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Performance of wheat (*Triticum aestivum* L.) varieties grown under *Ceiba pentandra* L. gaertn based agrisilviculture system

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Abstract
Field experiment was conducted to investigate the growth and biomass production of wheat varieties under *Ceiba pentandra* (L) Gaertn. Agri-silviculture system. The tree components comprise of *Ceiba pentandra* (L) Gaertn. The Agrisilviculture system was grown on vertisol soil in July 19th 1995. The study was done during Rabi season 1999-2000 with 40 treatments (Including for control 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)}. The experiment was laid out in factorial randomized block design with five replications. The wheat crop parameters like plant population, number of tillers, root shoot biomass, plant height, number of effective tillers and grain weight were found maximum in tree planted at wider spacing (4x8m). Highest grain yield (30.2 q/ha) was obtained in 4x8 m tree spacing, while in other two tree spacing's the grain yield was 29.9 q/ha (4x6) and 26.3 q/ha (4x4). Grain yield and growth parameters also varied with distance from the base. It was lowest near the tree base. The growth and development of crop was better as the distance from tree base increase. It is concluded that wheat can be grown successfully under *Ceiba pentandra based* agrisilviculture system. Among three wheat variety Kanchan is recommended for growing under agrisilviculture system. By combining suitable complementary varieties along with tree farming, the production level of both grain and timber can be sustained and economical beneficial for the farmers of Chhattisgarh.

Keywords: biomass production, grain yield, straw yield, spacing and agroforestry

Introduction
Agroforestry is collective term of all land use system and practices in which woody plants are deliberately grown in combination with the herbaceous crop. Although in agriculture we have made tremendous progress especially during green revolution period, there is still shortage of food in our country, the per capita availability of foods grain has increased from 144 to 173 kg during 1951-1990 in the country. The doubling the growth rate of food production is still required to feed burgeoning population. An attempt has been made to review the work done on agri-silviculture practices especially on wheat and kapok interactions. Kapok (C*eiba pentendra*) is a multipurpose fast growing valuable timber species has emerged as one of the most suitable tree species for agri-silviculture system. Kapok based agroforestry systems are economically viable and more sustainable than many other crop rotations prevalent in North India However, due to paucity of literature available, studies on related agrisilviculture system have been in corporate in order to understand the agri-silviculture complexities. Agroforestry systems not only arrest land degradation but also improve site productivity through interactions among trees, soil, crops, and livestock (Kumar, 2006) [7]. This is the most important way to practice agriculture without deteriorating agro-diseases and environmental degradation is highly appreciable (Garrity, 2004) [4]. Wheat (*Triticum aestivum* L.) is the most important food crop under agroforestry system in North Indian states, which accounted 88.31 million tones production in 2011- 12. In India, it is widely intercropped cereal crop during *rabi* season (November-April) with Kapok, Khamar and other fast growing short rotation tree species in Chhatisgarh Uttarakhand, Punjab, Haryana, U.P and Bihar states in north-and-parts of central and eastern states of M.P. Currently trees are viewed as having the potential to increase crop productivity, reduce soil erosion, improve soil fertility and check desertification (Young 1987) [18]. However, reports of the effects of trees on crop productivity are inconsistent. Under some circumstances crop productivity is lower under tree canopies (Puri *et al*., 1992) [10], whereas in other instances productivity is higher (Puri and kumar, 1992) [10]. It is often suggested that the increased productivity under tree canopies is due to the ameliorating influence of shade in a

hot, dry environment and increased soil fertility, while decreased productivity is due to shade and competitive interactions. (Schroth, 1999) [14].

Material and Method

Study was undertaken on five year old *Ceiba pentandra* (L.) Geartn 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 replications. 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 split doses as basal dose at the time of sowing and remaining half 30 days after sowing in the form of top dressing. The irrigation was applied four times at 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.

Observation of tree parameters

The tree growth measurements were made both on Kapok trees as well as on wheat crop. The parameters determined were plant population, number of tillers, shoot length, root length, shoot biomass, root biomass, grain yield and straw yield. Crop growth parameters viz., plant height and ear length was recorded on the bases of ten plants randomly selected from each plot. Yield was calculated by recording weight of grains from each plot. The statistical design RBD factorial was used to analyze the data.

Results and Discussion

The Variation in plant population in the varieties studied is presented in table 1. Plant population showed statistically significant differences ($P<0.05$) both for wheat variety and tree spacing. A Maximum population of (268.9 m^{-2}) was recorded in GW-174 variety. No significant variation in plant population was observed between Sujata and Lok-1 varieties. The maximum number of plant was recorded in Sujata variety. It is evident that the crop density is affected due to the variation in tree densities. It varied from 196.4 to 247.7 m^{-2}between tree spacing of 4x4m and 4x8 m. Number of plant reduced by 2.26, 3.64 and 22.48 per cent in 4x8 m, 4x6 m and 4x4m, respectively, as compared to sole crop. The plant population varied significant at different distance (d_1=0.5 to 1.0 m; d_2=1.5 to 2.0m and d_3=2.5 to 3.0 m) from the base of the. Overall impact of distance showed maximum population (266.7 m^{-2}at d_3 distances while the population was maximum (207.4) at d1 distance. The interaction effect between wheat varieties x tree spacing x distance from the tree base showed non significant differences in plant population (Table 4). Interaction effect of crop varieties x tree spacing was observed statistically significant for number of plants.

