Effect of canopy management on rooting pattern of *Albizia procera* and yield of crops under agrisilviculture system

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ABSTRACT: The canopy management is a potential tool to minimize competition between trees and crops for above and below ground growth resources in agroforestry system. A field experiment was initiated during 2006-08 to find out the impact of canopy pruning of white siris [*Albizia procera* (Roxb.) Benth.] on root length density (RLD) of trees and crops under agrisilviculture system at National Research Centre for Agroforestry, Jhansi, Uttar Pradesh. The experiment consisted of three pruning regimes (70% canopy pruning, 50% canopy pruning and un-pruned trees). Blackgram [*Vigna mungo* (L.) Hepper] - mustard (*Brassica juncia* L. Czern. & Coss) crop sequence was taken as intercrop with tree. The experiment was conducted in randomized block design (RBD) with three replications. The findings revealed that plant population of crops was significantly reduced under un-pruned trees as compared to 70% canopy pruning. The growth and yield attributing characters of blackgram and mustard i.e. plant height, branches plant^{-1}, pods plant^{-1} and siliquaes plant^{-1} were significantly higher in 70% canopy pruning and 50% canopy pruning than un-pruned trees. In general, growth, yield attributes and yield of crops increased with increasing distances from tree base. The grain yield of both the crops under different pruning regimes was in order of 70% canopy pruning > 50% canopy pruning > un-pruned trees. The grain yield of blackgram at 0.5 m away from tree base was 2 to 5 times less than the yield achieved at 1.0, 2.0, 3.0 and 4.0 m away from tree base. The RLD adjacent the tree was higher and it reduced with increasing distances from tree base. Root concentration at 0-15 cm soil depth was comparatively higher than 15-30 cm soil depth. The RLD of crops-blackgram and mustard was higher under 70% canopy pruning and lower under 50% canopy pruning and un-pruned trees. In general, RLD of crops was lowest at adjacent tree base (0.5 m) and increased with increasing distances from tree base. The higher RLD in crops under 70% canopy pruning provide a strong evidence of more availability of growth resources that helps in higher plant population and better crop growth.

Key words: Canopy pruning, Intercrops, Root length density, Rooting pattern

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1. INTRODUCTION

In agrisilviculture system, annual and perennial components compete to each other for growth resources and there are several experimental studies that findings show the adverse effect of perennial components on annual components. The adverse/competitive effect of trees on crops is due to aboveground competition for light or belowground competition for water and nutrients. In agrisilviculture system, root of crops is usually confined to upper soil layer that are also shared by the tree roots, but the trees can also exploit soil moisture beyond reach of the crops. Therefore, the competition for moisture and nutrient depends on the relative distribution of fine roots of both trees and crops. The competition between trees and crops may be avoided by removing some parts or the entire crown of the tree which obviously reduce the competition for light, soil moisture and nutrients. The competition is usually more severe if trees are shallow rooted and occupy the same soil layers as food crops. Previous studies with pruning and root barrier have addressed root growth and their ultimate effect on tree growth (Peter and Lehmann, 2000; Ram Newaj *et al.* 2010). These studies indicate that pruning of tree canopy affects their root system. Keeping these points in view the present study was initiated to analyze the effect of canopy pruning on root density of trees as well as crops and their subsequent effect on growth, yield attributes and yield of crops.

2. MATERIALS AND METHODS

A field experiment was conducted during 2006-08 at National Research Centre for Agroforestry, Jhansi, Uttar Pradesh located at an altitude of 271 m above mean sea level between 25° 27'N latitude 78° 35'E longitude. Average annual rainfall of the region is 806 mm; about 80 per cent of which occurs between June and September with several intermittent dry spells. The total rainfall during rainy season was 291.2 and 488.9 mm during 2006 and 2007, respectively. The mean monthly temperature is generally high, with high degree of variation between a maximum 39.8°C in May and June and minimum 5.8° C in December and January. In summer, temperature occasionally reaches up to 48°C. The soil of experimental field was intermixed black and red soil group of Bundelkhand regions, Uttar Pradesh covered under the order of Alfisol. The soil depth varied from 0.5 m to 0.6 m with several rocky patches. Its pH, EC (ds/m), organic carbon (%), available N, P and K were 6.49 , 0.073, 0.62, 193.93, 18.28 and 177.20 kg ha^{-1}, respectively within the 0-15 cm soil horizon and 6.54, 0.064, 0.46, 178.60, 14.77 and 154.74 kg ha^{-1}, respectively within the 15-30 cm soil horizon. The experiment was conducted in a well-established 6-year-old *Albizia procera* (Roxb.) Benth. (white siris) trees planted with the spacing of 8 m x 4 m. The experiment consisted of three pruning regimes viz., 70% canopy pruning, 50% canopy pruning and control (un-pruned trees). Blackgram (*Vigna mungo* (L.) Hepper) - mustard (*Brassica juncia* L. Czern. & Coss.) was grown as intercrop with trees. In one plot there were 18 trees with a gross plot size 576 m^2. The experiment was conducted in randomized block design (RBD) with three replications. Levels of canopy pruning were based on a percentage of green crown length. Pruning was done once in every year at least 15-days before sowing of intercrops during *rabi* season. Growth parameters of *A. procera* i.e. diameter at breast height (dbh), height and canopy diameter were measured in February during both the years. The height, dbh and canopy diameter of *A. procera* at the age of 8-year varied from 8.40-12.88 m, 19.0 -21.05 cm and 6.72-7.20 m, respectively under different pruning regimes.

