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Pruning Management in *Albizia* Species: Effect on Tree Growth, Understorey Forage Production and Floral Composition

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Abstract: An experiment was taken up at National Research Centre for Agroforestry, Jhansi, to determine suitable species of *Albizia* and an optimum pruning practice for increased natural forage production under tree canopy. Three species for *Albizia* (*A. amara*, *A. lebbek* and *A. procera*) were evaluated under four pruning heights (0, 25, 50 and 75% from the ground level) in split plot design with three replications. There were no significant differences in survival percentages, growth of *Albizia* spp. and forage production before pruning, but growth and forage production increased after pruning with maximum under 75% pruning. *A. procera* was superior in terms of growth, early development of canopy, dry leaf fodder and fuel wood production. Pruning of *Albizia* spp. at 50 or 75% intensity resulted into dominance and composition of *Dichanthium annulatum*, legumes and decrease in forbs indicating a good sign in improvement in quality of natural grassland. Introduction of *Albizia* spp. in natural grassland also brought improvement in soil fertility.

Key words: Pruning, *Albizia* spp., soil enrichment, composition, dominance, natural grassland.

The development of grazing areas and fodder cultivation has high potential in India in spite of the various constraints on the productivity of pastures and grassland. Livestock rearing is an integral part of dryland farming systems. The area under fodder cultivation is only 4% of the total cultivable area in India. The total area of permanent pastures and grasslands is about 12.4 Mha or 3.9% of the country's geographical area. An area of 15.6 Mha, classified as wasteland, is also used for grazing. Forests, and their associated grasslands and fodder trees, are another major source of grazing and fodder collection (Hazra, 1995). A similar scenario is seen world over especially in the semi-arid zones like the Sub-Saharan Africa and Central Australia (Boddey *et al.*, 2004; Hill, 2004).

Trees, an integral component in the forage production system, are of high economic value to the resource poor farmers due to economic returns from them. Shady conditions, in combination with other plant stresses, contribute to lower forage yields (Carpenter *et al.*, 2004). In addition, tree roots compete with grasses for water and nutrients. *Albizia* trees are generally tolerant of soil salinity and drought and are medium to fast growing and provide fodder, fuel and timber (Singh, 1982). The trees are found naturally growing in Bundelkhand region. Leaves contain more than 15% crude protein and are eaten by cattle, buffalo, sheep, goat, camel, etc. silvopasture under *Albizia*-based agroforestry system has not been widely studied with particular reference to pruning management and understorey forage growth. Hence, a study was taken up to determine a suitable species of *Albizia* and an optimum pruning practice for increasing natural forage production under tree canopy.

Materials and Methods

The experiment was carried out at NRC for Agroforestry, Jhansi, situated at 78°35′E longitude and 25°26′N latitude and about 275 m above mean sea level under rainfed conditions. Average annual rainfall for Jhansi is 900 mm, falling predominantly (80%) during July to mid September. The rainfall (number of rainy days) recorded during experimental period (1996 to 2002) was 952.7 (52), 986.4 (52), 905.6 (45), 1118.2 (52), 712.9 (37), 1139.6 (47) and 545.7 mm (29 rainy days), respectively. The soil of the experimental site was neutral in reaction, low in nitrogen and phosphorus and low to medium in potassium.

