Promising tropical grasses and legumes as feed resources in central Tanzania I. Effect of different cutting patterns on production and nutritive value of six grasses and six legumes

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Abstract

Six grasses: *Chloris gayana* cv. Samford and cv. Mpwapwa (CG-Mpwapwa), *Cenchrus ciliaris* cvv. Gayndah and Biloela, *Bothriochloa insculpta* cv. Hatch and *Panicum coloratum* cv. Bambatsi; and 6 legumes: *Stylosanthes hamata* cv. Verano, *S. scabra* cv. Seca, *Neonotonia wightii* cvv. Tinaroo and Mpwapwa (NW-Mpwapwa), *Macrotyloma axillare* cv. Archer and *Macroptilium atropurpureum* cv. Siratro were investigated in a 2-year study. Cutting regimes for the grasses during the growing season were 4–12–4, 6–8–6, 8–4–8 and 10–10 weeks in 1987/88 and 10–10 weeks in 1988/89; and for the legumes were 4–4–4–4, 6–6–6 and 10–10 weeks in 1987/88 and 4–4–4–4, 6–6–6, 8–8–8 and 10–10 weeks in 1988/89. There was a significant difference (P<0.05) in DM production between the grass species in both seasons with Bambatsi > Gayndah, Hatch and Samford in 1987/88; and Bambatsi, Gayndah and Biloela > Hatch and Samford in 1988/89. In 1987/88, the legumes had similar production except for Archer which produced least and in 1988/89, Seca, Verano and Tinaroo were best (P<0.05). Cutting regimes 6–8–6 for the grasses and 10–10 for the legumes (1988/89) gave the highest mean DM yields (P<0.05). In the grasses, crude protein levels declined on average 4% units and *in vitro* digestibility 13% units between 4 and 10 weeks of age. In the legumes, the corresponding decreases were only 2 and 4% units, respectively.

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Introduction

Improved grasses and legumes have been recommended for intensive dairy farming in Tanzania due to their high forage production and nutritive value (Mero and Masaoa 1991). Improved grasses are probably one of the cheapest high quality roughages available, provided these are grazed or harvested for conservation at early stages of maturity. Other maintenance feeds available like stovers and straws have a place but are high in lignin and fibre and low in CP concentration.

Most improved grasses fed at early stages of maturity are more digestible and are eaten in larger quantities than at more mature stages (Abate *et al.* 1981; Mero 1985). Legumes contain higher CP and minerals than grasses (Whiteman 1980) and increase total dry matter intake when used as supplements to low CP grass diets (Minson and Milford 1967; Mero and Udén 1990).

In central Tanzania, pasture species evaluation with the objective of identifying the most productive and adapted species has been of interest for a long time (Anon. 1988; Kusekwa *et al.* 1989). While limited work has been done on intensive management of the species, studies in northern Tanzania by Naveh and Anderson (1966) have shown that grass species respond differently to cutting frequencies and this affects their dry matter production and nutritive value.

The aim of the present study was to investigate the effect on seasonal DM productiion and nutritive value of applying different cutting regimes to promising grasses and legumes to give guidelines to assist in their use on farms.

Materials and methods

The experiments were conducted in a semi-arid zone at the Zonal Research and Training Centre, Mpwapwa, central Tanzania, during the rainy season of 1987/88 and 1988/89. Soils were deep sandy loams, with pH,6.2; C,1.3%; and N, 0.18%. The species were established as pure swards in 10 x 8 m plots in 1986, replicated 4 times. An area of land was divided into 4 blocks and the species were randomly allocated within blocks. Rainfall and temperature records taken during the experimental period are shown in Table 1. The species studied were: Grasses: *Chloris gayana* cvv. Samford and Mpwapwa (CG-Mpwapwa), *Cenchrus ciliaris* cvv. Gayndah and Biloela, *Bothriochloa insculpta* cv. Hatch and *Panicum coloratum* cv. Bambatsi; and Legumes: *Stylosanthes hamata* cv. Verano, *S. scabra cv.* Seca, *Neonotonia wightii* cvv. Tinaroo and Mpwapwa (NW-Mpwapwa), *Macrotyloma axillare* cv. Archer and *Macroptilium atropurpureum* cv. Siratro.

Table 1. Rainfall and maximum temperatures at the experimental site, 1987–1989.