Blackgram 'PU-39' was sown on 10th and 11th July during 2006 and 2007, respectively and 20: 40 kg N and P ha^{-1} was applied as basal dose. 'Varuna' mustard was sown on 18th and 23rd November during 2006-07 and 2007-08, respectively and N, P and K were applied @ 60:40:40 kg ha^{-1}, respectively. The urea, diammonium phosphate and muriate of potash were used to supply the N, P and K respectively. The full doses of phosphorus and potassium and half dose of N were applied as basal, whereas half of the nitrogen was applied at the time of first irrigation. Other cultural practices were applied as per recommended package of practices of the crop (Ram Newaj *et al.,* 2012).

A quadrate (50 cm x 50 cm) was laid stratified on the ground at 0.5 m, 1.0 m, 2.0 m, 3.0 m and 4.0 m from tree line on both the side of the tree in each treatment and replication. The plant that originates inside the sampling frame was counted and mean value of each distance was converted in per square meter. Similar method was used for obtaining grain yield. For other yield attributing characters, five plants were tagged and marked with wooden sticks at various distances from tree base at both the side of tree. The mean value of five plants at respective distances from both the side tree was used for statistical analysis. The pooled mean of two years data (2006-07 and 2007-08) of blackgram and mustard in relation with growth, yield and yield attributes was used for statistical analysis through SYSTATE-11.

Root sampling was carried out with core sampler (11 cm dia and 15 cm length) in October during both the years after harvesting of blackgram at 0-15 cm and 15-30 cm soil depth. The core samples were taken at both the sides of tree at four distances (0.5, 1.0, 2.0, 3.0 and 4 m from tree base). Before coring, a tree was marked from each pruning regimes and replication on the basis of having a mean tree height, dbh and canopy close to the average of all trees comes under each pruning regimes. After coring, core sample was placed in a labeled plastic bucket and soaked with water for a night. After soaking in water, the soil was removed carefully from core and washed with clean water. After complete washing, the root was filtered with 0.87 mm sieve and only fine roots (diameter < 2.0 mm) were sorted out from water. The live roots were sorted out and placed on soaking paper to minimize water content. The total root length was measured by using root image analysis software (Sky Root SI 725, Sky Instrument Ltd. U.K) and samples were kept in oven for drying at 70^0 C up to one hour. After drying the samples, the root weight was recorded and root length density (RLD) was calculated by using the method described by Friend (1991). In case of crop, core samples were taken at 60 days after sowing at 0-15cm soil depth, when crop has attained full growth. The core samples were collected at 0.5, 1.0, 2.0, 3.0 and 4.0 m from tree base in each crop under each pruning regimes and replication. Other techniques were same as followed in case of tree. The pooled mean of two years data for RLD at 0-15 cm and 15-30 cm soil depth in case of tree and at 0-15 cm soil depth in case of blackgram and mustard was presented in the paper.

3. RESULTS AND DISCUSSION

3.1 Effect of canopy pruning on crop growth

Plant population of blackgram and mustard was significantly ($P \leq 0.05$) lowest under unpruned trees and highest under 70% and 50% canopy pruning during both the years. The plant population of both the crop also significantly varied at various distances from tree base. It indicates that 70% canopy pruning provided more light to intercrop and have less competition with crop for soil moisture and nutrients. The plant population also significantly increased with increasing distances from tree base (Table 3 and 4). It might be due to fact that light availability to intercrop at adjacent tree base is normally less due to shade and it increased with increasing distances from tree base that helps in survival and maintenance of more number of plants per unit area. Puri and Bhargava (1992) also reported that in general adverse/negative impact of trees on understory crop was observed up to 3 m distance from tree base. Lesser root length density of tree in 70% canopy pruning as compared to 50% canopy pruning and un-pruned tree provide strong evidence that helps in minimizing competition with crop.

