NITROGEN CONTENT AND DRY-MATTER DIGESTIBILITY OF GUINEA AND SABI GRASSES AS INFLUENCED BY TREE LEGUME CANOPY

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SUMMARY

A research study was undertaken to study the grass layer across a mini landscape dominated by tree legume *Albizia lebbeck* to explore the nutritional differences of two introduced grasses, guinea grass (*Panicum maximum*) and sabi grass (*Urochloa mosambicensis*), paying particular attention to the presence or absence of tree legume canopy of *Albizia lebbeck*. The two grass species showed a tendency to replace the native spear grass (*Heteropogon contortus*); their dominance was more or less complete under tree canopies but was increasing in open areas between trees.

Nutritional differences were examined by nitrogen concentration and dry matter digestibility. For comparison, *Heteropogon contortus*, a native species only found in the open, was included in the nutritional determination using the same methods as the guinea and sabi grasses. The quality parameters of the pasture species were statistically compared (LSD, P=0.05).

The quality of herbage was different between the species. *Urochloa mosambicensis* was better than *Panicum maximum*. In the open, sabi grass has higher N content (0.62%) than guinea grass (0.55%), but they were similar when grown under the canopy (0.69% and 0.72%, respectively). Sabi grass has consistently higher dry matter digestibility (41.39% and 36.83%, respectively under the canopy and in the open), than guinea grass (27.78% and 24.77%). These two species are much higher in both N concentration and dry matter digestibility than the native spear grass. The native species has contained 0.28% N, and 17.65% digestible dry matter.

The feeding values of herbage were influenced by the canopy factor. Both guinea and sabi grasses have better quality when grown under the tree canopies than in between canopies. Nitrogen concentration and dry matter digestibility of the guinea grass under canopy were, 0.72% and 27.78%, respectively, significantly higher than those from the open area, 0.55% and 24.77%. Similarly, herbage of sabi grass under canopy has 0.69% and 41.39%, nitrogen content and digestible dry matter, respectively, which is significantly higher than herbage from the open sites, 0.62% and 36.83%.

Keywords: *Guinea grass, sabi grass, canopy, open area* and *transect*

KANDUNGAN NITROGEN DAN KECERNAAN BAHAN KERING RUMPUT GUINEA DAN RUMPUT SABI SEBAGAI AKIBAT NAUNGAN POHON LEGUM

RINGKASAN

Suatu penelitian telah dilakukan pada padang penggembalaan yang ditumbuhi pohon-pohonan (*woodland*) dengan dominasi legum *Albizia lebbeck*. Studi ini dimaksudkan untuk evaluasi perbedaan nilai pakan hijauan dua jenis rumput introduksi, *Panicum maximum* (rumput guinea) dan *Urochloa mosambicensis* (rumput sabi), dengan penekanan pada kehadiran naungan kanopi pohon *Albizia lebbeck*. Dua jenis rumput tersebut cenderung menggantikan rumput alam *Heteropogon contortus*. Dominasi penuh dua jenis rumput tersebut terjadi di bawah kanopi, dan cenderung meningkat di tempat terbuka.

Perbedaan nilai nutrisi dinilai melalui penetapan kandungan nitrogen dan daya cerna bahan kering hijauan yang dihasilkan Jenis rumput alam, *Heteropogon contortus* hanya ditemukan pada tempat terbuka, diikutkan dalam evaluasi nutrisi ini untuk menjadi bahan perbandingan. Mutu hijauan dibandingkan secara statistik menggunakan tingkat ketelitian 95% (beda nyata terkecil, P=0.05).

Mutu hijauan berbeda antara jenis rumput, *Urochloa mosambicensis* lebih baik dari *Panicum maximum*. Di tempat terbuka, rumput sabi menghasilkan hijauan dengan kandungan N (0.62%) yang nyata lebih tinggi dari rumput guinea (0.55%), tetapi keduanya tidak berbeda secara nyata jika tumbuh di bawah kanopi (masing-masing 0.69% and 0.72%). Kecernaan bahan bahan kering rumput sabi konsisten lebih tinggi, (41.39% dan 36.83%, berturut-turut di bawah kanopi dan di antara kanopi), dari rumput guinea (masing-masing 27.78% and 24.77%). Konsentrasi nitrogen dan kecernaan dua jenis rumput ini jauh lebih tinggi dibandingkan dengan *Heteropogon contortus* yang hanya memiliki 0.28% N, dan kecernaan bahan kering 17.65%.