	1987–1988		1988–1989	
Month	Rainfall (mm)	Temperature (°C)	Rainfall (mm)	Temperature (°C)
September	—	28.0	—	27.9
October	3.2	29.6	—	30.0
November	66.7	30.4	31.0	30.3
December	6.6	31.4	92.4	32.9
January	131.9	30.4	140.6	—
February	127.1	29.6	119.2	26.8
March	220.2	28.7	124.1	—
April	51.4	26.7	83.6	25.8
May	—	23.9	42.8	25.2
June	4.7	25.2	—	24.0
Total	611.8		633.7	

The species were in the second year of establishment and the legumes were nodulated. Weeding was done manually with hand hoes and by uprooting. Weed infestation was never serious enough to suppress the cultivated species. Before starting the experiment, on November 25, 1987, all species were slashed to 5 cm height before the commencement of the rains. The following cutting regimes were applied:

Grasses: 4 weeks–12 weeks–4 weeks (4–12–4); 6 weeks–8 weeks–6 weeks (6–8–6); 8 weeks–4 weeks–8 weeks (8–4–8); and 10 weeks–10 weeks (10–10) in 1987/1988. In 1988/89, due to limited resources, the grasses were cut twice at 10-week intervals.

Legumes: 4 cuttings at 4-week intervals (4W); 3 cuttings at 6-week intervals (6W); 2 cuttings at 8-week intervals (8W); and 2 cuttings at 10-week intervals (10W). Five cuttings were intended for the 4W regime but no regrowth occurred after the 4th cutting.

All grass species were fertilised with 250 kg N. The fertiliser rates for each application ranged from 50 kg N for the 4-week regrowth to 150 kg/ha N for the 12-week cuts. Fertilisers were applied immediately after slashing the sward to 5 cm. All legume species were fertilised with 125 kg triple superphosphate per hectare at the beginning of the experiment.

Sampling procedure

At the appropriate dates, four 1 × 1 m quadrats, placed at random, were harvested in each plot at 5 cm height using a sickle. The material was weighed while fresh and subsampled. The subsample was separated into whole plant leaf and stem fractions, which were then chopped by hand, subsampled again and dried in a forced-draught oven at 60°C.

In grasses, the stem fraction consisted of leaf sheath, stem and inflorescence, and in legumes, the leaf fraction included the lamina and petiole. Flowers were included with stems. The dried samples were milled through a 1 mm screen.

Laboratory analyses were made on the 4, 6 and 10-week samples from 1987/88. Crude protein (CP) was analysed by the Kjeldahl method according to AOAC (1975) and neutral detergent fibre (NDF) and true *in vitro* organic matter digestibility (IVOMD), as described by Van Soest *et al.* (1991) and modified by Mbwile and Udén (1991).

The data on DM yield from the grasses and legumes were analysed as for a split-plot design. Data from grasses for 1989 were analysed as for a randomised block design (Snedecor and Cochran 1980).

Results

The meteorological data presented in Table 1 show only minor difference in temperature and rainfall between the 1987/88 and 1988/89 growing seasons.

Table 2. Dry matter yields of 6 grasses under 4 cutting regimes during 1987-1988 and 1 cutting regime during 1988-1989.

	1987-1988					1988-1989
	Cutting regimes (weeks)					
Species[1]	4-12-4	6-8-6	8-4-8	10-10	Mean	10-10
			(kg/ha)			
Samford	4895a[2]	4093a	4036a	3859a	4221C[3]	3986C
CG-Mpwapwa	5999b	7440a	6849ab	6375ab	6666A	7454AB
Gayndah	4554ab	5773a	4096b	4808ab	4808C	8223A
Biloela	6318ab	6978a	5121b	5331b	5937B	7871A
Bambatsi	7585ab	8729a	6020c	6524bc	7215A	9369A
Hatch	5550a	5568a	3854b	4194b	4791C	5579BC
Mean	5817b	6430a	4996c	5182c	5606	7080

[1]Samford = *Chloris gayana* cv. Samford; CG-Mpwapwa = *Chloris gayana* cv. Mpwapwa; Gayndah= *Cenchrus ciliaris* cv. Gayndah; Biloela = *Cenchrus ciliaris* cv. Biloela; Bambatsi = *Panicum coloratum* cv. Bambatsi; and Hatch = *Bothriochloa insculpta* cv. Hatch.
[2]Values within a row followed by the same lower case letter do not differ significantly (P>0.05). LSD for species × regime = 1345 and for regimes = 549.
[3]Species means followed by the same upper case letter do not differ significantly (P>0.05). LSD for species in 1987–1988 = 716 and 1988–1989 = 3050.

