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Diversity of Herbage Species under Silvipastoral System

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ABSTRACT

Pasture grasses and legumes viz.; *Cenchrus ciliaris, Chrysopogon fulvus*, *Sehima nervosum* and *Stylosanthes hamata* were cultivated with fodder tree species *Acacia tortilis* and *Leucaena leucocephala* under rain fed condition in semi-arid climate of Jhansi (Bundelkhand). The canopy structure of *Acacia tortilis* and *L.leucocephala* tree stands at 4x4 m spacing attained de-current and ex-current type of tree architecture i.e. umbrella and club shape of crown with height growth of 4.9 m and 5.9 m respectively at six years. The structure of herbage community under tree canopy and open field was found directly related to the level of available climatic and edaphic features. Photosynthetically Active radiations played important positive role to govern the level of density and dominance, which were in order to open field > *A.tortilis* > *L.leucocephala*, while the level of species diversity increased with decrease of dominance. Thus after the six years of establishment of silvipasture system, the population of herbaceous species under the tree canopy and adjacent open land were studied to understand the process of colonization and community development as influenced by different canopy vigour of two tree species.

Key words: *Acacia tortilis, Cenchrus ciliaris, Chrysopogon fulvus, Sehima nervosum, herbage diversity, silvipastoral system, photosynthetically active radiation, under storey vegetation.*

1. INTRODUCTION

In the natural forests, the complex features of environment play an important role in determining the level of diversity in structure and function of community. The activities of top storey population are certain to influence the plant populations, because plants are relatively immobile and they are usually forced to live in the same lateral relationship with their neighbors till their life (Ramakrishanan, 1974). Plants react to their close proximity of growing and dominating species by failure of its seed germination, death or survival with plasticity development, which leads to change in structure and production behavior of community. The aim of this paper is to trace out the population and production dynamics of herbage species in associations with top storey of *Acacia tortilis* and *L.leucocephala* under silvipastoral system.

2. MATERIALS AND METHODS

2.1. Study Sites

The study site was a typical, undulating rocky terrain in wasteland area of Jhansi of Bundelkhand region which is geographically lying along the Vindhyan tract between 24°26' N latitude and 78°81'E longitude and 251 m above mean sea level attitude. The central situation of Bundelkhand region in India shows the features of sub-tropical climate. Rainfall ranged from 750 to 1200 mm with mean annual precipitation of 900 mm. More than 90 per cent precipitation is received during rainy season with occasional winter showers. Distribution of rainfall is erratic and even during monsoon period long dry spells are common. The hottest months are May and June with maximum temperature of 43°C to 47°C and January records the minimum temperature of 4°C to 5°C. The area is termed as semi-arid with moisture index from -40 to -60 (Hazra, 1981).

2.2. Plantation

The plantation of leguminous fodder tree species viz; *A.tortilis* and *L.leucocephala* was done during rainy season of 1982 at the spacing of 4 x 4 m in 96 x 24 m strip plots. Grass species viz. *Cenchrus ciliaris, Chrysopogon fulvus* and *Sehima nervosum* and legume species *Stylosanthes hamata* were grown by seed sowing in 50 cm lines under trees and in adjacent open plot (control). Pasture production was obtained by cut and carry system during October of every year for stall feeding. The analysis of phyto-sociological structure and production of under storey pasture crop at 0-1 and 1-2 m circumferences from tree stand was done after six years of growth of silvipasture system.

2.3. Population Study

Data on botanical composition and peak biomass production were recorded beneath the canopy of both the tree species and in adjacent open plot (control) during peak growth period of herbage crop i.e. October after six years growth of system. The quadrate of 50 cm^2 size was used for accounting the frequency, density, abundance and biomass of herbage species (Misra, 1961). The placement of quadrates were made randomly in open plot, while in case of silvipasture system it was placed in

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Table 1. Edaphic features of the study area

Attributes	*A. tortilis*		*L. leucocephala*		Open land (Control)
	0-1m	1-2 m	0-1m	1-2 m	
Av. field moisture (%)	3.290	2.280	3.210	2.170	2.090
pH	7.100	7.190	7.500	7.600	6.980
Organic Carbon (%)	0.405	0.544	0.356	0.376	0.415
Av. Nitrogen (%)	0.009	0.007	0.008	0.008	0.008
C/N Ratio	46.500	80.000	42.400	46.400	47.700

cross ward directions around the tree trunk at 0 to 1 and 1 to 2 m distance from the tree trunk. Statistical analysis of recorded population of herbage species were done for frequency, density, diversity (Simpson, 1949) and dominance (Margalf, 1968). The biomass production of herbage was also calculated after oven drying at 75° C. The soil characteristics of site were analyzed as the standard procedures. The solar radiation in terms of PAR were also measured by using LI COR quantum radiometer at observation site during the course of study.