Nilai pakan hijauan dipengaruhi oleh faktor kanopi. Mutu hijauan rumput guinea dan rumput sabi lebih tinggi jika tumbuh di bawah naungan kanopi pohon legum dibandingkan jika tumbuh di tempat terbuka. Kandungan N dan kecernaan rumput guinea di bawah kanopi masing-masing, 0.72% dan 27.78%, nyata lebih tinggi dibandingkan yang tumbuh di antara kanopi, masing-masing 0.55% and 24.77%. Demikian pula, rumput sabi di bawah kanopi memiliki kandungan N dan tingkat kecernaan, berturut-turut 0.69% dan 41.39%, secara signifikan lebih tinggi daripada yang tumbuh di antara kanopi, 0.62% dan 36.83%.

Kata kunci: *Rumput guinea*, *rumput sabi*, *kanopi*, *tempat terbuka* dan *transek*

INTRODUCTION

Low ruminant production in the tropics can be increased through improving the animal, the forage or the environment. In grazing situations, the environment and forage are related. Manipulating the microclimate for instance, by planting trees, affects pastures' composition,

and indirectly forage yield and quality. Yield and quality may also be changed directly for instance, by the addition of fertiliser or the sowing of improved pasture species.
The presence of trees in a landscape can play an important role in modifying the environment of associated plants such as: improving soil nutrient availability through enhanced nutrient cycling in leaf and tree-derived litter (Tiedemen and Klemmedson, 1977; Hogberg, 1986; Young, 1989; Belsky *et al*., 1993; Okeke and Omaliko, 1994; Smit and Swart, 1994; Srivastava and Ambasht, 1995); reducing soil and air temperatures (Wilson, 1990; Belsky *et al.*, 1993; Wilson and Wild, 1995); lowering the rate of evaporation, which is extremely important during dry periods (Wong and Wilson, 1980; Lowry *et al.*, 1988); and reducing the incidence of frost in cooler tropical regions where frost has been found to kill the tops of young plants (English and Hopkinson, 1985; Graham, 1992).

A number of studies have identified higher soil fertility under tree canopies than in the adjacent open areas: for example, under *Eucalyptus melanophloia* (Prebble and Stirk, 1980) and *E. regnans* (Polglase and Attiwill, 1992; Polglase *et al.*, 1992) in Australia; under trees in open savanna grasslands of north-west Nigeria (Isichei and Muoghalu, 1992); under *Dactyladenia barteria* at Ozala, Nigeria (Okeke and Omaliko, 1994); and under leguminous and non-leguminous trees in Transvaal, South Africa (Smit and Swart, 1994).

Pasture production under tree canopies has been shown to provide: better herbage yield and/or quality (Stuart-Hill *et al.*, 1987; Lowry *et al.*, 1988; Smit and Swart, 1994), improved lamb survival (Bird *et al.*, 1984; Roberts, 1984; Bird and Cayley, 1991), reduced losses of shorn sheep (Bird and Cayley, 1991), and increased milk production of dairy cattle (Silver, 1987).

In addition, tree legumes have the ability to fix nitrogen from the air, and the resultant herbage has high nutritive value. They may contribute fixed nitrogen into the soil; produce high quality of feed, shade for associated pasture, and shelter for the livestock. On the other hand, however, they have been noted to compete with associated grass species and reduce yield, particularly in dry years. Therefore, an attempt to understand the effects of tree legume canopy on underneath pasture is needed. The present work is restricted to the influences of *Albizia lebbeck* (Indian siris) tree canopy on the nutritive value of the herbage of *Panicum* *maximum* and *Urochloa mosambicensis* that are introduced species and had invaded a mini landscape.

MATERIALS AND METHODES

The study area

The study was carried out on the floodplain south of the Ross River, Townsville, North Queensland Australia. The area is part of an undeveloped area of about 350 ha. This presented study was conducted in a part of the area that is fenced.

The soil types range between sand and loamy sand with pH 4.5 to 5.0. Although pedologically the area was based on a major soil texture group, there were major differences in, for instance, thickness of overburden and depth to clay loam or clay subsoil (Liano 1990).

Monthly rainfall varied from 0 (August) to over 568 mm (March). During the dry months from August to November, the maximum rainfall was 34 mm in October. While monthly evaporation varied between 96 mm to 224 mm, during the period August to November it varied between 133 to 219 mm. Daily means of minimum and maximum temperature (monthly means) ranged from 10.1 to 22.5°C and 25.7 to 34.7°C, respectively and air relative humidity ranged from 53% to 75% where the lowest four month period occurred in the August to November.