DM production

Grasses. The DM production of the grasses in 1987/88 as affected by cutting regimes is given in Table 2. Average DM production of all treatments was 5606 kg/ha. There were significant differences between species (P<0.05) and also among cutting regimes (P<0.01). The effect of cutting regimes on DM production showed that 6–8–6 > 4–12–4 > 8–4–8 and 10–10 (P<0.05). Analyses of interactions between species and regimes were not significant (P>0.19), but for Bambatsi and Hatch, regime 6–8–6 was superior to 8–4–8 and 10–10 (P<0.05). Species comparisons showed that Bambatsi and CG-Mpwapwa yielded more than the other species (P<0.05).

In the 10–10 treatment, grass yields in 1988/89 were higher than in 1987/88. The highest yields were from Bambatsi, Biloela and CG-Mpwapwa in both years.

Legumes. The 8W regime for the first year was excluded as yields were abnormally low. Yields of legumes were constantly lower in 1988/89 than in 1987/88 and Archer did not survive the second year (Tables 3 and 4).

Cutting regimes strongly influenced cumulative yields in both seasons (P<0.001). The longer the cutting interval the higher the production, which was significant (P<0.05) in the 1988/89 season.

Table 3. Dry matter yields of 6 legumes defoliated at 4, 6 and 10-week intervals during the 1987-1988 growing season.

	Cutting intervals (weeks)			
Species[1]	4	6	10	Mean
		(kg/ha)		
Verano	2560a[2]	1760b	1830b	2050A[3]
Seca	2230b	1470c	2700a	2140A
Tinaroo	1500c	2330b	2780a	2200A
NW-Mpwapwa	1960b	1800b	2610a	2130A
Archer	1150b	1070b	1900a	1380B
Siratro	1840a	1860a	1730a	1810A
Mean	1880a	1710b	2260a	1950

[1]Verano = *Stylosanthes hamata* cv. Verano; Seca = *S. scabra* cv. Seca; Tinaroo = *Neonotonia wightii* cv. Tinaroo; NW-Mpwapwa = *N. wightii* cv. Mpwapwa; Archer = *Macrotyloma axillare* cv. Archer; and Siratro = *Macroptilium atropurpureum* cv. Siratro.
[2]Values within a row followed by the same lower case letter do not differ significantly (P>0.05). LSD for species x regime = 530 and for regimes = 420.
[3]Species means followed by the same upper case letter do not differ significantly (P>0.05; LSD = 600).

Only Siratro seemed to be unaffected by cutting intervals in both years. In Year 1, only Archer differed significantly (P<0.05), whereas the differences between species were highly significant in Year 2 (P<0.01). Verano, Seca and Tinaroo gave high yields in both years, whereas NW-Mpwapwa

Table 4. Dry matter yields of 6 legumes defoliated at 4, 6, 8 and 10-week intervals during the 1988-1989 growing season.

	Cutting intervals (weeks)				
Species[1]	4	6	8	10	Mean
Verano	1640a[2]	1510a	1720a	2120a	1750A[3]
Seca	1380b	1820ab	2060a	3050a	2080A
Tinaroo	1030b	1010b	2120a	2600a	1690A
NW-Mpwapwa	520b	870ab	1290a	1400a	1020B
Archer			Died out		
Siratro	730a	1180a	1120a	970a	1000B
Mean	1060c	1280c	1660b	2030a	1510

[1]Verano = *Stylosanthes hamata* cv. Verano; Seca = *S. scabra* cv. Seca; Tinaroo = *Neonotonia wightii* cv. Tinaroo; NW-Mpwapwa = *N. wightii* cv. Mpwapwa; Archer = *Macrotyloma axillare* cv. Archer; and Siratro = *Macroptilium atropurpureum* cv. Siratro.
[2]Values within a row followed by the same lower case letter do not differ significantly (P>0.05). LSD for species x regime = 660 and for regimes = 300.
[3]Species means followed by the same upper case letter do not differ significantly (P>0.05; LSD = 630).

and Siratro did well only in the first year. Interactions between species and regimes were highly significant in both years ($P<0.001$ and $P<0.05$, respectively).

Nutritive value

Grasses. Data from the analysis of CP, NDF and IVOMD in the grasses harvested in 1987/88 are presented in Table 5. The CP and IVOMD of all grasses declined with advancing age while NDF increased.

Among the plant parts, differences between leaf and stem were, on average, 4.1, 3.3 and 4.8% units for CP, 12.9, 11.5 and 16.6% units for IVOMD and −8.2, −9.1 and −6.1% units for NDF in the 4, 6 and 10-week samples, respectively. The absolute change from 4 to 10 weeks was higher in stems than in leaves for IVOMD (10.8 *vs.* 7.1) and for CP (3.6 *vs.* 2.9) but lower for NDF (12.3 *vs.* 14.4).

