Vegetatio **95**: 167–175, 1991.

Effect of tree canopy cover on the yield, crude protein and fibre content of forb species in Nigerian Guinea savanna

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Accepted 1.7.1991

Keywords: Forb species, Tree canopy cover, Savanna

Abstract

The relationship between tree canopy cover and forb species in savanna was investigated by examining the effect of tree canopy cover on the yield, crude protein, fibre and lignin content of forb species.

The yield of some forb species show a tendency of being higher under tree canopy than in the open though no statistical significance can be shown. A higher forb yield is obtained under high tree canopies than under lower ones.

No significant differences in mean crude protein, fibre and lignin content were observed between forb species growing under tree canopy and those in the open.

Introduction

Forbs make a negligible contribution to herbage yield in the savanna, grasses being the main utilizable resource. Possibly due to this, very little attention has been given to forb species in the savanna. This approach overlooks the contribution the forbs make in the savanna ecosystem such as the valuable contribution to the nitrogen economy of the soil by the leguminous species among them and the supply of nutritious fodder in most cases superior to grass fodder to livestock longer into the dry season. Afolayan and Fafunsho (1978) have however advocated that 'it is very important to pay attention to trees, shrubs and forbs while managing savanna habitats for livestock and wildlife and any management policy that advocates the total removal of trees and shrubs in favour of grass should be avoided'. De Leeuw (1979) has documented a number of forbs grazed by livestock in Nigerian savanna. On the average forbs though much less abundant than grasses in the savanna, have higher crude protein, minerals and dry matter digestibility especially the legumes among them. Observations in the field show that they remain green for considerably longer period into the dry season than do the grass species and may also probably maintain their fodder quality far into the dry season.

Just like grasses, forbs interact with trees in the savanna ecosystem. The effect of tree canopies on grass yield has been investigated by a number of workers. Herbage production has been reported to decrease as tree density increased (Du Toit 1968; Beale 1973). Tall trees have also been reported to suppress grass growth more than shorter trees while tree removal significantly decreased grass growth (Staut-Hill & Tainton 1989). However, Belsky *et al.* (1989) and Georgiadis (1989) have reported higher herbage-layer productivity

Table 1. Summary of the important characteristics of the study sites.

Characteristic	Site		
	Plot 1	Plot 2	Plot 3
a) Geology and soils			
Parent material	Nupe sandstone	Nupe sandstone	Basement complex
Soil type	Tropical ferrugeneous[1)]	Tropical ferrugeneous	Tropical ferrugineous
% Sand	54.64 ± 2.60	73.02 ± 2.02	76.84 ± 1.36
% Silt	30.96 ± 1.88	18.13 ± 1.54	14.66 ± 1.02
% Clay	14.11 ± 0.88	8.87 ± 0.64	8.50 ± 0.54
pH (KCl)	5.60 ± 0.24	5.76 ± 0.25	5.63 ± 0.16
% Organic matter	2.49 ± 0.16	1.64 ± 0.18	1.32 ± 0.11
% Total nitrogen	0.111 ± 0.013	0.063 ± 0.007	0.046 ± 0.004
$\mu g\ g^{-1}$ Available phosphorus	2.94 ± 0.16	4.97 ± 1.32	3.80 ± 0.51
Total exchangeable bases (Ca; Mg; K; Na) (me/100 g)	6.26 ± 0.34	5.25 ± 0.30	2.63 ± 0.14
Cation exchange capacity (me/100 g)	10.65 ± 0.46	9.73 ± 0.68	5.83 ± 0.38
Percentage base saturation	56.99 ± 2.78	56.86 ± 3.08	47.80 ± 2.89
b) Percentage tree canopy cover	37.30 ± 1.51	28.10 ± 1.32	21.50 ± 0.70
c) Mean maximum herbaceous biomass ($g\ m^{-2}$)	221.57 ± 20.08	246.08 ± 30.27	316.85 ± 28.93
d) Percentage contribution of grass species to the total biomass	76.33	93.08	94.31
e) Percentage contribution of forb species	23.67	6.92	5.69

[1)] Acrisol accord to FAO/UNESCO Classification

under tree canopy than in the open. But the relationship between grasses and trees may not necessarily be the same as that between forbs and trees since the rooting patterns of forbs and grasses are different and in some cases the modes of nutrition may be different as in legumes.