The dominant trees and herbaceous vegetation

The *Albizia lebbeck* trees, a leguminous species, are dominant for the upper stratum in this small landscape, particularly in an area of about 25 ha close to the Ross River side. There are also some other tree species such as *Eucalyptus alba* and *Eucalyptus tesselaris*, *Mangifera* sp. and rain tress (*Samanea saman*). The present study was carried out in this particular site.
There are some grass species; the four dominant species are guinea grass (*Panicum maximum*), sabi grass (*Urochloa mosambicensis*), spear grass (*Heteropogon contortus*), and *Sporobolus* spp. However, the latter two species were found only in between canopy (Amar, 1991). The first two species are not native to this country; therefore, they may have been

introduced into the area many years ago. Those species, seem to replace spear grass even in the open area, were examine for their herbage qualities in respect to the ‘lebbeck’ tree canopy.

Experimental design

Two factors of the study are plant species (guinea and sabi grasses), and tree canopy (under tree canopy and between tree canopies). The study was carried out along fixed transects between numbered trees. There are 14 large ‘lebbeck’ trees in a group where the transects were set, subsequently from tree 1 to tree 2, tree 2 to tree 3 and so forth.

Samples of the guinea and sabi grasses were collected along the fixed transects, but omitting data around tree 1 when the ground vegetation had been burned, and the data under canopy tree 11 since this tree died and the area became covered by the canopy of a nearby mango tree. The vegetation is mosaiced and, on occasions, the fixed transects failed to locate even relatively common species, particularly *Urochloa mosambicensis* which is probably only just recently invading the area. In such instances, small, additional transects were undertaken so as provide enough balance data to the guinea grass, that is transect from tree 1 to tree 8, and from tree 8 to tree 10.

Experimental procedure

Collection of herbage samples

A “paired”system of sampling was therefore employed, and the study restricted to the two major grass components of the sward, *Panicum maximum* and *Urochloa mosambicensis* that were present both under and between the tree canopies. Cutting samples were undertaken along the transects. Two samples for each species were harvested that is under each canopy and between each pair of trees.

Differences in plant growth form caused a problem; whereas *Urochloa mosambicensis* is a creeping, ‘*rhizomatous’* plant with high ground cover; while *Panicum maximum* produces well-defined clumps. For the former species, therefore, herbage samples were cut at 5 cm from the ground within 0.5 m^2 quadrat, while for the latter individual plants were cut at about 30 cm from the base of the plants according to the grazing level of this species on the grazed area.

All collected samples were dried in an oven at 100^0C for 48 for dry matter information. Then samples of each species were separated into leaf and stem. This separation was done with a proportion of each sample (of about ¼ of total each sample). They were dried again for 24 hours, and weighed for the leaf stem ratio.

Determination of herbage quality

The grass samples of each species with separated leaf and stem were ground to pass through a 1 mm mesh for determination of N concentration and dry-matter digestibility.

- *Nitrogen analysis*

N concentration was determined by Kjeldahl digestion. Samples weighing about 0.35 g were used with duplicates of each. Each sample was placed in a 75 ml graduated digestion tube to which was added 6 ml sulfuric acid and 1 Kjeldahl catalyst tablet. Also, two small glass balls and one drop of kerosene were put in each tube to prevent the sample from boiling over. The tubes were then heated in a digestion block (1016 tecator digestion system 40, Sweden). The digesta were heated to 180^0C for 30 minutes, 250^0C for 1.5 hours, and then 400^0C for about 1 hour approximately, till the samples digested). After cooling, approximately 40 ml of distilled water was added to each of the digested samples, and then made up to 100 ml in a 100 mm volumetric flask. The solution was then ready for analysis. The nitrogen level was recorded by a graphic chart recorder using an 'Autoanalyser II'. This analysis was conducted in the Nutrition Laboratory in the Graduate School of Tropical Veterinary Science and Agriculture at James Cook University of North Queensland.

Dry matter digestibility

The dry matter digestibility was determined by the nylon bag technique (Playne *et al.* 1978; Boniface *et al.* 1986). This technique is a simple method for obtaining basic information about the digestibility of feed dry matter or feeds organic matter in the rumen, which provides an estimate of the amount of rapidly fermented substances and an estimate of the rate of degradation of more slowly digested substances. Indeed, this method does not cover the post ruminal digestion. Incubation time of 24 hours was applied. The digestibility measurement was carried out at Lansdown CSIRO research Station about 50 km south of Townsville. Sample weighing 3 g dry matter was placed in nylon bags with three replicates for each sample.

In this determination, three steers which were fed a sorghum hay basal diet were used for three replications. The bags were secured at intervals along a 40 cm length. Each bag was attached by forcing the open end transversely through the tube slits provided and securing it with an elastrator ring.

