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DRY MATTER YIELDS AND BOTANICAL COMPOSITION OF THREE GRASSES AND TWO LEGUME MIXTURES GRAZED BY CATTLE IN A DERIVED SAVANNA AREA OF NIGERIA

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ABSTRACT

A field experiment was conducted at the International Livestock Research Institute Ibadan, Nigeria between July 1998 and August 2000 to evaluate the dry matter yields and botanical composition of *Panicum maximum* (local), *Panicum maximum* (Ntchisi) and *Brachiaria ruziziensis* planted in mixtures with *Centrosema pubescens* ILRI 152 and *Stylosanthes guianensis* ILRI 164 (CIAT 184 cv. Pucallpa) and these species in sole stands. The grass/legume and sole pasture species were mob-grazed by White Fulani and N'Dama cattle one year after planting beginning from March 1999. Thirty-two mature animals (average of 3 years old) of mixed sex, amounting to a stocking density of 250 head ha^{-1} grazed the plots at each grazing period. The pastures were evaluated for dry matter yield, botanical composition, and response of the species components to grazing effects. The dry matter yields of the pastures were lower at the year of planting than the subsequent years and the mean dry matter values averaged over the three years indicated that *P. maximum* (Ntchisi)/*S. guianensis* (9.7 t/ha), Sole *P. maximum* Ntchisi (10.2 t/ha) and sole *S. guianensis* (9.9 t/ha) produced significantly more than the other pastures. The yields by pastures that had *B. ruziziensis* (6.4 - 7.1 kg/ha) as sole crop or as grass/legume mixtures were among the lowest. During grazing, dry matter yields declined from March to December, apparently in response to effects of the intensive grazing. The mean values for dry matter yield indicated that *P. maximum* Ntchisi/*S. guianensis* mixture was more persistent under the heavy grazing effects with the value of 16.9 t/ha compared to 10.6 t/ha for sole *B. ruziziensis*. *S. guianensis* and *C. pubescens* constituted 18-21% and 24-25% respectively of the biomass of the grass/legume pastures one year after mob-grazing indicating that *C. pubescens* could be more resilient under intensive grazing in the derived savanna area of southwest Nigeria.

Keywords: dry matter yield, botanical composition, mob-grazing, cattle, derived savanna

INTRODUCTION

The cattle supply meat and milk which are major sources of protein for Nigerians. They also provide employment for millions of people that are involved in production and marketing (Mohammed, 1990), in addition to arable crop production through the provision of manure and animal traction (ILRI, 1995). Resource Inventory Management Limited (RIM, 1992) and ILCA (1993) estimated the cattle population in Nigeria as 14 million an appreciable index (Nuru, 1982; Nuru and Buvannendran, 1984; Jabbar, 1992) of contribution to the Gross Domestic Product (GDP). It was estimated that the general contribution of the livestock sub-sector amounted to about 8% of the nation's GDP in the early 1980's.

In sub-Saharan African countries, of which Nigeria is one, there are indications that the demand for animal products, especially those of ruminant animal origin, will increase dramatically in the nearest future as human population in some of these countries will double by year 2050 (Smith *et al*., 1997; Delgado *et al.,* 1999). Livestock production in these countries is projected to expand by more than 3% annually in order to be able to cope with this expected rapid increase in human population (Winrock, 1992; Qusman, Badiane and Delgado, 1995). One major anticipated result of these expanding animal and human populations, apparently on a fixed land base is greater intensification of agricultural activities (Smith *et al*., 1997). This will have implication for continued availability of the expansive natural rangeland that presently supplies the bulk of the feed of the grazing ruminants. As noted (Oyenuga and Olubajo, 1975) more research efforts should be focused towards the development of improved, all seasons good quality pasture as there will be the need for stock farmers to depend more on sown pasture to feed their animals. The study reported here evaluated the dry matter yields and botanical composition of some grasses, legumes and their mixtures under intensive grazing by cattle.