A knowledge of the yield, crude protein, fibre and lignin contents of forbs under tree canopy and in the open and at a particular stage of growth will give an idea of the effect of these two factors on the yield and nutritive quality of forb species in the savanna.

Study area

The study area is located in the Kainji Lake Basin in Northwestern Nigeria. Three of ten research plots which lie between latitudes 10° and 13° N and longitudes 3° 5′ and 5° 50′ E used by the Nigerian Man and Biosphere (MAB) Programme for savanna studies were used for the study namely MAB plots 1, 3 and 7. All the plots are in the Northern Guinea zone (Keay 1959). Afolayan (1982) has described the climate of the area.

A summary of the geology, soil properties and percentage tree canopy cover of the study sites is presented in Table 1.

The major grass species in plot 1 are *Andropogon gayanus**, *Rottboellia cochinchinensis*, *Setaria pumila* and *Sorghastrum bipennatum* and forb species are *Aspilia helianthoides*, *Borreria scabra*, *Cissus rubiginosa*, *Hibiscus asper*, *Stylochiton lancifolius* and *Vigna racemosa*. In plot 3 *Andropogon gayanus*, *Andropogon schirensis*, *Digitaria argillacea*, *Hyparrhenia involucrata*, *Hyperthelia dissoluta* and *Rottboellia cochinchinensis* are the major grass species while *Borreria scabra*, *Calcitrapoides praecox*, *Cassia mimosoides*, *Melanthera elliptica*, *Pandiaka heudelotii*, *Pandiaka involucrata*, *Sebastiania chamaelea* and *Vigna racemosa* form the major forb species. In plot 7

* Botanical nomenclature is according to Hutchinson and Dalziel (1954–72).

the major grass species are *Andropogon schirensis*, *Hyparrhenia involucrata* and *Schizachyrium sanguineum* and forb species are *Aspilia africana*, *Crotalaria microcarpa*, *Indigofera bracteolata*, *Monechma ciliatum* and *Tinnea barteri*.

Materials and methods

Three 1-hectare sample plots were used for this study. Each plot was divided into four equal quadrants. In each quadrant five 25 m-long line transects were randomly laid in a staggered manner. The heights of all trees which provided canopy cover along the transects were measured with a Haga altimeter. The trees were grouped into three canopy classes based on the height measurements namely: canopy 1 provided by trees less than 3 m high, canopy 2, between 3 and 7 m and canopy 3 above 7 m.

Cover estimation

Forb aerial cover was taken in July and basal cover in October.

Aerial cover was used in July because at this period the plants were at their early growth stage and were so small that it was difficult to know when a forb base was hit while in October the plants were at their peak growth and their bases were very discernible.

The aerial cover was taken by dropping a pointed metal rod perpendicularly at every metre point along the transect and counting the number of touches of the aerial parts of forbs on the rod. The sum of touches divided by the number of sampling points per transect multiplied by a hundred gave the percentage aerial cover. The same procedure was followed for basal cover but in this case, the hits on the forb bases were recorded.

Forb yield

Forb species yield was estimated twice a year, in July (early growth period) and October (peak growth period) in 1985 and 1986. This was done by placing a 50 cm × 50 cm quadrat systematically at every fifth-metre point along the transects and clipping all forb plants rooted within the quadrat at ground level. The clipped material was sorted into species, oven-dried at 80 °C to a constant weight, weighed, ground and preserved for chemical analysis. Tree canopy cover and type of canopy were recorded when directly above the quadrats used for yield sampling.

Data from the transects were used to calculate the means and variances for the quadrants and overall plot mean was calculated as for stratified sampling (Cochran 1963).

Chemical analysis

Total nitrogen content of the ground samples was determined by the Kjeldahl method. This was multiplied by 6.25 to get the crude protein content (Allen *et al.* 1974). Fibre (acid-detergent fibre (ADF); neutral-detergent fibre (NDF)) and acid-detergent lignin were determined by the method of Goering and Van Soest (1970).

Results

Percentage forb cover

Percentage forb cover values are presented in Table 2. In July and October plot 1 has the highest forb aerial and basal cover followed by plot 3 while plot 7 has the lowest. The mean percentage aerial and basal cover is lower under tree canopy than in the open though not statistically significant (Table 2).