On removal, the bags were washed under running water for about 30 minutes until no more turbidity was visible, and slightly squeezed to assist in removal of rumen fluid. Then the bag and samples were dried at 70ºC in a forced drought oven for 48 hours and weighed to determine dry matter loss.

Either nitrogen content or digestibility of entire cut herbage sample (leaf + stem) was calculated by using the following equation, (modified from Bamualim, 1981):

$$N \text{ or } D\ (\%) = \frac{L_{ND} \times L/S + S_{ND}}{L/S + 1}$$

Where: N or D = either Nitrogen concentration (%), or dry matter digestibility (%)
L_{ND} = either N concentration of the leaf (%), or Leaf digestibility (%)
S_{ND} = either N concentration of the stem (%), or Stem digestibility (%)
L/S = leaf-stem ratio

RESULTS

The effect of plant species and tree canopy

The interaction between grass species with tree canopy had significant effects on the nitrogen concentration and dry matter digestibility of the cut herbage. Both *P. maximum* and *U. mosambicensis* produced herbage of higher nitrogen content and dry matter digestibility when grow under the tree canopy than in the open between canopies (Tables 1 and 2).

Table 1 Nitrogen concentration (%) of the harvested herbage

Species	Site	
	Under canopy	Between canopies
Panicum maximum	0.72 aA	0.55 bB
Urochloa mosambicensis	0.69 aA	0.62 aB
s.e. (P<0.05)	0.045	

Means in a column followed by the same lower case letter are not significantly different.
Means in a row followed by different upper case letters are significantly different.

As for comparison, the native grass *Heteropogon contortus* that was only found in the open, has average 0.28% N concentration and very low 17.7% dry matter digestibility.

Table 2 Dry-matter digestibility (%) of the harvested herbage

Species	Site	
	Under canopy	Between canopies
Panicum maximum	27.78 bA	24.77 bB
Urochloa mosambicensis	41.39 aA	36.83 aB
s.e. (P<0.05)	1.050	

Means in a column followed by the same lower case letter are not significantly different.
Means in a row followed by different upper case letters are significantly different.

U. mosambicensis has consistently higher dry matter digestibility than *P. maximum*, both under the tree canopy and in the open. The former species has also higher nitrogen content than the latter when grow in the open area, but has not under the tree canopy.

The effect tree canopy and plant fraction

Both leaf and stem fractions of the guinea grass grows under the tree legume canopy were consistently higher in nitrogen content and dry matter digestibility than those in between the canopies (Table 3). Another introduced grass, *U. mosambicensis* under canopy had also produced herbage of higher leaf nitrogen content, both leaf and stem digestibility than herbage from the plants grow in the open area, but the canopy factor did not significantly influence the nitrogen content of the stem of this species (Table 4).

Table 3 Nitrogen concentration and dry-matter digestibility of *P. maximum* fractions

Site	N (%)		Digestibility (%)	
	Leaf	Stem	Leaf	Stem
Under canopy	1.13 aA	0.42 aB	37.62 aA	21.28 aB
Between canopies	0.88 bA	0.35 bB	32.19 bA	19.76 bB
s.e. (P<0.05)	0.030		1.030	

Means in a column followed by the same lower case letter are not significantly different. Means, either N content or digestibility, in a row followed by different upper case letters are significantly different.

Table 4 Nitrogen concentration and dry-matter digestibility of *U. mosambicensis* fractions

Site	N (%)		Digestibility (%)	
	Leaf	Stem	Leaf	Stem
Under canopy	1.22 aA	0.37 aB	45.63 aA	39.39 aB
Between canopies	0.99 bA	0.40 aB	42.15 bA	34.82 bB
s.e. (P<0.05)	0.040		1.050	

Means in a column followed by the same lower case letter are not significantly different. Means, either N content or digestibility, in a row followed by different upper case letters are significantly different.

It was noted during the study period that the stems of *U. mosambicensis* were maintained fresh (reddish green in colour) though the leaves turn hayed off in progress of dry season. In contrast to the nitrogen concentration, however, these fresh stems from open area could not maintain digestibility at the same level to those from under the tree canopy. Nevertheless, these two introduced grasses were consistently posses higher nitrogen contents and dry matter digestibility for both leaf and stem in comparison to the native spear grass. The low nutritive value of the spear grass was indicated by nitrogen concentrations of 0.28%, and dry matter digestibility at level 17.65%.