Table 1: Variation in morphological characters of wheat variation grown under difference spacing of *Cieba pentandra*

Treatment	Plant Population /m^2	No. of tillers/m^2	Shoot length (cm)			Root length (cm)		Shoot biomass (g/plant)			Root biomass (g/plant)		
			30 DAS	60 DAS	90 DAS	30 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Sujata (V_1)	211.4^c	405.9^b	42.2	109.2^a	116.6a	14.1^a	15.8^a	0.56^a	3.3^a	4.17^a	0.09^a	0.61^a	0.84^a
Lok-1 (V_2)	220.9^c	453.1^a	38.2	90.7^b	87.6^b	10.3^b	15.4^b	0.45b	2.7b	3.22b	0.05b	0.52b	0.77b
Kanchan (V_1)	240.5^b	459.5^a	42.3	76.8^c	72.4^c	10.2^b	13.1^c	0.26^c	2.3^c	2.50^c	0.04^b	0.37^c	0.64^c
GW-174 (V_1)	268.9^a	471.1	41.7	65.1	62.3	9.3	10.4	0.37	1.5	1.82	0.04	0.26	0.49
SE (m) ±	5600	9.300	-	0.300	0.430	0.200	0.120	0.10	0.040	0.040	0.005	0.010	0.021
C.D. at 5%	15.900	26.200	NS	0.900	1.200	0.700	0.350	0.030	0.120	0.090	0.010	0.030	0.060
Tree Spacing 4 x 4 m (S_1)	196.4^b	408.8^c	41.4	80.2^d	83.0^c	11.3	13.7^b	0.4^b	2.42	2.83^b	0.04^c	0.41^b	0.68
4 x 6 m (S_2)	244.2^a	470.3^a	41.1	84.9^c	83.8^{bc}	11.0	13.3^{bc}	0.39^b	2.49	2.99^a	0.05b^c	0.45^a	0.74
4 x 8 m (S_3)	247.7^a	477.2^a	41.8	87.5^b	84.8^b	11.0	14.4^a	0.44^a	2.32	2.93^a	0.06^{ab}	0.47^a	0.69
Without Tree (S_0)	253.4^a	433.4^b	39.9	89.3^a	87.1^a	10.6	13.3^c	0.41^b	2.4	2.97^a	0.07^a	0.45^a	0.66
SE (m) ±	5.600	9.300	-	0.300	0.400	NS	0.120	0.010	-	0.030	0.005	0.005	-
C.D. at 5%	15.900	26.200	NS	0.900	1.200		0.350	0.030	NS	0.090	0.090	0.010	NS

The wheat population increase with an increase in tree spacing. No significant variation in plant population of GW-147 variety was found when grown with tree at different spacing's as well as when grown as sole crop. However, as it was evident from the interaction, all other wheat varieties were affected in crop density due to presence of tree. Maximum reduction was observed in these varieties (Sujata, Lok-1 and Kanchan) when grown under 4x4 m spaced trees. These results are in confirmation with the findings of Dhillon *et al* (1998). Lal (1989) they also reported a distance in plant population in close spacing (4x4) as compared to wider spacing (4x8m).

Table 2: Effect of distance in the growth and yield of wheat

Treatment	Plant Population/m^2	Effective tillers/m^2	Shoot length (cm)	Root length (cm)	Shoot biomass (g/plant)	Root biomass (g/plant)	Grain Yield (q/ha)	Straw Yield (q/ha)
Distance								
d_1	207.4^c	330.9^c	81.2	13.1b	2.7b	0.65c	24.7c	31.5c
d_2	231.3b	357.4b	83.5	13.8b	2.8b	0.69b	28.2b	36.3b
d_3	266.7a	384.6a	83.8	14.6a	3.1a	0.74a	31.6a	42.7a
SE (m) ±	4.1	4.42	-	0.9	0.06	0.004	0.27	0.34

C.D. at 5%	1140	12.1	-	0.25	0.16	0.01	0.74	0.94
V x S x d	NS	NS	NS	0.88	0.69	0.04	2.56	NS

Note: Figures followed by the same letter do not differ significantly (P<0.5) within a column; NS- Nonsignificant
V1- Sujata, V2 - Lok-1, V3- Kanchan, V4- GW-174, S1- 4 x 4m, S2-4 x 6m, S3- 4 x 8m S0- No tree
d1- 0.5 to 1.0m, d2- 1.5 to 2.0m, d3- 2.5 to 3.0m