MATERIALS AND METHODS

Experimental site

The pastures were carried out on the research farm of the International Livestock Research Institute (ILRI) at the International Institute of Tropical Agriculture (IITA), Ibadan Nigeria ($7^{o}20^{1}$N; $3^{o}54^{1}$E). The area is characterized by a bimodal rainfall pattern that typically peaks around June and September with a break of about two to three weeks in August. Long-term data obtained from the IITA weather records show a mean annual rainfall of 1250mm. The soil at the experimental site belongs to the Iwo series of the Alfisol soil order. A bulked soil sample was taken at 0-15 cm depth of the site for routine nutrient determination before planting (Table 1). The vegetation cover on the experimental site was mowed and the land ploughed and harrowed in early June 1998.

The grasses used were *Panicum - maximum* (local accession), *P. maximum* (Ntchisi) and, *Brachiaria ruziziensis* while *Stylosanthes guianensis* accession ILRI 164 (CIAT 184 cv. *Pucallpa*) and *Centrosema pubescens* accession ILRI 152 were the legumes. The two *P. maximum* species and *B. ruziziensis* were established from crown splits and rooted stolons, respectively. The legume seeds were scarified with hot water for about 15 and 60 seconds for *S. guianensis* and *C. pubescens,* respectively before planting (Crowder and Chheda, 1982). The grasses were planted in the third week of June 1998. The three grasses were planted at 1m x 0.5m spacing and the legume seeds drilled between the grass rows immediately at the seed rates of 6.0 and 4.5kg ha^{-1} for *S. guianensis* and *C. pubescens,* respectively. The sole legume plots were established by drilling the legume seeds at 1m apart (i.e. between the grass rows) at the respective seed rates as stated above. Fertilizer N-P-K (15:15:15) was broadcast as a basal application at the rate of 200-kg ha^{-1} during planting. A randomized complete block design with four replicates was used. There were 11 pasture treatments, namely: *P. maximum* (Local)/*S. guianensis; P. maximum* (Local)/*C. pubescens; P. maximum* (Ntchisi)/*S. guianensis; P. maximum* (Ntchisi)/*C. pubescens; B. ruziziensis*/*S. guianensis; B. ruziziensis*/*C. pubescens; P. maximum* (Local) sole stand; *P. maximum* (Ntchisi) sole stand; *B. ruziziensis* sole stand; *S. guianensis* sole stand; *C. pubescens* sole stand. Each plot measured 4m x 5m with 1m spaces between plots and 2m spaces between the replicates.

Plots were weeded at weeks 4, 8 and 12 after planting (WAP) and inter-plot spaces were kept weed-free throughout the growing season. Mixtures were cut back to about 15cm above ground level in late October 1998 after animals were introduced to lightly graze them. The plant materials, made up of the ungrazed planted grass, legume and other volunteer species, were removed from plots and 60kg ha^{-1} single super phosphate (SSP) fertilizer applied. The site was fenced round before experimental grazing commenced on March 13, 1999. The grazing was repeated thereafter at six-weekly intervals i.e. on the 13th of May, July, September and December 1999. At each grazing occasion, an average of 42 mature cattle made up of undetermined numbers of White Fulani (WF), N'Dama and WF x N'Dama crosses, amounting to an estimated stocking density of 250-head ha^{-1} at each of the grazing period. On each day of grazing, animals were let into the pasture plots between 08.30 a.m. and 12.30 p.m. Plots were grazed for one or two days until the forage had been grazed down to a fairly uniform height of about 30 cm before the animals were removed until another grazing time.