Table 1. Growth and yield attributing characters of blackgram under different pruning regimes and distances from tree base (Pooled mean of 2006-07 and 2007-08)

Distances from tree base (m)	Pruning regime															
	70% canopy pruning	50% canopy pruning	Un-pruned tree	Mean	70% canopy pruning	50% canopy pruning	Un-pruned tree	Mean	70% canopy pruning	50% canopy pruning	Un-pruned tree	Mean	70% canopy pruning	50% canopy pruning	Un-pruned tree	Mean
	Plant population (No. of plant m^{-2})				Plant height (cm)				No. of branches $plant^{-1}$				No. of pods $plant^{-1}$			
0.5	15.44	13.07	6.21	11.58	26.80	19.00	12.25	19.35	7.22	6.16	3.22	7.22	16.71	13.67	9.13	13.17
1.0	21.38	16.82	10.19	16.13	31.00	24.00	15.76	23.58	12.50	6.35	3.49	12.50	19.32	16.14	9.29	14.92
2.0	26.11	18.75	13.33	19.40	31.90	24.50	16.74	24.39	13.94	9.58	3.76	13.94	23.76	16.88	9.89	16.84
3.0	28.72	21.08	15.09	21.63	35.40	26.30	17.62	26.46	14.46	11.20	4.41	14.46	26.03	18.94	13.21	19.53
4.0	28.86	22.03	15.91	22.27	42.50	27.60	19.45	29.86	16.03	12.28	5.49	16.03	27.32	20.71	14.53	20.72
Mean	24.10	18.35	12.14		33.50	24.30	16.36	-	12.83	9.11	4.07	12.83	22.63	17.27	11.21	-
LSD (P= 0.05)	Pruning = 4.42, Distance = 1.37				Pruning = 8.3, Distance = 2.1				Pruning = 1.44, Distance = 0.64				Pruning =1.91, Distance = 1.15			
	Pruning x distance = 4.69				Pruning x distance = 7.3				Pruning x distance= 1.54				Pruning x distance = 2.39			
Pure crop	29.69				44.73				7.92				29.71			

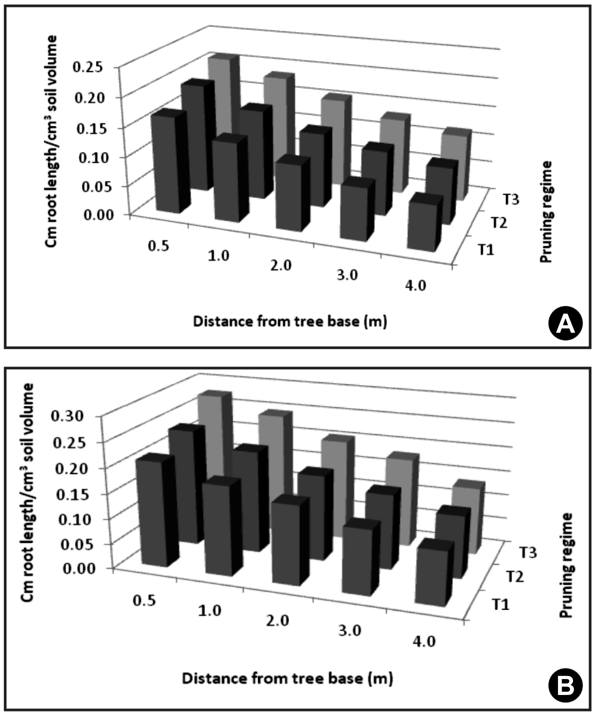
The plant height, No. of branches $plant^{-1}$, No. of pods $plant^{-1}$, No. of siliquae $plant^{-1}$ was significantly higher in 70% canopy pruning and lower in un-pruned trees. The similar patterns were also recorded in these characters as plant population (Table 1 & 2). Several studies conducted at NRCAF, Jhansi and elsewhere also indicated that canopy management alleviated shading and facilitate penetration of light to intercrops which improve the growth of crops than un-pruned trees (Thakur and Sehgal, 2000; Dar and Ram Newaj, 2007)