The field experiment was laid out during June, 1996 with three species of *Albizia* (*A. amara*, *A. lebbek* and *A. procera*) and four pruning heights (0, 25, 50 and 75% from the ground level) in split plot design with three replications. The *Albizia* species were allotted to main plot and pruning height of trees as sub-plot treatments. Any branch/ canopy upto 25 (P_{25}), 50 (P_{50}) and 75% (P_{75}) of tree height attained cumulatively each year after imposition of treatment were pruned in respective pruning treatments. The plot size was 20 x 16 m and tree spacing was 5 x 4 m. Thus, there were 16 plants in each plot with 64 trees per main plot. During July 1997, casualty replacement was done. A basal dose of 20 kg N + 20 kg P_2O_5 ha^{-1} was applied to natural grassland in each treatment every year. Data on botanical composition of the grassland was recorded during September 1996 and 2001 by line interception method (Cainfield, 1941). From each plot two 3 m long transects were taken. The forage production was recorded during October every year. The forage yield was taken on sample basis of each plot from the area of 4 x 10 m keeping two trees in each sample area. Initially, natural grassland consisted of mixture of natural grasses. Among grasses, *Dichanthium annulatum* was dominant followed by *Apluda mutica*, *Eulaliopsis binata*, *Heteropogon contortus*, *Desmostachya bipinnata* and others (Table 3). In composition, *A. mutica* was highest followed by other grasses, forbs, *Themeda quadrivalvis*, *D. annulatum* and others. The productivity of natural grassland at the initiation of the experiment was 4.01 t ha^{-1}.

The pruning treatments were imposed in year 1999 when trees were three and half year old. Therefore, the effects of pruning imposed at the age of 3.6, 4.6 and 5.6 years were expected to be apparent at the age of 4.6, 5.6 and 6.6 years, respectively. The pruning was done during the end of November to middle of December in year 1999 and onwards as *Albizia* spp. remains dormant during this period. This minimized the injury to the trees as well as provided nutritious leaf fodder during the period as grasses mature after September and quality of grasses decreased. Data on survival and growth of trees was recorded at the time of pruning each year. Soil samples at 0.15 cm depth were taken with 10 cm diameter auger from each plot after three years of tree plantation and analyzed for pH, electrical conductivity, organic carbon, total N and available K using standard procedures (Jackson, 1958). The representative samples of herbage, leaf fodder and fuel wood were collected separately and oven dried at 80°C till constant weight to determine the dry matter content.

Results and Discussion

There were no significant differences in survival, tree height, diameter at breast height, canopy and forage production before pruning (Table 1). After pruning at 75% intensity at the age of 6.6 years of *Albizia* spp., showed highest survival of 72.9% and the lowest survival was recorded in the unpruned trees. This could be due to adaptability of *Albizia* spp. to different pruning intensities. It may also be due to the below average rainfall received during 2002 (6.6 years of age). Pruning at the age of 3.6 and 4.6 years significantly influenced the *Albizia* spp. height with maximum being under 25% pruning treatment, whereas effect of pruning at the age of 5.6 years was non-significant. This could be due to the fact that higher canopy supported the growth of the tree, which was not evident in the case of higher pruning percentages. This is in confirmation with the findings of Elfadl and Luukkanen (2003). At the age of 6.6 years, unpruned *Albizia* spp. had the minimum height (3.60 m). This could be due to more utilization of photosynthates in canopy development and less in growth in height (Sanginga *et al*., 1994). Further, before pruning dbh differences were non-significant and also pruning did not influence the dbh significantly. However, higher dbh was recorded at 50 and 75% pruning intensities. Significant effect of pruning intensity on canopy of *Albizia* spp. was observed at the age of 5.6 and 6.6 years. Canopy decreased with increase in pruning intensity. These results suggest that initiation of pruning at the age of 3.6 years did not affect tree growth consistently.

The dry leaf fodder and fuel wood productions were significantly influenced due to pruning intensity (Table 1). Dry leaf production in 75% pruning was significantly higher as compared to 25% pruning, whereas it was at par to 50%, except at 6.6 years age, wherein it was higher in 50% pruning. Further, dry fuel wood production was highest at 75% pruning intensity followed by 50 and 25% pruning intensity. Pruning at the age of 6.6 years (4^{th} pruning) resulted into substantial reduction in both fuel wood and dry leaf fodder as compared to 3^{rd} pruning (at 5.6 years age). After imposition of pruning at the age of 3.6 years, understorey forage production differed significantly due to different pruning intensities. Forage production under 75% pruning at the age of 4.6 and 5.6 years of age was significantly higher in comparison to 25 and 50% pruning, whereas at the age of 6.6 years forage production under 75 and 50% pruning was at par.