Pasture treatments were sampled for determination of DM yield and botanical composition in November 1998, five months after planting and in July 1999 and year 2000. Two $1m^2$ quadrats were randomly selected per plot and all the plants within each cut at 15cm above ground level. The plant materials were weighed and sorted into planted grass, legume, other grasses and broadleaf weeds. Each component was then bulked according to the replicate, mixed and sub-samples weighing 300g taken. The sub-samples were oven-dried at 65^oC until their weights were constant to obtain the percent dry matter (%DM) for each component. The DM yield of each component was then estimated by multiplying the fresh weight by the %DM and the total DM yields were obtained by summing the component yields. Forage sampling was also carried out a day before and after each grazing occasion to estimate DM on offer and residual, respectively in order to estimate DM consumption by difference. Data were analysed by ANOVA using SAS (1988). Differences between means were compared (Duncan, 1955).

RESULTS AND DISCUSSION

The soil of the experimental site (Table 1) was fairly acidic, sandy and low in major plant nutrients, especially nitrogen and available phosphorus. These two major plant nutrients are noted as limiting in tropical agricultural soils and it is one of the major causes of the low DM yields and nutrient quality of tropical natural pastures (Mohamed-Saleem, 1994). It is also for this reason that routine basal application of a compound fertilizer is generally recommended for pasture establishment in south-west Nigeria (Onayinka, 1973).

The total DM yields of the pastures were lower in 1998 than the values for year 1999 and year 2000 (Table 2). However the sole *P. maximum* (Ntchisi) which produced the

Table 3: Estimated dry matter yields (t ha^{-1}) of pastures before each round of mob-grazing in 1999

Pasture Treatments	Months of mob-grazing					Totals
	March	May	July	Sept.	Dec.	
P. maximum (Local)/*S. hamata*	3.7bc	3.4b	2.5ab	2.2ab	1.5ab	13.1c
P. maximum (Local)/*C. pubescens*	3.6bc	3.1b	2.1ab	2.2ab	1.3ab	12.3cd
P. maximum (Ntchisi)/*S. hamata*	4.6b	5.7a	2.5ab	2.4a	1.7a	16.9a
P. maximum (Ntchisi)/*C. pubescens*	3.1c	3.6b	2.3ab	2.1ab	1.7a	12.8c
B. ruziziensis/ *S. hamata*	3.5bc	2.9	3.0a	2.1ab	1.8a	13.3c
B. ruziziensis/ *C. pubescens*	3.9bc	2.6b	2.8a	2.4a	1.3b	13.0c
P. maximum (Local) sole	4.4b	2.8b	3.1a	1.9ab	1.5ab	13.7bc
P. maximum (Ntchisi) sole	6.4a	1.7b	1.7b	1.5b	1.3b	14.7bc
B. ruziziensis sole	3.2c	2.2ab	2.2ab	2.4a	0.8c	10.6db
S. hamata sole	3.2c	3.2a	3.2a	2.0ab	1.2bc	15.2b
C. pubescens sole	1.0d	2.2ab	2.2ab	2.6a	1.0bc	12.3cd

Table 4: Estimated dry matter yields (t ha^{-1}) of the planted grasses and legumes components of pastures

Pasture Treatments	1998		1999		2000	
	grass	legume	grass	legume	grass	Legume
P. maximum (Local)/*S. hamata*	3.0c	0.3c	8.5b	3.5b	4.2c	1.6e
P. maximum (Local)/*C. pubescens*	3.1c	0.3c	6.1c	3.6b	4.6c	2.6d
P. maximum (Ntchisi)/*S. hamata*	3.3c	0.5c	10.4a	2.6c	6.8a	2.0d
P. maximum (Ntchisi)/*C. pubescens*	2.7c	0.3c	8.1b	2.9ab	6.2b	4.3c
B. ruziziensis/ *S. hamata*	32.9c	0.3c	5.0d	3.3b	2.8d	1.5e
B. ruziziensis/ *C. pubescens*	3.3c	0.4c	5.2d	3.7b	2.2e	1.3e
P. maximum (Local) sole	4.2b	-	11.8a	-	6.5b	-
P. maximum (Ntchisi) sole	6.1a	-	11.4a	-	7.1a	-
B. ruziziensis sole	2.2d	-	6.8c	-	3.2d	-
S. hamata sole	-	2.2a	-	7.2a	-	5.8b
C. pubescens sole	-	0.9b	-	7.1a	-	9.2a