Tree canopy and forb yield

Forb yield species by species in relation to tree canopy cover and in the open is presented in Table 3.

Forb species individually reacted differently to tree canopy cover. The leguminous species tend to have higher yields in the open than under tree canopy while the Asteraceae species tend to have

Table 2. Mean percentage aerial and basal cover of forbs ± 95% confidence interval under tree canopy cover and in the open in three study plots in the Guinea savanna zone of Northwestern Nigeria.

	Canopy	Open	Plot mean
Aerial cover (July)			
Plot 1	16.20 ± 8.46	21.00 ± 11.43	19.21 ± 10.32
Plot 3	4.90 ± 5.40	9.80 ± 6.54	8.42 ± 6.22
Plot 7	2.70 ± 3.35	6.30 ± 4.65	5.53 ± 4.37
Basal cover (October)			
Plot 1	1.90 ± 2.28	2.50 ± 2.14	2.28 ± 2.19
Plot 3	0.50 ± 1.09	1.80 ± 2.08	1.43 ± 1.80
Plot 7	–	0.20 ± 0.18	0.16 ± 0.14

higher yields under canopy than in the open though no statistical significance can be shown. Other species such as *Ipomea heterotricha* (Convolvulaceae), *Pandiaka involucrata* (Amaranthaceae) and *Stylochiton lancifolius* (Araceae) occurred more and performed better under tree canopies than in the open.

When the composite yield of all forb species under tree canopy and in the open is compared there is no significant difference between yield under tree canopy and in the open in any of the plots.

Forb yield in relation to three canopy classes

The result of the forb yield under the three canopy classes is presented in Table 4.

In plots 1 and 3, forb yield under canopy 3 is consistently higher than that under the other two canopy classes. In plot 7, the yield under canopy 2 is greater than that under other canopy classes. Analysis of variance shows this difference in forb yield under the three canopy classes to be statistically significant ($P < 0.001$) only in plot 1 in July and in plots 1 and 3 ($P < 0.01$) in October.

Table 3. Mean forb yield ($g \cdot m^{-2}$) ± 95% confidence interval under tree canopy and in the open in three study plot in Nigerian Guinea savanna.

Plot 1						
Species	July			October		
	Canopy	Open	Total	Canopy	Open	Total
Aspilia helianthoides	1.65 ± 0.73	1.32 ± 0.86	2.97 ± 1.01	2.07 ± 0.91	2.00 ± 0.95	4.07 ± 1.21
Borreria radiata	0.02 ± 0.01	0.02 ± 0.01	0.04 ± 0.02	–	0.93 ± 0.29	0.93 ± 0.29
Borreria scabra	0.62 ± 0.42	1.22 ± 0.99	1.84 ± 1.00	0.90 ± 0.44	2.65 ± 0.79	3.55 ± 0.83
Cassia mimosoides	0.08 ± 0.09	0.14 ± 0.11	0.22 ± 0.14	0.76 ± 0.85	12.62 ± 6.00	13.38 ± 5.72
Cissus rubiginosa	–	–	–	1.68 ± 0.45	1.48 ± 0.58	3.16 ± 0.74
Commelina diffusa	0.04 ± 0.02	0.09 ± 0.08	0.13 ± 0.05	–	0.14 ± 0.04	0.14 ± 0.04
Crotalaria sp.	–	0.006 ± 0.01	0.006 ± 0.01	–	–	–
Hibiscus asper	0.28 ± 0.20	0.31 ± 0.24	0.59 ± 0.34	6.02 ± 2.56	6.49 ± 3.56	12.51 ± 3.72
Indigofera dendroides	0.12 ± 0.19	0.12 ± 0.03	0.24 ± 0.19	0.16 ± 0.08	0.28 ± 0.26	0.44 ± 0.16
Ipomea heterotricha	0.16 ± 0.14	0.12 ± 0.10	0.28 ± 0.13	0.84 ± 0.48	0.27 ± 0.22	1.11 ± 0.57
Monechma ciliatum	0.37 ± 0.19	1.10 ± 0.07	1.47 ± 0.07	1.80 ± 0.61	3.41 ± 1.66	5.21 ± 1.60
Pandiaka heudelotii	0.19 ± 0.18	0.65 ± 0.57	0.84 ± 0.55	0.46 ± 0.40	1.25 ± 0.06	1.71 ± 0.93
Sida rhombifolia	–	0.04 ± 0.06	0.04 ± 0.06	0.05 ± 0.02	0.74 ± 0.16	0.79 ± 0.16
Stylochiton lancifolius	0.48 ± 0.38	0.56 ± 0.41	1.04 ± 0.38	1.39 ± 0.44	–	1.39 ± 0.44
Tephrosia bracteolata	–	–	–	–	0.25 ± 0.08	0.25 ± 0.08
Tephrosia pedicellata	–	–	–	–	0.03 ± 0.01	0.03 ± 0.01
Vigna racemosa	0.21 ± 0.23	0.29 ± 0.09	0.50 ± 0.43	1.89 ± 0.61	1.89 ± 0.98	3.78 ± 1.00
Plot mean	4.22 ± 1.38	5.99 ± 1.40	5.33 ± 1.39	18.02 ± 2.25	34.43 ± 4.47	28.31 ± 3.64