Among *Albizia* spp. irrespective of pruning intensities, survival of *A. procera* was highest followed by *A. lebbek* and *A. amara* (Table 2). Similarly, *A. procera* attained significantly higher height, dbh and tree canopy followed by *A. lebbek* and *A. amara*. Dry leaf fodder and fuel wood production at the age of 3.6 years (1^{st} year of pruning), 4.6 years (2^{nd} year of pruning) and 5.6 years (3^{rd} year of pruning) was significantly higher in *A. procera* followed by *A. lebbek* and *A. amara*, whereas it was at par to *A. lebbek* at the age of 6.6 years. There was a drastic

Table 1. Effect of pruning treatments on tree survival, height, dbh, canopy, leaf fodder, fuel wood and understorey forage production averaged across Albizia spp.

Pruning regimes	Years before pruning				Years after pruning		
	0.6	1.6	2.6	3.6	4.6	5.6	6.6
			Survival (%)				
P_0	99.3	100	88.0	87.7	68.0	68.0	59.4
P_{25}	97.9	100	86.8	86.8	77.8	78.0	66.1
P_{50}	98.6	100	92.4	88.2	80.6	81.0	64.9
P_{75}	97.9	100	87.5	87.5	79.9	81.0	72.9
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	8.9
			Tree height (m)				
P_0	0.56	1.25	1.65	2.00	2.40	3.20	3.60
P_{25}	0.60	1.30	1.93	2.40	3.20	3.90	4.20
P_{50}	0.55	1.30	1.76	2.00	2.70	3.40	3.70
P_{75}	0.59	1.30	1.69	2.20	2.80	3.80	3.90
LSD (P=0.05)	NS	NS	NS	NS	0.42	0.53	NS
			Diameter at breast height (cm)				
P_0	–	–	1.86	2.60	4.60	5.50	5.80
P_{25}	–	–	2.60	3.10	4.90	6.40	6.40
P_{50}	–	–	2.20	3.00	5.00	6.50	6.50
P_{75}	–	–	23.0	3.10	5.00	6.50	6.50
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS
			Tree canopy (m)				
P_0	–	–	1.01	1.37	2.30	2.90	3.20
P_{25}	–	–	1.43	1.77	2.30	2.90	3.00
P_{50}	–	–	1.09	1.56	2.40	2.70	2.00
P_{75}	–	–	1.07	1.60	2.50	2.10	2.30
LSD (P=0.05)	NS	NS	NS	NS	NS	0.58	0.64
			Forage production (t ha^{-1})				
P_0	1.26	6.08	5.80	6.16	5.16	5.46	4.71
P_{25}	4.30	5.71	5.23	5.78	5.61	6.00	5.05
P_{50}	3.93	5.98	5.94	5.73	6.09	6.67	5.33
P_{75}	4.09	6.72	6.49	6.06	7.30	7.59	5.73
LSD (P=0.05)	NS	NS	NS	NS	0.77	0.85	0.68
			Dry leaf fodder (t ha^{-1})				
P_0	–	–	–	0.00	0.00	0.00	0.00
P_{25}	–	–	–	0.21	0.28	0.58	0.35
P_{50}	–	–	–	0.27	0.84	0.93	0.80
P_{75}	–	–	–	0.60	1.17	1.47	0.73
LSD (P=0.05)	–	–	–	0.26	0.60	0.75	0.23

Table contd.....

Table 1. contd.........