Means in the same column followed by any identical letters are not significant ($p>0.05$)

highest yield in 1998 remained so in 1999 while the sole *C. pubescens* which had the lowest yield in 1998 and 1999 recorded the highest yield in year 2000. The mean DM yield values for the three years showed that *P. maximum* (Ntchisi)/*S. guianensis*, sole *P. maximum* (Ntchisi) and the sole *S. guianensis* produced significantly more than all the other pastures. The DM yields recorded for *P. maximum* (Local)/*C. pubescens*, *B. ruziziensis/S. guianensis*, *B. ruziziensis/C. pubescens*, sole *B. ruziziensis* and sole *C. pubescens* were similar but significantly ($p<0.05$) lower than the values obtained for the other mixtures. The DM produced by *B. ruziziensis* either as a sole crop or in mixtures with the legumes was among the lowest in the study period. The significant increase in DM yields of pastures one year after establishment suggested better establishment and consolidation of the planted species and consequently higher exploitation of environmental resources, and soil nutrients as the plants matured. As observed in this study, higher DM yields of Panicum/Centro mixtures than sole Panicum had earlier been reported in southwest Nigeria (Akinyemi and Onayinka, 1982). Higher DM yields by grass/legume than sole grass pastures has been attributed to the additional nitrogen input into the pasture system by the associated legume. This is especially meaningful when the legume in the mixture contributes a significant proportion of the total biomass (Evans and Bryan, 1973). Higher DM yields were recorded in the first two rounds of grazing in March and May 1999 and then till the end of grazing in December (Table 3). The pastures with the highest and lowest total yields during the grazing were *P. maximum* (Ntchisi)/*S. guianensis* with 16.9 kg ha^{-1} and sole *B. ruziziensis* with 10.6 kg ha^{-1} respectively. The yields of the grass components in the various grass/legume pastures were similar in the year of planting in 1998 (Table 4). The solely planted *P. maximum* (Ntchisi), however, significantly out-yielded the other grasses while *P. maximum* (Local) yielded more than *B. ruziziensis*, which produced the lowest yield of 2.2 t ha^{-1}. Similarly the yields of the legume components were generally similar for all the mixtures but *S. guianensis* in sole legume plots significantly out-yielded sole *C. pubescens*. The yields recorded by *B. ruziziensis* in mixtures with *S. guianensis* (5.0 t ha^{-1}) and *C. pubescens* (5.2 t ha^{-1}) were the lowest for the grasses in year 1999. *P. maximum* (Ntchisi) yielded significantly better than *P. maximum* (Local) both in the mixtures with the legumes and in sole stand while *P. maximum* (Local) was better in yield than *B. ruziziensis* in 1999. The general decline in DM after the high yields following establishment year might be due, in part, to the effects of grazing.

Animal grazing is noted to contribute to declined DM production of pastures over time, especially when stocking rates or grazing pressures are high (Onifade *et al*., 1992). The effects of grazing pressure became more apparent as DM yields of pastures clearly declined with each round of grazing. A similar diminishing trends in DM yields was reported when *B. ruziziensis* and *C. nlemfuensis* Ib8 in association with *S. guianensis* or *C. pubescens* species, used in the present study, were subjected to mob-grazing at Ibadan, Nigeria with White Fulani cattle (Olanite, 1998).