Plot 3

Species	July			October		
	Canopy	Open	Total	Canopy	Open	Total
Alternanthera nodiflora	–	–	–	–	0.02 ± 0.01	0.02 ± 0.01
Alysicarpus rugosus	–	–	–	0.17 ± 0.22	–	0.17 ± 0.22
Aspilia africana	1.08 ± 0.29	0.25 ± 0.07	1.33 ± 0.29	0.65 ± 0.61	0.57 ± 0.56	1.22 ± 0.83
Blepharis linariifolia	–	–	–	0.03 ± 0.01	0.70 ± 0.25	0.73 ± 0.26
Blumea perrottetiana	–	–	–	–	0.09 ± 0.02	0.09 ± 0.02
Borreria radiata	0.24 ± 0.29	0.51 ± 0.33	0.75 ± 0.45	0.35 ± 0.32	1.38 ± 0.84	1.73 ± 0.77
Borreria scabra	0.50 ± 0.27	0.46 ± 0.35	0.96 ± 0.38	0.14 ± 0.21	0.42 ± 0.36	0.56 ± 0.42
Calcitropoides praecox	0.07 ± 0.11	–	0.07 ± 0.11	0.04 ± 0.06	0.77 ± 1.22	0.81 ± 1.21
Cassia mimosoides	0.01 ± 0.02	–	0.01 ± 0.02	0.22 ± 0.22	0.29 ± 0.19	0.51 ± 0.28
Commelina diffusa	0.38 ± 0.30	–	0.38 ± 0.30	0.33 ± 0.06	–	0.33 ± 0.06
Crotalaria macrocalyx	–	–	–	0.17 ± 0.04	0.52 ± 0.11	0.69 ± 0.11
Crotalaria microcarpa	–	–	–	0.04 ± 0.03	0.26 ± 0.17	0.30 ± 0.19
Curculigo pilosa	–	0.04 ± 0.06	0.04 ± 0.06	–	–	–
Hibiscus asper	–	–	–	0.03 ± 0.01	0.29 ± 0.07	0.32 ± 0.08
Indigofera dendroides	–	0.02 ± 0.01	0.02 ± 0.01	0.29 ± 0.08	0.45 ± 0.12	0.74 ± 0.15
Indigofera macrocalyx	–	–	–	–	0.24 ± 0.32	0.24 ± 0.32
Indigofera polysphaera	–	–	–	–	0.40 ± 0.32	0.40 ± 0.32
Melanthera elliptica	–	–	–	1.91 ± 1.78	–	1.91 ± 1.78
Monechma ciliatum	0.98 ± 0.19	–	0.98 ± 0.19	–	–	–
Pandiaka heudelotii	0.02 ± 0.01	0.04 ± 0.03	0.06 ± 0.03	0.13 ± 0.09	0.22 ± 0.17	0.35 ± 0.19
Pandiaka involucrata	0.50 ± 0.57	0.22 ± 0.25	0.72 ± 0.58	1.51 ± 1.79	0.63 ± 0.77	2.14 ± 1.78
Sebastiania chamaelea	–	0.04 ± 0.04	0.04 ± 0.04	0.03 ± 0.01	0.08 ± 0.02	0.11 ± 0.03
Stylochiton lancifolius	0.92 ± 0.59	0.31 ± 0.39	1.23 ± 0.62	–	–	–
Tephrosia bracteolata	0.26 ± 0.04	–	0.26 ± 0.04	0.09 ± 0.14	1.02 ± 0.92	1.11 ± 0.93
Tephrosia elegans	–	–	–	0.06 ± 0.02	0.35 ± 0.13	0.41 ± 0.14
Vernonia purpurea	–	–	–	0.09 ± 0.07	–	0.09 ± 0.07
Vigna ambacensis	–	–	–	0.92 ± 1.07	0.35 ± 0.27	1.27 ± 1.10
Vigna racemosa	–	–	–	0.33 ± 0.11	0.45 ± 0.11	0.78 ± 0.15
Plot mean	4.96 ± 1.15	1.89 ± 0.66	2.75 ± 0.80	7.53 ± 2.87	9.50 ± 2.20	8.95 ± 2.39