3. RESULTS AND DISCUSSION

3.1. Soil Characteristics

The soil of the study site was typical, undulating, rocky -terrain red-laterite (Entisols) in nature. The physical and chemical characteristics of soil were analysed during study period. i.e. after six years of plantation of fodder tree species and cultivation of pasture crop. Soil samples were collected from 0 to 1m, 1 to 2m-circumference area of tree stands of *A.tortilis* and *L.leucocephala* and open field. The maximum available field moisture up to 25 cm depth was found at 0 to 1 m circumference area and minimum was found at adjacent open plot . The pH level of soil was recorded higher under *L.leucocephala* (7.6) followed by *Acacia tortilis* (7.1) and open plot (6.48) respectively but the level of pH was more in outer circumference (1 to 2 m) than the inner one (0 to 1 m). The status of available nitrogen at all sites were more or less equal. The organic carbon was found maximum in outer circumference, similar tendency was found in the C/N ratio (Table 1).

3.2. Photosynthetically Active Radiation (PAR)

Photosynthetically Active Radiation was measured by using LI COR quantum radiometer. The maximum PAR was recorded in open plot (1997 µE/m²/sec) and the sun flacks reaching on ground through the foliage crown of tree species had varied PAR values due to directional movements of the Sunlight. The intensity of these sun flaks bear 60 to 30 percent PA R in *A.tortilis* and *L.leucocephala* as compared to the open plot. The intensity of PAR was higher in outer circumference (1-2m) than inner one (0-1m) and it was 1398 and 999 µE/m²/sec in *A.tortilis* and while 799 and 399 µE/m²/sec in *L.leucocephala.*

3.3. Tree Growth Pattern

The height of *L.leucocephala* was more (5.6 m) in compared to *A.tortilis*. (4.9 m) with MAI of 93 and 82 cm/ year respectively after six years of growth. The collar diameter was recorded more or less similar in both the species with mean annual increment of 1.2 cm/year, while diameter at breast height was 6.7 cm in *A.tortilis* and 7.6 cm in *L.leucocephala* with MAI of 1.12 cm and 1.27 cm respectively. The canopy of *Acacia tortilis* was normally umbrella shaped, while in case of *L.leucocephala* it was club shaped. The crown diameter of *A.tortilis* was 3.58± 0.14 m with de-current type of branching pattern. In case of *L.leucocephala*, crown diameter was recorded 3.98 ± 0.27 m with ex-current type of branching pattern (Table 2).

3.4. Under Storey Vegetation

The population structure of under storey herbage vegetation after six years of establishment of pasture as well as top storey fodder tree crop, showed that the total densities was maximum in open plots (546 plants/m²) but it was 85 to 60 per cent under *A.tortilis* and 45 to 40 per cent under *L.leucocephala* of the open plot. The abundance of herbage population was higher

Table 2. Tree growth observations of six-year-old silvipastoral system

Tree species	Height (m)	CD (cm)	DBH (cm)	Branching pattern	Crown shaped
A. tortilis	4.9	7.2	6.7	De-current	Umbrella
L. leucocephala	5.6	7.4	7.6	Ex-current	Club

Table 3. Phytosocialogical structure of under storey herbage crops

Attributes	*A. tortilis*		*L. leucocephala*		Open plot
	0-1m	1-2 m	0-1m	1-2 m	
Total density (m^{-2})	324.000	468.000	226.000	249.000	546.000
Total abundance.(m^{-2})	358.000	721.000	580.000	655.000	673.000
Total A.G. Bio mass (g m^{-2})	753.400	836.000	551.100	601.000	797.600
Diversity	0.775	1.045	1.129	1.047	0.748
Dominance	0.219	0.149	0.099	0.127	0.266
Total Species	11.000	25.000	20.000	19.000	11.000
Annual grasses	1.000	1.000	0.000	2.000	1.000
Perennial grasses	2.000	2.000	3.000	2.000	4.000
Legumes	3.000	9.000	9.000	8.000	5.000
Forbs	5.000	13.000	8.000	7.000	1.000

at outer circumference (1 to 2 m), where maximum abundance was 721 plants/m^2 under *A.tortilis* and the minimum abundance was recorded in inner circumference (0 to1 m) under the same tree canopy (358 plants/m^2). The abundance in open plot was 673 plants/ m^2. In case of *L.leucocephala* it was lesser than open plot (Table 3).

The above ground dry biomass of herbage during the peak growth period was found maximum under *A tortilis* (836 g/m^2) followed by open land (798 g/m^2). The minimum dry matter production was recorded under *L.leucocephala* (551.1 g/m^2). The dry matter production of herbage was found 10 per cent higher in outer circumference than the inner one under both the tree canopies.