However, diminishing DM productivity of pastures under intensive grazing in the course of a year may also be attributed to reduced soil moisture level as the dry season approaches. Furthermore, repeated defoliation of forages by grazing or cutting invariably removes the photosynthetic parts of the

Table 1: Pre-planting chemical component and physical characteristics of the composite samples taken at 0-15 cm soil depth of the experimental site before sowing of pastures in 1998

Chemical/physical parameters	Values
pH (H20) 1:1	6.4
Total Nitrogen (g kg-1)	1.4
Organic Carbon (g kg-1)	13.0
C:N ratio	9.3
Available P (mg kg-1)	10.1
	0.81
Exchangeable cations (cmol kg-1)	
Ca	
Mg	0.33
K	0.48
Na	0.22
Mn	0.15
ECEC	3.8
Soil texture (g kg-1)	
Sand	756
Silt	114
Clay	121

Table 2: Annual total biomass yields (t ha^{-1}) of pastures for the duration of study (1998-2000)

Pasture treatments	1998	1999	2000	Averages
P. maximum (Local)/*S. hamata*	3.7bc	12.6bc	6.8c	7.7bc
P. maximum (Local)/*C. pubescens*	3.6bc	10.6c	7.8b	7.3c
P. maximum (Ntchisi)/*S. hamata*	4.6b	13.9b	10.6ab	9.7a
P. maximum (Ntchisi)/*C. pubescens*	3.1c	11.7c	11.9a	8.9b
B. ruziziensis/ S. *hamata*	3.5bc	11.9c	5.8c	7.1c
B. ruziziensis/ C. *pubescens*	3.9bc	11.0c	4.2d	6.4c
P. maximum (Local) sole	4.4b	12.3bc	7.6b	8.1bc
P. maximum (Ntchisi) sole	6.4	15.2a	8.9ab	10.2a
B. ruziziensis sole	3.2c	12.2bc	5.1d	6.8c
S. hamata sole	3.2c	9.5d	8.3b	9.9a
C. pubescens sole	1.0d	18.9e	11.1a	7.0c

Means in the same column followed by any identical letters are not significant ($p>0.05$)

plants, thereby reducing the amount of food available for storage in the underground portion of the plants, leading to reduced vigour and subsequent DM accumulation (Leach *et al*., 1976). Onifade *et al.* (1992) also recorded decreasing forage yields as sheep stocking rate increased as reported elsewhere for Kikuyu grass *P. clandestinum* (Mears and Humphreys, 1974). The increased stocking rates used in those studies implied increased grazing pressure that was similar to the mob-grazing approach used in the present study. Thus the high grazing pressure offered by the defoliation technique might also have contributed to the decline in DM productivity recorded with each grazing round.

The progressively declining proportion of legumes in the mixtures with grazing was due in part to grazing effects, especially that of trampling (Leach *et al*., 1976). An important prerequisite for successful use of grass-legume pastures for animal production is that the legume component must be maintained at a reasonably high level in the pasture to ensure an adequate supply of nitrogen to the pasture system (Adjei and Fianu, 1985). This helps to maintain sustained high biomass yield and quality, and requires that legumes that are vigorous, persistent and compatible with the associated grasses should be found and used (Larbi, *et al*., 1999). With mean values of 18-21 % for Stylosanthes and 24-25 % for Centrosema in their respective mixtures in the present study (Table 5), the latter legume could play this role better than the former in south-west Nigeria as obtained in earlier reports (Ademosun, 1973; Oyenuga and Olubajo, 1975; Olanite, 1998). In the sole legume plots, Centrosema also had higher proportion than Stylosanthes with corresponding lower and higher proportions of weed (Table 5). This also indicates that the former legume has higher ability to smother weeds and thus establish itself faster in areas where high weed pressure is a problem in early stages of pasture establishment.

