

Effect of Lopping Intensities on Leaf Area and Leaf Nutrient Concentration under *Dalbergia sissoo* Based Silvipastoral System

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Abstract This study was carried out during 2011-2012 in *Dalbergia sissoo* based silvipastoral system raised on sodic land at main experiment station (Forestry) of Narendra deva University of Agriculture and Technology, Kumarganj, Faizabad. The silvipastoral system had *Dalbergia sissoo* (Forest tree species) in combination with three stress tolerant perennial grasses viz., *Pennisetum purpureum*, *Brachiaria mutica* and *Panicum maximum*. The investigated area was divided into five equal quadrats (20 × 25 m size) within 0.25 ha area. Of these, four quadrates were chosen for trials of different intensities of lopping (25, 50, 75, 100% lopping intensities) and one quadrat was treated as control (0% lopping intensity). The maximum leaf nutrient concentration (N, P and K) was recorded during summer. A declining trend of nutrients was recorded towards increasing leaf age, and steep decline of nutrients were obtained during senescence. An increase in leaf area across lopping intensities was discernible from summer to winter season (3.94 to 5.88 cm² leaf⁻¹) in this study. The average annual increment in leaf area across different lopping

intensities was 1.94 cm² leaf⁻¹ yr⁻¹. The specific leaf dry weight (mg cm⁻²) was in the order : winter (9.21) >rainy (8.15) >summer (6.0). During senescence, the dry weight sharply declined and the leaf specific weight by this time was lower (7.50 mg cm⁻²) than those of winter and rainy seasons.

Keywords Concentration, Lopping, Nutrient, Quadrant, Season.

Introduction

The eastern part of the Uttar Pradesh abounds rich alluvium transported by river Ganga and its tributaries, however a sizeable area is rendered unutilized due to sodic and other problem wastelands. The shisham (*Dalbergia sissoo* Roxb.) is a pioneer species, leguminous N-fixing tree species and adapted even under nutrient poor sodic land condition. It endures high soil pH (8.5 to 9.0) and ESP (Exchangeable sodium percentage) levels [1]. Tree canopy modifies soil conditions to promote microbial activity and the rate of soil mineralization which benefits the understorey vegetation. In case of agroforestry systems raised on nutrient poor soils (i.e., sodic soil), the nutrient concentration of tree leaves is of the great ecological significance. Apart from this, another important aspect is the nutrient conserving strategy of plants grown under such soils. Thus, transfer of nutrients from senescing leaves to woody parts of the tree reduces the likelihood of nutrient loss in litter dropped on the soil [2, 3] found initial tree height

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across different lopping intensities ranged from 12.8-15.2 m (averaged 13.9 m) and dbh from 10.8-13.9 cm (averaged 12.4 cm). Across lopping intensities Tree growth increments were maximum in rainy season (tree height increment = 0.20-0.60 m/season; dbh increment = 0.20-0.80 cm/season) followed by summer season.

Materials and Methods

The site lies (26°47' N lat. and 82°12' E long.) in the indo-gangetic plains and is located about 42 km in south-west direction of Faizabad town at 113 m elevation. The climate of the area is governed by south-west monsoon.

The sodic soil of open adjacent area had greater bulk density (0.99 g cm⁻³, up to 30 cm soil depth) than soil of *D. sissoo* based silvipastoral system (0.96 g cm⁻³) under present study. Greater soil pH (10.30), EC (3.52 dS m⁻¹), and ESP (38.96) were evident for open area than silvipastoral system (pH = 8.6, EC = 1.5-2.0 dS m⁻¹, ESP = 25.8). Lower organic carbon (0.167%) was indicated in the soil of open area than value (0.31%) for silvipastoral system. Thus, there is a marked improvement in soil properties after 12 years of establishment of the silvipastoral system. Trees of *Dalbergia sissoo* were spaced at 8 × 4 m distance. Between rows of trees three grasses were planted in randomized block design. Under this system, trees were given different lopping intensities to investigate tree growth and its effect on grass yield. An area under *Dalbergia sissoo* based silvipastoral system which had not been lopped since establishment was chosen for the study. The investigated area was divided into five equal quadrats (20×25 m size) with in 0.25 ha area. Of these, four quadrats were chosen for trials of different intensities of lopping (25, 50, 75, 100% lopping intensities) and one quadrat was treated as control (0% lopping intensity). All trees were identified and marked with metal tags in each of the quadrats. A black strip was painted at breast height on all the trees. All marked trees were lopped by a fixed intensity in each quadrat. Crown height, defined as the distance from the lowest live branch to the tip of the crown was divided into four equal length parts. Lopping of the trees was done during February, 2011. Tree height, dbh, canopy width and canopy length for *Dalbergia sissoo* trees were measured in

the beginning of experiment and after the end of each season in the annual cycle. Tree height was measured by ravi-multimeter. The tree canopy diameter was measured with measuring tape in two directions (east-west and north-south) and the average of two directions was calculated each time.