Plot 7

Species	July Canopy	July Open	July Total	October Canopy	October Open	October Total
Aspilia africana	0.76 ± 0.61	0.09 ± 0.10	0.85 ± 0.60		–	–
Borreria radiata	–	–	–		0.08 ± 0.03	0.08 ± 0.03
Borreria scabra	0.07 ± 0.11		0.07 ± 0.11	–	–	–
Cassia mimosoides	–		–	1.40 ± 0.82	1.43 ± 0.73	2.83 ± 1.35
Crotalaria macrocalyx	–		–	0.23 ± 0.31	0.32 ± 0.50	0.55 ± 0.59
Crotalaria microcarpa	0.14 ± 0.18	0.30 ± 0.10	0.44 ± 0.34	0.22 ± 0.07	0.04 ± 0.06	0.26 ± 0.09
Curculigo pilosa	0.10 ± 0.16	0.18 ± 0.18	0.28 ± 0.24	–	–	–
Indigofera bracteolata	0.23 ± 0.37	0.34 ± 0.14	0.57 ± 0.48	1.87 ± 1.66	2.43 ± 2.27	4.30 ± 2.64
Indigofera dendroides			–	–	0.42 ± 0.67	0.42 ± 0.67
Indigofera paniculata	–	–	–	–	0.27 ± 0.35	0.27 ± 0.35
Kaempferia aethiopica	0.35 ± 0.29	0.15 ± 0.14	0.50 ± 0.31	0.22 ± 0.21		09.22 ± 0.21
Melanthera elliptica	–	–	–	0.18 ± 0.28	–	0.18 ± 0.28
Monechma ciliatum	0.31 ± 0.15	1.89 ± 1.42	2.20 ± 1.46	1.35 ± 2.14	1.99 ± 1.28	3.34 ± 2.13
Pandiaka heudelotii			–	0.08 ± 0.08	0.12 ± 0.17	0.20 ± 0.19
Tephrosia elegans			–	1.80 ± 1.86	0.20 ± 0.12	2.00 ± 1.80
Tinnea barteri	0.31 ± 0.48	0.26 ± 0.31	0.57 ± 0.58	–	0.46 ± 0.74	0.46 ± 0.74
Vigna racemosa	0.02 ± 0.15	0.03 ± 0.02	0.05 ± 0.03	2.12 ± 2.06	0.81 ± 0.69	2.93 ± 2.48
Plot mean	2.29 ± 0.93	3.24 ± 0.87	3.04 ± 0.88	9.47 ± 3.28	8.57 ± 2.78	8.76 ± 2.89

Table 4. Mean forb yield, $gm^{-2} \pm 95\%$ confidence interval under three different canopy classes in three study plots in the Guinea savanna zone of Northwestern Nigeria.

Plot	July			October		
	Canopy 1	Canopy 2	Canopy 3	Canopy 1	Canopy 2	Canopy 3
1	0.65 ± 0.33	0.33 ± 0.04	3.24 ± 0.33	1.02 ± 0.32	3.80 ± 0.75	13.19 ± 2.07
3	1.05 ± 0.28	1.22 ± 1.14	2.69 ± 0.57	0.58 ± 0.18	1.12 ± 0.28	5.82 ± 1.48
7	0.74 ± 0.30	1.06 ± 0.74	0.49 ± 0.27	0.88 ± 0.34	6.53 ± 1.36	2.07 ± 0.70

Canopy 1, <3 m high; canopy 2, 3–7 m high; canopy 3, >7 m.