The similarity index of herbage species among all five situations was very low and only 17.4 per cent species were common. When it was calculated for shady situations only it increased and 26.7 per cent species were found common. Species were common between inner and outer circumference by 55.6 and 61.5 per cent under *A. tortilis* and *L. leucocephala* respectively. There was 45.2 per cent species found common between *A. tortilis* and *L. leucocephala* at 0-1 m and 63.6 per cent at 1-2 m circumference. The higher degree of similarity index in shady communities showed the immigration and establishment of shade loving species which can also be tolerant for alleolopathic effect of trees, if present in tree species.

The distribution of the ground flora in different micro habitats showed the higher level of species diversity under *L. leucocephala* (1.047 to 1.129) followed by *A. tortilis* (0.775 to 1.045) and the lowest diversity was recorded in open field (0.748). But the level of dominance showed remarkable relationship with diversity, where the dominance was at higher level (0.266) the diversity was at lower level (0.748). The maximum level of dominance was found in the open plot (0.266) while the minimum level was in *L.leucocephala* (0.099) at area closer to main stand (0 to 1 m).

3.5. Distribution Pattern of Herbage Species

Out of total 34 species, 4 perennial and 2 annual grass species, 13 legumes and 19 other forbs were encountered during the course of study at all the situations (Table 4). The higher frequency level of herbage flora were restricted to few species. The species which had more than 50 per cent frequency level were *Apluda aristata, Eremopogon favaelatus, Heteropogon contortus, Iseliema laxum, Sehima nervosum* in grasses, *Alysicarpus monilifer, Atylosia scarabaeoides, Hylandia latebrosa, Indigofera linifolia, Stylosanthes hamata* in legumes and *Justica diffusa, Lapidogathes trinervis* in forbs. But out of these species only *Apluda aristata, Heteropogon contortus, Sehima nervosum, Alysicarpus monilifer, Justica diffusa, Lapidogathes trinervis* were predominant species with more than 20 plants/m^2 at either observation sites.

In the open field, the species number were minimum with maximum share of grass species *H.contortus* (56.91%) and *S. nervosum* (36.21 %) while rest of the species shared with one or less than one per cent and thus accounting only 6.88 per cent population contribution. Distribution of herbage species under both the tree canopies were varied. In the closer proximity to tree bole (0 to 1m), *A. aristata, H.contortus* and *S.nervosum* contributed 96.77 per cent under *A.tortilis* while under *L.leucocephala,* the species contributed only 48.6 per cent population strength were *H.contortus* and *S.nervosum.* In the outer periphery (1 to 2m) 88.6 per cent population was contributed by *H. contortus, S.nervosum* and *Seteria glauca* under *A.tortilis* while in case of *L.leucocephala,* perennial grasses, *H. contortus* and *S. nervosum* contributed 59.7 per cent population.

The distribution of under storey herbage species showed the high level of species diversity under *L.leucocephala* compared to *A.tortilis* in the closer proximity while large number of species were associated with *A.tortilis* in the

Table 4. Distribution pattern of herbage species under silvlpasture system.