Ezenwa (1995) reported an increase in the proportion of *S. hamata* cv. Verano in grass-legume mixtures under a six-week cutting regime unlike the rapidly declining content of *S. guianensis* recorded in the present study. Differences in defoliation techniques and species in the two studies could have been largely responsible for the different results obtained. Unlike when forages are cut, species under grazing suffer from such effects as trampling, pulling, bruising and tearing of branches by animal hooves as well as dropping of excreta by the grazing animals all of which could reduce the survival of species under grazing (Mislevy *et al*., 1982; Rhonda *et al*., 1987). The absence of these effects from the mixtures evaluated (Ezenwa, 1995) was therefore an advantage for his species under study. Also, the Stylosanthes species in such studies (Ezenwa, 1995) was allowed to seed, and so, seedling regeneration could have enhanced the subsequent proportion of the legume in the mixtures (Mohamed-Saleem, 1986; Onifade and Agishi, 1990). Oyenuga and Olubajo (1975) attributed rapid disappearance of *Stylosanthes gracilis* from the pastures that were grazed for two years by heifers to preferential grazing. Observations in the present study may not necessarily suggest such effect as legume proportion was also noted to have diminished from the pastures in the rainy season, a time of the year when grazing animals are generally known to eat less of the legumes in grass-legume mixtures (Paladines and Lascano, 1993). So the decline in legume proportion observed in this study could be more attributed to trampling effects rather than selective grazing *per se*. As noted (Leach *et al*., 1976) some forage species that are grazed year-round are prevented from producing seeds leading to low or non-regeneration in the on-going season. Stylosanthes species are noted to persist in pasture through seedling regeneration and therefore intensive grazing especially towards the time of seeding could adversely affect their persistence and might lead to their gradual elimination from the pasture. This suggests that grazing should be scheduled so as to allow for seeding, seed maturity and seed shedding (Jones and Clements, 1987; Humphreys, 1991).

The planted grasses, sown legumes, other grasses and broadleaf weeds were the major botanical components of the pastures throughout the period of the experiment (Table 5). The proportions of the two *P. maximum* species in the DM yields under sole planting were significantly higher than in the mixtures. The proportion of *B. ruziziensis* either as the sole crop or in the mixture with the legumes was the least among the planted grasses. The proportions of the sown legumes were significantly higher in the sole legume than in the mixture plots and the proportion of *C. pubescens* was significantly higher than that of *S. guianensis*. The proportions of the sown legumes in the mixtures were above 20% except for *S. guianensis* in *P. maximum* (Ntchisi). The highest proportions of other grass species (24%) and broadleaf weeds (13%) were recorded in sole *B. ruziziensis*. The lower proportion of *Panicum* in the biomass of *Panicum*/*Centrosema* than those of *Panicum*/*Stylosanthes* was probably due to higher competitiveness of *Centrosema* with the grass for growth resources, especially sunlight, than *Stylosanthes*. The weeding carried out between 4 and 12 WAP would have contributed significantly to the observed low proportions of broadleaf weeds in the pastures as the pasture species were, thereafter, able to out-compete and smother the weeds. The legumes which were lightly eaten in the rainy season were heavily consumed in the dry season as observed in earlier reports (Stobbs, 1977; Gardner, 1980; Paladines and Lascano, 1993; Gardner and Ash, 1994; Coates, 1996).

Table 5: Proportions (%) of the various pasture components in the pastures for the study period (1998-2000)

Treatments	Pasture components			
	Planted grasses	Sown legume	Other grasses	Broadleaf weeds
P. maximum (Local)/*S. hamata*	69b	20c	7c	4b
P. maximum (Local)/*C. pubescens*	68b	24c	6c	3b
P. maximum (Ntchisi)/*S. hamata*	73b	18c	5c	5b
P. maximum (Ntchisi)/*C.pubescens*	69b	24c	5c	2b
B. ruziziensis/ *S. hamata*	58c	21c	17b	4b
B. ruziziensis/ *C. Pubescens*	62c	25c	11b	2b
P. maximum (Local) sole	93[a]	-	3c	5b
P. maximum (Ntchisi) sole	90a	-	6c	4b
B. ruziziensis sole	63c	-	24a	13a
S. hamata sole	-	71b	17b	11a
C. pubescens sole	-	85a	14b	2b

Means in the same column followed by any identical letters are not significant (p>0.05)

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