Effect of tree canopy on crude protein, fibre and lignin content of forb species

The chemical composition of forb species in relation to tree canopy cover and in the open and stage of growth is presented in Table 5.

Crude protein content

There is no statistical significant difference between the mean crude protein content of forb species growing under tree canopy and in the open. However, the response of crude protein content of the forb species to tree canopy cover and open areas tended to vary among the species. Some species tended to have higher crude protein under tree canopy cover than in the open. In some, the crude content response to tree canopy varied with the growth stage of the plant being higher under tree canopy at early stage of growth and lower at peak stage of growth and vice versa. In others the response varied from one plot to another (see Table 5).

Crude protein content varied among groups of species. Leguminous forb species have higher mean crude protein content than non-legumes in October in all the plots.

Fibre content

No statistical significant difference was found between the fibre content of forb species growing under tree canopy and those in the open though a trend towards a higher or lower fibre content in some forb species under tree canopy than in the open occurred (Table 5).

C. mimosoides, *H. asper*, *I. bracteolata* and *V. racemosa* growing under tree canopy tended to have higher NDF content than those in the open. It is only in *A. helianthoides* that the NDF content is lower under tree canopy than in the open.

The ADF content of forb species growing under tree canopy tended to be higher than those in the open (exception, ADF content of *A. helianthoides* in July and *C. mimosoides* in October in plot 3) (see Table 5).

Lignin

Almost all the forb species on which lignin analysis was carried out have statistically insignificant higher lignin content under tree canopy than in the open. These are *C. mimosoides*, *H. asper*, *I. bracteolata* and *V. racemosa*. It is only *A. helianthoides* that has statistically insignificant lower lignin content under tree canopies than in the open.

Discussion

Tree canopy cover and forb yield

The leguminous species, *Cassia mimosoides*, *Crotalaria macrocalyx*, *Crotalaria microcarpa*, *Indigofera bracteolata*, *Indigofera dendroides*, *Tephrosia bracteolata*, *Tephrosia elegans* and *Vigna racemosa* encountered in this study show a trend to have higher yield in the open than under tree

Table 5. Some chemical attributes of forb species (per cent of dry matter of whole plant) under tree canopy and in the open in July and October 1985–1986 in three study plots in the Guinea savanna zone of Northwestern Nigeria (Mean ± 95% confidence Interval).

Species	July				October			
	%CP	%NDF	%ADF	%ADL	%CP	%NDF	%ADF	%ADL
Plot 1								
Aspilia helianthoides								
Canopy	10.05 ± 1.01	–	49.75 ± 2.47	5.62 ± 0.48	3.40 ± 0.23	69.84 ± 3.04	61.96 ± 1.81	8.72 ± 0.21
Open	9.80 ± 0.62	–	52.08 ± 1.76	6.69 ± 0.24	3.53 ± 0.34	70.51 ± 2.12	61.48 ± 3.39	8.88 ± 0.26
Borreria scabra								
Canopy	9.32 ± 0.74	–	–	–	3.91 ± 0.25	–	–	–
Open	9.71 ± 0.85	–	–	–	4.94 ± 1.05	–	–	–
Cassia mimosoides								
Canopy	–	–	–	–	7.25 ± 0.07	67.15 ± 2.63	56.90 ± 2.70	–
Open	17.11 ± 3.50	58.56 ± 3.50	–	–	7.16 ± 0.07	66.40 ± 2.60	53.05 ± 3.15	–
Hibiscus asper								
Canopy	–	–	–	–	5.35 ± 0.30	63.93 ± 1.01	52.96 ± 1.84	8.62 ± 0.45
Open	18.20 ± 0.82	37.37 ± 1.25	–	–	5.55 ± 0.54	63.80 ± 2.38	48.80 ± 2.04	8.31 ± 0.65
Vigna racemosa								
Canopy	16.17	–	–	–	9.97 ± 0.97	62.55 ± 1.98	43.00 ± 3.48	–
Open	12.83 ± 0.14	–	–	–	10.00 ± 0.35	59.40 ± 1.02	39.74 ± 3.00	–
Plot 3								
Borreria scabra								
Canopy	8.46	–	–	–	5.61 ± 0.71	–	–	–
Open	9.26	–	–	–	4.00 ± 0.25	–	–	–
Cassia mimosoides								
Canopy	–	–	–	–	9.49	56	–	–
Open	–	–	–	–	8.12 ± 0.16	54.87 ± 2.60	40.09 ± 2.30	–
Stylochiton lancifolius								
Canopy	10.13 ± 0.83	–	–	–	–	–	–	–
Open	11.26	–	–	–	–	–	–	–
Plot 7								
Cassia mimosoides								
Canopy	–	–	–	–	7.90 ± 0.43	53.00 ± 1.37	46.37 ± 2.68	8.02 ± 0.65
Open	–	–	–	–	8.22 ± 0.14	52.75 ± 1.14	45.00 ± 1.81	7.33 ± 0.38
Indigofera bracteolata								
Canopy	8.50	58.6	55.3	8.93	6.31 ± 0.77	68.90 ± 6.67	58.28 ± 4.57	9.37 ± 0.84
Open	8.86 ± 0.07	–	54.95	7.53	5.96 ± 0.41	65.27 ± 1.73	56.54 ± 0.97	8.67 ± 0.38
Vigna racemosa								
Canopy	–	–	–	–	10.42 ± 0.93	55.84 ± 1.69	44.80 ± 2.18	7.24 ± 0.79
Open	–	–	–	–	9.02 ± 0.56	54.86 ± 0.78	42.80 ± 0.61	6.40 ± 0.50