Results and Discussion

The *Dalbergia sissoo* (Shisham) selected in present investigation is a winter deciduous tree species with enormous growth potential in agroforestry systems. The gradual increase in leaf area and leaf weight occurred up to the stage of leaf maturity; thereafter during senescence a dramatic decline in leaf mass was observed. Interestingly, the leaf area was constant from steady state until senescence. The maximum leaf nutrient concentration (N, P and K) was recorded during summer. A declining trend of nutrients was recorded towards increasing leaf age, and steep decline of nutrients were obtained during senescence.

Seasonal variation in leaf area and leaf area increment

An increase in leaf area across lopping intensities was discernible from summer to winter season (3.94-5.88 cm² leaf⁻¹) (Table 1). The rainy season followed by winter season had greater leaf area than summer. The difference leaf area between summers to rainy was sizeable; however between rainy and winter the difference was very little. The average annual increment in leaf area across different lopping intensities was 1.94 cm² leaf⁻¹ yr⁻¹. The specific leaf dry weight

Table 1. Leaf area and leaf area increment across lopping intensities of *D. sissoo* trees under silvipastoral system.

Pruning intensity of <i>D. sissoo</i> trees (%)	Leaf area (cm ² leaf ⁻¹)			Increment in leaf area (cm ² yr ⁻¹)
	Summer	Rainy	Winter	
0	3.50	4.88	4.91	1.41
25	3.75	4.98	5.69	1.94
50	4.25	6.84	6.89	2.64
75	4.98	6.64	6.82	1.84
100	3.21	4.78	5.08	1.87
Mean	3.94	5.62	5.88	1.94
CD (5%)	0.1023	0.0654	0.0321	0.0865

Table 2. Seasonal changes in leaf nutrient concentration (%) in *D. sissoo* along different lopping intensities.

Lopping intensity (%)	Summer			Rainy			Winter			Senescence		
	N	P	K	N	P	K	N	P	K	N	P	K
0	2.89	2.90	0.68	2.84	2.60	0.60	2.60	2.52	0.50	1.74	2.03	0.44
25	2.83	3.21	0.76	2.67	2.93	0.68	2.40	2.87	0.66	1.61	2.31	0.58
50	2.86	2.87	0.69	2.53	2.38	0.62	2.26	2.32	0.54	1.51	1.87	0.47
75	2.78	3.26	0.72	2.28	3.04	0.65	2.08	2.98	0.58	1.39	2.40	0.51
100	2.80	2.88	0.70	2.00	2.68	0.63	2.38	2.65	0.52	1.59	2.13	0.46
Mean	2.83	3.02	0.71	2.46	2.73	0.64	2.34	2.67	0.56	1.57	2.15	0.49
CD (5%)	0.02	0.21	0.01	0.12	0.05	0.04	0.10	0.13	0.10	0.44	0.01	0.02

(mg cm⁻²) was in the order : winter (9.21) > rainy (8.15) > summer (6.0). During senescence, the dry weight sharply declined and the leaf specific weight by this time was lower (97.50 mg cm⁻²) than those of winter and rainy season.

The leaf area after attaining maximum size at leaf maturity becomes in a steady state and remains constant till the senescence period. This differed from the leaf weight which increases in the beginning and assumes steady state but afterwards declines towards senescence. Interestingly, the specific leaf area showed considerable rise at senescence due to dry mass loss from the senescing leaves. Here Somavilla et al. [4] described the morphoanatomical leaf structure of deciduous forests species as mesomorphic because these species have thinner leaves at elevated values of specific leaf area (80-270 cm² g⁻¹). Based on this information and taking into account the leaf economic spectrum [5] and the edaphic aspects of such systems [6], one may expect elevated concentrations of macronutrients in leaves of deciduous forest species.