Pruning regimes	Before pruning				After pruning		
	0.6	1.6	2.6	3.6	4.6	5.6	6.6
			Dry fuel (t ha^{-1})				
P_0	–	–	–	0.00	0.00	0.00	0.00
P_{25}	–	–	–	0.24	0.74	1.38	0.52
P_{50}	–	–	–	0.32	1.85	1.94	0.87
P_{75}	–	–	–	0.68	3.15	2.64	0.92
LSD (P=0.05)	–	–	–	0.43	0.08	NS	0.24

reduction in both dry leaf fodder and fuel wood yield of *A. procera* at the age of 6.6 year of planting as compared to the other two species. The results are in confirmation with those of Carpenter *et al.* (2004).

Data on botanical composition recorded at the age of 5.6 years of *Albizia* spp. revealed that the population of *D. annulatum* increased compared to its initial population (Table 3), which is one of the most preferred grass species by the animals. However, highest composition of 18.6% was recorded in pruning upto 50% height. Further, maximum dominance of 25.4% was also recorded in pruning upto 50% height, while it was slightly lower in other pruning heights as compared to initial. Similar results were reported by Schulte *et al.* (2003). Data further showed that *S. nervosum* disappeared completely under 5.6-year-old *Albizia* spp. based silvopastoral system. In case of legumes, the composition and dominance were increased in all the pruning treatments showing a healthy sign of natural grassland as legumes are more nutritious than grasses. However, highest increase in composition (14.8%) and dominance (6.43%) was recorded at 75% pruning. In case of forbs, decrease in composition was observed in comparison to initial composition, which is also healthy sign for grassland as forbs are generally unpalatable. Dominance of forbs also decreased in all pruning heights, but there was no decrease in unpruned trees showing the importance that pruning of *Albizia* spp. is required to eliminate the unpatable species. Similarly, *D. bipinnata*, which is an unpalatable grass species, decreased in composition and dominance as compared to its initial composition and dominance. Further, pruning of *Albizia* spp. decreased the composition and dominance of *D. bipinnata* with maximum decrease in pruning upto 50% height. Inclusion of *Albizia* spp. in natural grassland increases the palatable grass spp., while unpalatable spp. decrease as compared to initial botanical composition. Further, it is observed that pruning upto 50 and 75% height is beneficial over unpruned and 25% pruning. It can be concluded tree *A. procera* is suitable for silvopasture in semi-arid tracts at 75% pruning levels and one can expect maximum economic and ecological benefits in terms of grass yield.

During third year pruning treatments were not imposed, hence soil parameters were averaged across the pruning treatments. Data revealed that in surface soil (0-15 cm) organic carbon, total N and available K enhanced by 0.12-0.86, 0.08-0.11 and 27-36 units under

Table 2. Survival, height, dbh, canopy, leaf fodder, fuel wood and undersgtorey forage production averaged across pruning regimes under Albizia spp.

Tree spp.	Years before pruning				Years after pruning		
	0.6	1.6	2.6	3.6	4.6	5.6	6.6
			Survival (%)				
P. procera	98.5	100	93.8	91.6	90.1	90.1	89.1
A. lebbek	99.0	100	83.9	86.9	73.5	73.5	54.7
A. amara	97.9	100	89.0	84.9	66.2	66.2	50.0
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	13.9
			Tree height (m)				
P. procera	0.61	1.60	2.31	3.20	4.40	6.00	6.20
A. lebbek	0.67	1.10	1.63	1.70	2.10	2.60	2.80
A. amara	0.45	1.10	1.32	1.60	1.80	2.20	2.50
LSD (P=0.05)	NS	NS	0.62	0.25	0.68	0.81	1.33
			Diameter at breast height (cm)				
P. procera	–	–	3.60	5.30	9.20	10.5	11.1
A. lebbek	–	–	1.90	2.10	3.80	5.10	5.50
A. amara	–	–	1.30	1.50	1.70	2.00	2.20
LSD (P=0.05)			NS	NS	NS	NS	NS
			Tree canopy (m)				
P. procera	–	–	2.17	2.98	4.40	3.70	3.50
A. lebbek	–	–	0.68	0.93	1.50	2.50	2.40
A. amara	–	–	0.59	0.82	1.10	1.60	1.60
LSD (P=0.05)			NS	NS	NS	0.58	0.64
			Forage production (t ha^{-1})				
P. procera	4.10	6.65	6.89	6.18	5.89	5.88	4.83
A. lebbek	4.10	6.05	5.79	5.74	6.30	6.40	5.13
A. amara	4.09	5.67	4.93	5.88	5.93	5.44	5.66
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS
			Dry leaf fodder (t ha^{-1})				
P. procera	–	–	–	0.81	1.34	2.68	1.12
A. lebbek	–	–	–	0.27	0.35	0.25	1.12
A. amara	–	–	–	0.01	0.03	0.04	0.05
LSD (P=0.05)				0.58	0.05	0.73	0.14
			Dry fuel (t ha^{-1})				
P. procera	–	–	–	0.85	2.90	3.77	0.87
A. lebbek	–	–	–	0.37	1.22	0.48	0.75
A. amara	–	–	–	0.02	0.19	0.22	0.14
LSD (P=0.05)				0.66	0.82	2.52	0.49