Discussion

The lebbeck tree's canopy has positively increased nutritive value of *U. mosambicensis* and *P. maximum* that were the only grasses invade the area under the canopy. The presence of tree canopies contributes to the higher nitrogen content of the two introduced species when grown under canopies than in exposed areas (Table 1). This is an evidence of the important role of tree legumes in modifying micro-environment underneath, particularly to the soil where ground cover plants may gain advantages. One of these beneficial effects is higher soil fertility, such as soil nitrogen concentration that has been proved by many researchers, for instances, Smit and Swart, (1994) found this better soil fertility under leguminous and non-leguminous trees than in the open sites. It has long been recognised the potential used of nitrogen fixing trees, however, this result might not merely the influence of the tree legume itself. There some possible contributors namely, the tree was there due to the better nature of the soil, or birds and other animals whose drop manure and urinate when come to the tree either on the tree or resting under the tree and this may has significant effects, or there may some physiological advantages in the shaded plants themselves, and many other possibilities, including the interaction among two or more of those contributors.

The dry matter digestibility has added proves to the concepts of tree legume advantages. The introduced grasses grown under tree canopies have higher digestibility levels than when grown in the full sun (Table 2). These phenomena are suggested as the benefit effects of some environmental comforts provide by the tree canopies such as improving soil nutrient availability, reducing soil and air temperatures, lowering the rate of evaporation, and so forth which might affect plant maturity and cell components. However**,** *U. mosambicensis,* whether in between or under canopies, has higher values than those *P. maximum* (Tables 1 and 2). The native grass, *H. contortus* again has lower digestibility values.

It was not unexpected that nutritive values of leaf were higher than stem fractions of the studied grasses, either introduced or native species. In respect to canopy effect, however, nitrogen content of the *U. mosambicensis* stems was not significantly affected, but others were influenced significantly (Tables 3 and 4). It is suggested that the non-significant effect of the tree canopy on the digestibility of the *U. mosambicensis* stems was partly due to the ability of the species to maintain fresh reddish-green stem inside the dry-off leaf sheath in the open site. On the other hand, the leaves of the plant grown under the tree canopy stay green longer than those in the open that hayed of quickly as the dry season progress.

In relation to the present situation with heavy demands for agricultural products, this study has revealed one of the important roles of tree legumes in a farming system. The results shown that the present of tree legume canopy improves nutritive values of herbage resulting from associated grasses. This agrees with the founding of other researchers, such as Lowry *et al.* (1988), Wild *et al*. (1993), and Smit and Swart (1994).

It is imperative to be considered that land and soil are the basic needs for agricultural production, therefore must not be 'mined'. Investigations of different potential cultivation system on any form of landscape need much more attention, and land use capability must be considered. In addition to the positive effects of tree legumes canopy on herbage underneath, the tree can offer nutritious herbage (Nitis, 2000), which is particularly important during drought periods. As a result, the association of trees in a farming land can be expected to maintained production, while alleviate the over exploit of land and soil. It is increasingly gain attention that potential use of grazing land, especially in the tropics is not only an interesting matter for the graziers, but also for ecologists and scientists in general.

The application of technology and the use of fertiliser only solves the short term need for increasing production, but we may then face other problems such as cost, fertiliser effect on soil acidity, and pollution. On the other hand, the use of legumes and tree species in agricultural practices can reduce the need for fertiliser, and trees provide shading for associate plants or livestock. The use of tree legumes has been popularised in many farming systems, particularly browse species. Some approaches for increased production with environmental considerations have been practices wherein trees play important roles, such as in mixed farming and alley cropping systems.

Finally, some important points may be highlighted are:

a) there appears to be some benefits associated with tree legumes, but much more research is requested, such an approach and investigation of land use may help to make best use of the soil for sustainable agriculture;
b) a better understanding of the interaction between associated tree legumes with pasture species is needed to improve agricultural productivity and sustainability in many regions;
c) environmental aspects - soil, climate, time of the year - interact with plant and animal features; species of grass cover, presence or absence of trees and grazing animals interact to produce various possibilities on feeding values and cover of the herbaceous species.

CONCLUSIONS

a) The presence of the lebbeck tree's canopy has positively increased nutritive value of the two introduced species, *U. mosambicensis* and *P. maximum.*
b) Most herbage nutritive parameters of the introduced species were significantly influenced by the tree legume canopy, but nitrogen content of the *U. mosambicensis* stems.
c) Nutritive values of leaf were higher than stem fractions of the studied grasses, either introduced or native species.
d) The introduced species *U. mosambicensis* and *P. maximum* produced herbage that higher in nutritive value than herbage of native *H. contortus*.
e) More studies are recommended for better understanding on and practicing of such approach for more productive and sustainable use of a 'landscape'.

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