3.2 Effect of canopy pruning on grain yield of crops

The pruning of 70% canopy produced significantly ($p \leq 0.05$) higher yield of blackgram and mustard (24.04 and 27.50 g m^{-2}, respectively) as compared to un-pruned tree (12.04 and 14.14g m^{-2}, respectively). Grain yield of blackgram was 38.2 and 99.6% higher under 70% canopy pruning than 50% canopy pruning and un-pruned tree, respectively. Similar pattern was also observed in case of mustard. The grain yield of blackgram and mustard at 0.5 m away from tree base was 2 to 5 times less than the yield achieved at 1.0, 2.0, 3.0 and 4.0 m away from tree base. The grain yield of pure crop was higher as compared to that of agrisilviculture system. Similar results were also obtained in mustard crop but the variation in yield under different pruning regimes was wider than blackgram (Table 1). Similar results were also found by Patil and Channabasappa (2008). They recorded that the significantly higher seed yield at 12 to 14 m distance from tree row (742 kg ha^{-1}), which was on par with 10 to 12 m distance from tree row (714 kg ha^{-1}). The seed yield of blackgram was significantly lower with the combination of control and 0 to 2 m distances from tree row. The impact of plant population of crop had direct influence on crop yield obtained at various distances from tree base and under different pruning regimes. Ram Newaj *et al.* (2010) also reported grain production in 70% canopy pruning was 4.53 to 145.06% higher than 50% canopy pruning and un-pruned trees during different year, respectively.

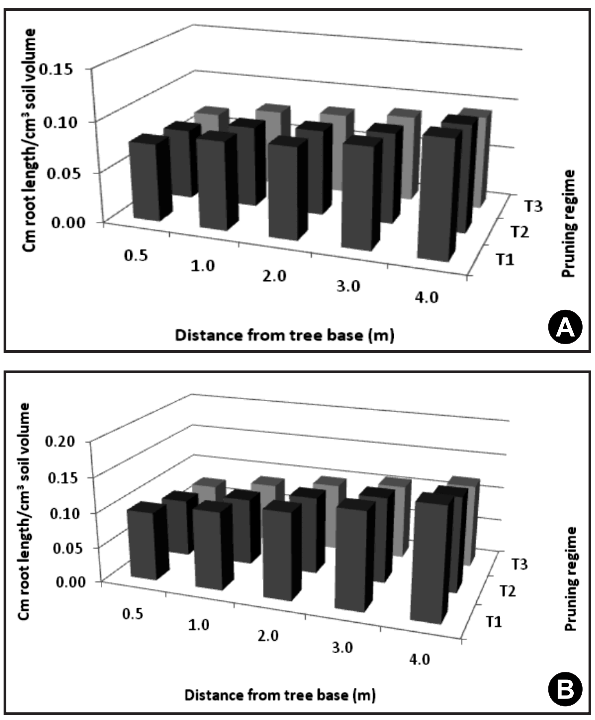
3.3 Effect of canopy pruning on root length density of tree and crops

Among all pruning regimes applied to this study, 70% canopy pruning had significantly ($p \leq 0.05$) lower root length density (RLD) at different distances (0.5,1.0, 2.0, 3.0 and 4.0 m) from tree base compared to 50% canopy pruning and un-pruned trees. In general RLD at 0.5 m away from tree base was higher and declined sharply with increasing distances from tree base (Figure 1). In a similar study Siriri *et al.* (2010) reported that shoot pruning initially sustained crop performance but shoot + root pruning became necessary when tree age exceeded 2 years; shoot + root pruning increased maize yield by 88, 40, 11 and 31% in the calliandra, alnus, sesbania and tree mixture systems relative to un-pruned trees**.** Many other workers also reported that in general, the root density declines with vertical depth and distances from tree base (Ram Newaj *et al.*2001; Peter and Lehmann, 2000). Removal of green leaves due to pruning, reduces the



T_1 = 70% canopy pruning T_2 =50% canopy pruning
T_3= Un-pruned trees

Figure 1. Root length density of *Albizia procera* at 0-15 cm soil depth (A) and 15-30 cm soil depth (B) under blackgram-mustard crop sequence.