CP = Crude protein; NDF = Neutral detergent fibre; ADF = Acid detergent fibre; ADL = Acid-detergent lignin.

canopy though no statistical significance can be shown. It has been suggested that the normal growth and photosynthetic rate advantage that C_4 grass have over C_3 legumes would be reduced under shaded situations and that in these circumstances the grass and legume would have equal competitive ability (Ludlow, Wilson & Heslechurst 1974; Mott & Popenoe 1977). In this way it is hoped that the proportion of legumes in a grass-legume pasture should be more easily maintained under shade. The above result which is in agreement with the result of Eriksen (1977), for other tropical legumes indicates that leguminous species may not compete favourably with grasses under shaded conditions and would actually be more disadvantaged under such conditions. Also some grass species have been shown to have higher yield under tree canopy than in the open (Kennard & Walker 1973; Muoghalu 1989) and preference of shade for growth (Pratt & Gwynne 1977; Isichei 1982). So the possibility of maintaining legume proportion in a grass legume mixture under shade may not be possible in the light of the findings of this study and that of Eriksen (1977) and will depend on the shade tolerance of both the grass and legume species used in such pastures.

A higher forb yield is obtained under tree canopy provided by trees above 7 m in plots 1 and 3 and under canopy provided by trees between 3 and 7 m in plot 7 and lowest under canopy provided by trees 3 m high in all three plots. This is in accord with the result of Sanford *et al.* (1982) but at variance with that of Stuart-Hill and Tainton (1989), that tall trees suppressed grass growth more than shorter trees. It is possible that such high canopy permits more light to reach forb species under it for adequate photosynthesis. The lower yield obtained under the lowest canopy is possibly due to deeper shading of this canopy class and direct competition for space and nutrients by woody plants providing such canopy. These small trees would not be as effective in temperature amelioration, mineral cycling and addition of organic matter to the soil as larger trees (Sanford *et al.* 1982).

Crude protein, fibre and lignin

A higher crude protein, fibre and lignin in some species than in others under tree canopy than in the open is observed. This difference is however not statistically significant. Tree canopy cover therefore does not have significant effect on the crude protein, fibre and lignin content of forb species growing under them in the study area.

The crude protein of the leguminous species among them is higher than that of non-legume species and this is more pronounced at the latter stages of growth. The crude protein content of all the forb species decreased and fibre and lignin contents increased as the plants aged. Similar decrease in protein and increase in structural components such as acid-detergent fibre, cell wall constituents and lignin of forb species with advancing age have been reported (Ademosun 1970). The increase in structural components is probably due to the high proportion of stem at later stages of growth.

Acknowledgements

The authors thank the reviewers of this paper whose useful comments have helped to improve the quality of the paper.

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