Table 3. Effect of pruning regimes on composition (%) and dominace (%) of natural grassland averaged across tree species (at 5.6 yrs age)

Pruning regimes	C/D	Natural grass spp.										
		DA	SN	HC	DB	EB	TQ	AM	IL	Leg	Forbs	OG
P_0	C	10.0	0	10.9	4.07	6.00	9.37	11.8	4.83	10.8	11.5	20.7
	D	16.9	0	17.9	7.73	7.30	13.6	14.4	5.33	5.23	5.27	9.07
P_{25}	C	16.6	0	9.03	3.34	4.20	7.37	13.4	6.80	9.9	6.07	23.2
	D	18.8	0	10.3	4.57	7.97	9.33	20.0	10.4	3.93	3.43	6.60
P_{50}	C	18.6	0	13.5	1.43	3.17	8.63	10.2	6.45	12.4	6.83	18.7
	D	25.4	0	22.6	2.50	6.47	11.3	13.3	7.83	4.77	1.93	4.27
P_{75}	C	12.3	0	7.23	4.27	9.40	9.20	11.4	7.63	14.8	7.10	16.8
	D	17.7	0	11.2	3.47	12.7	13.3	14.8	13.2	6.43	1.90	5.37
Intial	C	9.02	2.75	4.75	6.44	4.00	13.6	17.5	1.55	7.78	15.8	16.8
	D	21.2	7.97	11.8	9.28	12.8	8.78	15.5	3.01	1.80	3.95	9.15

Abbreviations: C = Composition, D = Dominance, I = Initial, F = Final, DA = *Dichanthium annulatum*, SN = *Sehima nervosum*, HC = *Heteropogon contortus*, DB = *Desmostachya bipinnata*, TQ = *Themeda quardrivalvis*, EB = *Eulatiopsis binata*, AM = *Apluda mutica*, IL = Iseilema laxum, OG = *Other grasses*, Leg = *Legumes.*

Table 4. Soil pH, EC (dS m^{-1}), OC (g kg^{-1}), total N (g kg^{-1}) and available K (kg ha^{-1}) uder three years' old Albizia species based silvopastoral system

Tree species	pH	EC	OC	Total N	Available K
A. procera	6.81	0.09	7.55	0.70	249
A. lebbek	6.82	0.09	6.82	0.67	246
A. amara	6.74	0.09	7.56	0.69	240
Pasture alone	6.87	0.09	6.70	0.59	213

Albizia species-based silvopastoral system over pasture alone (Table 4). Further, soil pH lowered slightly by 0.05-0.13 units.

The comparison of the three tree species clearly indicated that *A. procera* was superior in terms of growth, early development of canopy, dry leaf fodder and fuel wood production. Pruning at 75% height of the tree irrespective of the species was seen to be the best management practice among the treatments studied.

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