Attribute	*A. tortilis*				*L.leucocephala*				Open plot	
	0-1m		1-2m		0-1m		1-2m			
	Fq.	Den.	Fq.	Den.	Fq.	Den.	Fq.	Den.	Fq.	Den.
Apluda aristata. Linn	77.8	130.70	88.90	108.00	-	-	11.1	4.40	66.7	1.4
Eremopogon favaelatus. Stapf	-	-	-	-	55.5	7.11	-	-	22.2	1.4
Heferopogm contortus P.Beauv	77.8	112.90	100.00	168.40	44.4	66.70	55.5	80.00	88.9	77.8
Iseliema laxum. Hack	-	-	-	-	-	-	-	-	66.7	0.6
Sehima nervosum. Stapf	44.4	68.00	55.60	138.70	55.6	45.30	33.3	68.90	100.0	49.5
Seteria glauca. Linn	-	-	-	-	-	-	11.1	1.30	-	-
Alysicarpus monilifer.P.C Prod	-	-	33.30	2.70	55.6	3.10	33.3	35.60	22.2	0.2
Atylosia scarabaeoides. Benth	44.4	1.80	44.40	3.10	11.1	0.44	55.5	2.20	66.7	0.6
Crotolariajuncea. Linn.	-	-	44.40	3.60	22.2	8.90	-	-	-	-
Cassia pumila Lamk	11.1	0.44	33.30	6.70	33.3	4.00	-	-	22.2	0.2
Hylandia latebrosa .DC	-	-	-	-	-	-	-	-	88.9	1.0
Indigofera cordifolia Linn.	-	-	11.10	0.44	-	-	-	-	-	-
Indigofera linifoha. Retz .	-	-	-	-	-	-	-	-	66.7	2.2
Indigofera sp. Linn.	-	-	22.20	1.30	11.1	0.44	11.1	0.44	-	-
L. leucocephala. Dewit .	-	-	-	-	44.4	9.80	11.1	1.30	-	-
Macroptelium atroperpureum	-	-	-	-	-	-	11.1	0.44	-	-
Phaseobis aconitifolius. Jacq	-	-	22.20	2.20	11.1	1.30	11.1	1.80	-	-
Sfyhsantheshamafa.(L)Taub	44.4	5.80	22.20	1.30	22.2	2.70	55.5	2.70	-	-
Zorniadiphila.Pres.Syn	-	-	11.10	0.44	22.2	0.80	-	-	-	-
Boehravea diffusa. Linn	-	-	11.10	0.44	22.2	0.80	-	-	-	-
Boehravea diffusa. K. Schum	-	-	-	-	-	-	11.1	0.44	-	-
Borreria stncta. K. Schum	11.1	0.44	33.30	3.10	-	-	-	-	-	-
Convolvulus pluricaulis. hols	11.1	0.44	33.30	1.80	33.3	4.00	-	-	-	-
Evolwlus alsinoides. Linn.	-	-11.10	0.40	22.20	4.0	-	-	-	-	-
Justica diJffusa. Wilid	-	-	22.20	4.00	100.0	23.10	66.7	19.60	-	-
Lapidogathes trinervis Nees	11.1	0.44	44.40	7.10	66.7	26.20	77.8	19.60	-	-
Lebiatae sp.	-	-	1.11	0.44	-	-	-	-	-	-
Lucus aspera Spreng	-	-	1.11	0.44	-	-	-	-	-	-
Merramia tridentata Linn.	-	-	-	-	11.1	0.44	-	-	-	-
Sida carpinifolia Linn	33.3	1.80	33.30	2.70	-	-	11.1	0.44	-	-
Tridex procumbus Linn.	-	-	44.40	6.20	-	-	-	-	-	-
Vemonia cinerea Less	-	-	1.11	0.44	-	-	11.1	0.44	-	-
Xanthium strumarium Linn.	-	-	22.20	0.80	33.3	12.40	44.4	7.60	-	-
Misllanious	22.2	0.90	22.20	1.80	22.2	4.80	22.2	0.80	66.7	1.8

Fq. - Frequency (%); Den. - Density (m^{-2})

outer periphery. The weeds and legumes had maximum association with the *L. leucocephala* canopy compared to *A.tortilis*. These changes in community of under storey vegetation are directly related with three component, first of them is sun flacks filtered from top storey crowns, second is alleleopathic effect of tree species and third is species association (both positive and negative) which developed between species (Turkington and Cavers, 1979).

Forage production was recorded maximum (836 gm/m²) in outer periphery of *A.tortilis* followed by open field (797.6 gm/m²). The canopy of *L. leucocephala* adversely affected pasture crop yield which were 551.1 and 601 gm/m² at inner and outer periphery respectively. This behavior of crop production was certainly influenced by lower frequency and density level of perennial grasses which showed the negative association with *L. leucocephala* due to allelopathic interactions. This similar negative allelopathic effect due to mimosin content has been identified by Rizvi et al. (1990).

Such man made silvipastoral systems where the physical environment of under storey crops was more or less governed by top story woody species the structural and functional relationship of herbage species community was expressed in species diversity. May (1973) has shown in his theoretical models that increasing diversity should destabilize inter active systems. Here the increasing diversity of the herbage species was not only reduced the population density but also minimized the productivity and dominance as well (Table- 3). Similar relationship of diversity, dominance, productivity and population density have been observed by Naugraiya and Pathak (1993) in study of winter

annuals colonization after clear felling of man made *L. leucocephala* forest.

This feature of the herbaceous community has shown that succession was accompanied by increased biological diversity and reduced dominance (Mc Naughton 1967). Further Millinger and Mc Naughton (1975) advocated after their study that increased diversity and reduced dominance has to be associated with increased stability of the system.

The process of stabilizing the species of herbage community under tree canopy has shown the response directly to availability of illumination and its intensity and alleleopathic effect received from residues of woody species. These two parallel physical and chemical components generate successional stages of different herbage species with relationship among their structures and functions viz; population density, biomass, dominance and diversity for making a stable ecosystem with woody species. Thus in the study while tree species have been found to influence herbage colonization, the C/N ratio is directly related to forage biomass production comparatively higher negative interactions were observed under *L.leucocephala*.

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