Seasonal variation in leaf nutrient concentration

The maximum nutrient concentration (N, P and K) in leaves was noticed in summer season. In senescing leaves a dramatic decline of nutrients was discernible. The N concentration noticed in leaves during summer was significantly higher over rainy and winter seasons. The order of N concentration in leaf was: Summer (2.83%) > rainy (2.46%) > winter (2.34%) > senescence (1.57%). A similar pattern was also indicated for P and K. It has nutrient concentration (Average

across lopping intensities) in *D. sissoo* trees under silvipastoral system during senescence. The leaf nutrient mass across different lopping intensities is indicated in Table 2. Data on leaf nutrient concentration for tropical forests and savannas are available in the literature [7], particularly for growing vegetation on poor and acidic soils. This might be probably due to the greater quantity of K in the soil of the sodic land of the present study. N predominated over P and K concentration in the leaves of all the species. The present estimates for foliar N and P was consistent with afore-mentioned finding. The data are partially in accordance with the results obtained by Neilsen et al. [8] who reported that there were no cultivar differences in leaf N content and inconsistent differences in leaf P. However, results of others authors confirmed the great variability of leaf mineral composition due to genotype, year, root stock and environment [9]. Nagy et al. [10] reported that cv Germersdorfer under Hungarian conditions contained higher levels of leaf K and Ca as compared with our results.

Forage yield under *D. sissoo* based silvipastoral system

Table 3 indicates forage yield for three grasses planted in combination with *D. sissoo* trees. Across different lopping intensities, the annual green fodder yield for *Pennisetum purpureum* grass was maximum (33.5-45.5 t ha⁻¹; average, 40.54 t ha⁻¹), followed by *Brachiaria mutica* (19.4-28.9 t ha⁻¹). The yield was found minimum (20.3-23.9 t ha⁻¹) for *Panicum maximum* under this study. This may be due to *Pennisetum purpureum* grass was suitable species under silvipastoral system. Opening of canopy may increase the possibility

Table 3. Forage (green fodder) yield for three grasses under *D. sissoo* based silvipastoral system on sodic land.

Season	0	25	Lopping intensity (%)			Mean	CD (5%)
			50	75	100		
Green fodder yield (t ha ⁻¹)							
<i>Pennisetum purpureum</i>							
Summer	9.40	10.20	11.80	12.40	12.80	11.32	0.2542
Rainy	18.40	20.40	22.80	23.90	24.30	21.96	0.9820
Winter	5.80	6.90	7.40	7.80	8.40	7.26	0.1654
Total (Annual)	33.60	37.50	42.00	44.10	45.50	40.54	0.9854
<i>Brachiaria mutica</i>							
Summer	6.80	7.50	8.60	9.10	9.40	8.28	0.0965
Rainy	9.70	10.80	11.60	12.90	13.60	11.72	0.5641
Winter	2.90	3.10	4.60	5.30	5.90	4.36	0.1021
Total (Annual)	19.40	21.40	24.80	27.30	28.90	24.36	1.0030
<i>Panicum maximum</i>							
Summer	8.40	9.20	9.60	10.10	10.80	9.62	0.0853
Rainy	9.80	10.50	11.60	12.10	12.70	11.34	0.0854
Winter	2.10	2.50	2.90	3.50	3.80	2.96	0.0120
Total (Annual)	20.30	22.20	24.10	25.70	27.30	23.92	0.9876

of above ground grass production even under the odd condition of sodic land. According to some farmers, trees can also influence grass growth positively, because some species grow better under the cooler conditions beneath tree crowns. Ludwig et al. [11] argue that tree shade limits productivity of understorey grasses during the wet season when water and nutrient availability do not limit production in open sites.

Conclusion

These review papers clearly suggested that there was a clear cut decline in seasonal nutrient concentration of all three grasses along increasing lopping intensities. Complete lopping of trees results in a rapid drain of stored reserves leading to reduction in tree growth. The gradual increase in leaf area occurred up to the stage of leaf maturity, there after during senescence a dramatic decline in leaf mass was observed. Interestingly, the leaf area was constant from steady state until senescence. The maximum leaf nutrient concentration (N, P and K) was recorded during summer. A declining trend of nutrients was recorded towards increasing leaf age and steep decline of nutrients were

obtained during senescence. Frequent complete lopping of trees results in a rapid drain of stored reserves leading to reduction in tree growth. The results of this study indicate that a partial lopping of *D. sissoo* trees less than 50% under silvipastoral system on sodic wasteland stimulates the remaining leaves to a higher rate of photosynthesis, which leads to increase in tree growth. Although the trees can tolerate the complete loss of leaves and shoots for a few years, they cannot be subjected to such an intensive treatment beyond a certain period. There would be some time lag for the emergence of lopping effect on growth of trees. Opening of canopy may increase the possibility of above ground grass production even under the odd condition of sodic land. Forage yield for three grasses planted in combination with *D. sissoo* trees. Across different lopping intensities, the annual green fodder yield for *Pennisetum purpureum* grass was maximum compared to other grasses.

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