T_1 = 70% canopy pruning T_2 =50% canopy pruning
T_3= Un-pruned trees

Figure 2. Root length density of blackgram (A) and mustard (B) at 0-15 cm soil depth

Table 2. Growth, yield attributing characters of mustard under different pruning regimes and distances from tree base (Pooled mean of 2006-07 and 2007-08)

Distances from tree base (m)	Pruning regime															
	70% canopy pruning	50% canopy pruning	Un-pruned tree	Mean	70% canopy pruning	50% canopy pruning	Un-pruned tree	Mean	70% canopy pruning	50% canopy pruning	Un-pruned tree	Mean	70% canopy pruning	50% canopy pruning	Un-pruned tree	Mean
	Plant population (No. of plant m^{-2})				Plant height (cm)				No. of branches plant^{-1}				No. of siliquae plant^{-1}			
0.5	8.04	6.28	5.21	6.51	139.50	112.15	98.14	116.55	4.25	4.04	2.08	3.46	35.89	26.53	22.54	28.32
1.0	9.81	8.07	6.31	8.06	144.00	117.40	105.90	122.45	5.42	4.60	2.40	4.14	58.57	50.91	38.05	49.17
2.0	11.14	9.14	7.05	9.11	146.00	124.70	106.95	125.90	6.38	5.27	2.99	4.88	80.87	70.74	55.09	68.90
3.0	11.96	10.11	8.32	10.13	153.30	125.75	114.35	131.15	6.80	5.80	3.77	5.46	120.79	107.25	88.66	105.56
4.0	13.13	10.90	8.75	10.93	157.75	134.65	117.65	136.65	7.29	6.28	4.26	5.94	143.89	126.50	109.11	126.50
Mean	10.82	8.90	7.13		148.10	122.95	108.60	126.55	6.03	5.20	3.01	4.77	88.00	76.39	62.69	75.69
LSD (P= 0.05)	Pruning = 0.67, Distance = 0.53				3.97, Distance = 5.33				Pruning = 0.32, Distance = 0.44				Pruning = 9.19, Distance = 11.49			
	Pruning x distance = 1.01				Pruning x distance =9.19				Pruning x distance= 0.75				Pruning x distance = 20.00			
Pure crop	13.73				116.55				7.92				163.76			

Table 3. Yield and yield attributes of blackgram and mustard (Pooled mean of 2006-07 and 2007-08)

Distances from tree base (m)	Pruning regime															
	Test weight of Blackgram (g)				Grain weight of Blackgram (g m^{-2})				Test weight of Mustard (g)				Grain weight of Mustard (g m^{-2})			
	70%	50%	Control	Mean	70%	50%	Control	Mean	70%	50%	Control	Mean	70%	50%	Control	Mean
0.5	30.92	28.56	27.08	28.85	5.72	5.60	5.38	5.57	3.07	2.93	2.355	2.785	11.29	9.77	7.76	9.61
1.0	32.39	29.77	27.72	29.96	11.06	9.80	8.52	9.80	3.245	3.295	2.715	3.085	16.85	14.65	10.70	14.07
2.0	34.01	31.81	29.67	31.83	29.36	18.71	11.72	19.93	4.16	4.045	2.965	3.725	31.96	23.69	15.92	23.86
3.0	36.91	34.38	31.44	34.25	35.88	24.23	15.58	25.23	4.55	4.44	3.44	4.145	35.80	29.71	16.90	27.47
4.0	38.12	34.83	32.81	35.25	38.21	28.57	19.01	28.60	4.975	4.69	3.75	4.47	41.61	34.20	19.43	31.75
Mean	34.47	31.87	29.74		24.04	17.39	12.04		4.00	3.88	3.045	3.64	27.50	22.40	14.14	
					(219)	(155.3)	(99.5)						(358.6)	(262.9)	(113.2)	
LSD (P= 0.05)	Pruning = 0.72, Distance = 0.78; Pruning x distance = NS				Pruning = 1.14, Distance = 1.10; Pruning x distance = 2.00				Pruning = 0.4, Distance = 0.4; Pruning x distance= NS				Pruning = 3.41, Distance = 2.47; Pruning x distance = NS			
Pure crop	39.44				46.62 (394.4)				5.03				52.36 (911.45)			

Note: Figures in parentheses are grain yield kg ha^{-1}

assimilation rate, and consequently produces a shallower root system and hence higher RLD at surface soil (Erdmann *et al.,* 1993 and Schroth and Zech, 1995).

Tree pruning had significant effect on rooting pattern of crops at different distances from tree base. RLD of crops (blackgram and mustard) was significantly higher under 70% canopy pruning of tree while lower RLD of these crops was recorded with unpruned tree. RLD of crop at adjacent tree base was lower and increased with increasing distances from tree base (Figure 2). Plant population had direct impact on root length density and it increased with increasing plant population of crop at different distances from tree base. Livesley *et al*., 2000 reported that maize root length density decreased with greater proximity to the tree rows, potentially reducing its ability to compete for soil resources. The similar finding had been obtained in the present study where RLD of crops had decreased in the proximity of the trees which had ultimately resulted in decrease of crop yield.

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