The results of our study also found that the poor wheat population in agrisilviculture system is attributed to prolong the shade of *C pentendra* which affected the population. The lodging of crop was observed during growth period. Number of tillers increased significantly in wider spacing due to higher amount of available light for photosynthesis which increased the activity of auxiliary bud, consequently increasing tillers. The population near to crop tree at spacing of 4x4 m reduced up to 20% as compared to population at 4x8 m spacing the reduction in plant population near to base may be due to competition for available resources between *C, pentendra* and wheat. Similar results reported by Sharma (2000) [16] where the wheat was grown in association with *P deltoids*. Kessler (1992) [6] also reported that in sorghum plant population near to tree base was reported, and they attributed it to competition between the two (crop and tree).

Grain yield

Data on wheat yield is shown in Table 3 and Table 4 different treatments were found to be effective in influencing the grain yield. Significantly 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. The tree spacing showed significant effect on the grain yield. It ranged from 26.3 q/ha in 4x4 m spacing to 38.6 q/ha in sole crop. Maximum grain yield of 38.6 q/ha was observed in the sole crop. It decreased by 21.77, 27.65 and 31.83 per cent in the crop grown under tree spacing of 4x8 m, 4x6 m and 4x4 respectively. (Table 3 & 4).

Table 3: Yield attributes of wheat varieties grown under different spacing's of *Ceiba pentendra*

Treatment	Number of effective tillers/m^2	Ear length (cm)	Number of seeds/ear	1000 seed weight (g)	Grain yield (q/ha)	Straw yield (q/ha)
Variety						
Sujata (V_1)	307.5^b	9.0^a	39.8^b	42.8^b	24.2^c	41.4^b
Lok-1 (V_2)	341.0^a	8.4^b	40.2^a	52.4^a	30.4^b	44.8^a
Kanchan (V_3)	357.0^a	7.6^c	36.8^b	37.8^d	36.9^a	31.3^d
GW-174 (V_4)	373.0^a	7.1^d	25.4^c	40.1^c	31.6^b	33.9^c
SE(m) ±	6.2	0.07	0.2	0.23	0.56	0.49
C.D. at 5%	17.7	0.21	0.57	0.66	1.58	1.4
Spacing						
4 x 4 m (S_1)	313.6^b	8.2^a	35.5	43.09	26.3^d	36.2^c
4 x 6 m (S_2)	382.9^a	7.8^b	35.3	43.11	27.9^c	36.3^c
4 x 8 m (S_3)	376.5^a	7.9^b	36	43.26	30.2^b	37.9^b
Without tree (S_0)	305.4^b	8.3^a	35.4	43.76	38.6^a	41.0^a
SE (m) ±	6.2	0.07	-	-	0.56	0.49
C.D. at 5%	17.7	0.2	NS	NS	1.58	1.4
Note: Figures followed by the same letter do not differ significantly (P <0 5) within a column; NS- Nonsignificant						

The distance from the tree based influence grain yield. It was significantly higher at d_3 distance as compare to d_1 and d_2 distances. Grain yield varied from 24.7 to 32.6 q/ha in d1 and d3 distances, respectively. The yield reduced upto 76 per cent in d1 treatment (Table 3). The interaction between wheat varieties x tree spacing x distance from the tree based showed significant differences on grain productivity. The interaction between wheat varieties x tree spacing showed significant differences on grain productivity (Table 4). With an increase in tree spacing it increased in all the four varieties studied. The Sujata, Lok-1, Kanchan and GW-17, the grain yield ranged 21.2 to 24.0, 24.8 to 29.2, 32.4 to 36.4 and 26.9 to 31.3 q/ha in 4x4 m, 4x6m and 4x8 m tree spacing respectively. Grain yield is due to the result of growth in reproductive part and yield attributing character viz., number of effective tillers/m^2, seed /spike, grain weight and ear length these parameters determines quantitative yield of grain due to regular increment in yield attributing character. It was observed that the grain yield in Kanchan variety was maximum (36.5q ha^{-1}) in control. The lowest grain yield was recorded in Sujata variety with a spacing of 4x4 m. Increasing the spacing and distance resulted in better growth and higher crop yield, maximum yield was found in wider spacing as compare to narrow spacing in various tree+ crop interaction by many workers (Chauhan *et al*.1995, Jha and Chaturvedi 1995 and Marlats *et al*. 1995) [1, 5, 9].

Table 4: Interaction between wheat variety (V) and tree spacing's (S) on the yield and yield attributes of wheat.

