and ethical approval

The first author conducted the research experiment and collected the data, analyzed the data and evaluated the result.

Second author gave continuous inspiration, guidance and supervision, sustained interest throughout the preparation of this research paper. This article does not contain any studies with human participants or animals performed by any of the authors.

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