Treatment	Numberof effective tillers/m^2	Length of spike (cm)	No. of seeds/ spike	1000 seed weight (g)	Grain yield (q/ha)	Straw yield (q/ha)
V_1S_1	280.20	8.80	38.70	42.39	21.19	40.60
V_1S_2	344.16	8.36	38.34	41.65	23.37	38.60
V_1S_3	340.18	9.11	41.33	43.43	24.02	39.00
V_1S_0	265.60	10.01	40.80	43.97	28.27	47.28
V_2S_1	324.60	8.51	40.80	51.88	24.82	42.80
V_2S_2	392.50	8.30	40.35	52.19	26.69	42.90
V_2S_3	365.28	8.06	40.71	52.51	29.18	45.50
V_2S_0	281.60	8.70	39.28	52.98	41.05	48.24
V_3S_1	313.22	7.90	37.53	37.49	32.40	30.71

V_3S_2	401.22	7.49	37.00	38.71	32.93	29.30
V_3S_3	399.36	7.68	36.63	37.11	36.42	31.80
V_3S_0	314.40	7.58	36.22	38.09	46.15	33.60
V_4S_1	336.60	7.51	24.96	40.63	26.90	30.60
V_4S_2	394.00	7.07	25.61	39.86	28.80	34.64
V_4S_3	401.36	6.95	25.44	40.00	31.34	35.47
V_4S_0	360.00	7.10	25.00	39.99	39.17	35.08
SE (m) ±	-	0.14	0.4	0.46	1.12	0.10
C.D. at 5%	NS	0.42	1.43	1.32	3.17	2.80
V_1-Sujata, V_2- Lok-1, V_3-Kanchan, V_4-GW-174,NS-Non Significant						
S_1-4 x 4 m, S_2- 4 x 6 m, S_3 4 x 8 m, S_0- No tree						

The present study revealed that crop distance from the tree base also effected the yield of wheat significantly. It seems that the variation in grain yield was due to contrasting characters among the varieties of Sujata and Lok-1were tall varieties. On the contrary, Kanchan (V_3) and GW-174 (V_4) were the dwarf varieties. Severe attack of windstorm and heavy rainfall produced lodging in taller varieties due to which shedding of panicles occurred which drastically affected the yield. As maximum vegetative was noticed under Sujata (V_1) and Lok-1(V_4) 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 contrary, the dwarf varieties Kanchan and Gw-174, showed minimum vegetative growth and utilized the resource efficiently during the reproductive stage of their life cycle. Wheat yield was always lower near the tree base and it increased with an increase in crop distance. The maximum wheat yield (32.6q ha^{-1}) was recorded at 2.5 to 3.0 m distance which was found significantly superior over 1.5 to 2.0 m and 0.5 to1.0 m distance. The reduction in yield near the tree base reflects higher level of competition between the tree and crop for soil resources and light intensity. These results are in confirmation with the finding of Dhillon *et al*. 1998 [2] and Sharma *et al* 1996 [17]. They also observed that agriculture crop yield increased with increasing the crop distance from the tree base, as the competition for nutrient and moisture decreases with the increase in distance between tree and crop. This might be the reason for higher wheat yield under 2.5 to 3.0 m distance as compared to 1.5 to 2.0 m and and0.5 to 1.0 m distances. Similarly result was noticed by Schroth and Lehmann 1995 [15], and Salzar *et al*. 1993 [12].

Straw Yield

Straw yield also found to be significant influenced by different treatments (Table 3). Among the different varieties of wheat, the straw yield was significant higher in Lok-1variety as compared to Sujata, Kanchan and GW-174 varieties. The straw yield was significant higher at $d_3$distance than at d_1 and d_2 distances. The straw yield increased with an increase in distance from the tree base (table 2). As the vegetative growth was maximum in Lok -1 during crop growth period, hence the straw yield was found to be maximum in Lok-1 variety.

It is evident from the present results of that all the tested varieties has lower crop productivity when grown under tree system as compared to sole crop. In line with the present study, many other studies had also revealed that decrease crop productivity in agroforestry practices was due to shade and competitive interactions between trees and intercrop (Puri and Bangarwa, 1992; Puri *et al*. 1994; Dupraz, 1999; Schroth, 1999) [10, 11, 3, 14].

Conclusion

Agrisilviculture is a traditional practice followed in Chhattisgarh plains. In case of agrisilviculture practices are followed in a scientific way, the productivity of land can be increased. The present studies enumerate this fact. The result revealed that the grain yield was highest in Kanchan variety. The order of yield reduction was found to be: Sujata (34.5%) >Lok-1(17.6)>Gw-174(14.5%). It can be concluded that wheat can be grown successfully under agri-silviculture system. In Chhattisgarh region with *C. pentandra* as tree component provide soft wood and floss. Wheat variety Kanchan is recommended for growing under agri-silviculture system based on *C. pentandra*. By combining suitable complementary varieties along with tree farming, the production level of both grain and timber can be sustained.

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