Legumes. The CP concentration and IVOMD of the whole plant decreased only slightly with advancing plant age from 19.5 to 18.3% and from 76.5 to 72.6%, respectively (Table 6). In all species and ages, leaves had higher CP and higher IVOMD than stems. The average difference was 9.6% for CP and 21.7 units for IVOMD. Generally, legume species had higher CP concentration and IVOMD values in both leaves and stems than grasses harvested at the same ages (Tables 5 and 6). Differences were particularly pronounced in the leaf fraction and with increased maturity.

Discussion

The present experiment has shown that, under the prevailing environmental conditions, cutting these grass species using regime 6–8–6 resulted in higher yields compared with the other regimes (Table 2). A possible explanation for the observed responses to defoliation is that the 4-week interval, included in some of the regimes, probably was too short and did not allow the plants to grow sufficiently before the next cutting to overcome the initially slow growth phase. Stoddart *et al.* (1955) pointed out that, in semi-arid environments, total forage yields decrease with increased frequency of clipping and Barker and Kidar (1989) reported higher dry herbage yields from *Cenchrus ciliaris* clipped at monthly intervals compared with biweekly clippings.

The longer cutting intervals of 10 and 12 weeks probably allowed the plants to grow beyond the vegetative phase and lead to initiation of flowering, cessation of growth, shading of lower by upper leaves, reduced photosynthesis and leaf death and could thus result in lower DM production than the 6–8–6 regime.

Bambatsi was consistently the highest and Samford the lowest yielder (Table 2). There were no statistical differences between the 2 *Cenchrus* varieties, whereas a comparison between *Chloris gayana* cvv. Mpwapwa and Samford showed Mpwapwa to be superior.

In general, legume yields increased with longer cutting intervals as found by Jones (1967;

Table 5. Crude protein (CP), neutral detergent fibre (NDF) and true *in vitro* organic matter digestibility (IVOMD) in whole plant (WP), leaf (L) and stem (S) fractions of 6 grasses harvested at 4, 6 and 10 weeks of age during the 1987-1988 season.

		CP			NDF			IVOMD		
Species[1]	Age	WP	L	S	WP	L	S	WP	L	S
						(%)				
Samford	4	16	17	13	62	60	62	68	69	64
	6	15	17	13	63	60	63	66	65	60
	10	10	16	9	—	76	80	61	67	51
CG-Mpwapwa	4	15	16	12	64	57	66	71	75	57
	6	14	15	12	64	61	68	66	73	56
	10	11	14	9	75	75	78	50	59	41
Gayndah	4	15	17	11	61	56	70	70	74	57
	6	12	15	11	62	55	71	66	73	57
	10	10	14	8	78	69	80	63	70	51
Biloela	4	14	17	11	63	55	67	74	78	64
	6	12	13	11	66	59	72	69	69	67
	10	12	13	11	75	69	78	—	70	62
Bambatsi	4	15	16	14	62	62	67	66	71	62
	6	14	15	12	65	63	70	62	71	59
	10	13	13	9	75	74	79	60	68	50
Hatch	4	14	16	14	62	62	67	71	78	64
	6	13	15	10	65	63	70	71	72	56
	10	13	13	9	75	74	79	51	68	48
Mean	4	15	17	13	62	59	67	70	74	61
	6	14	15	12	64	60	69	67	71	59
	10	11	14	9	76	73	79	57	67	50

[1]Samford = *Chloris gayana* cv. Samford; CG-Mpwapwa = *Chloris gayana* cv. Mpwapwa; Gayndah= *Cenchrus ciliaris* cv. Gayndah; Biloela = *Cenchrus ciliaris* cv. Biloela; Bambatsi = *Panicum coloratum* cv. Bambatsi; and Hatch = *Bothriochloa insculpta* cv. Hatch.

Table 6. Crude protein (CP) concentration and true *in vitro* organic matter digestibility (IVOMD) of whole plant (WP), leaf (L) and stem (S) fractions of 6 legumes harvested at 4, 6 and 10 weeks during 1987-1988.

		CP			IVOMD		
Species[1]	Age	WP	L	S	WP	L	S
				(%)			
Verano	4	22	24	16	82	89	70
	6	21	26	15	84	89	73
	10	22	27	15	78	89	68
Seca	4	17	18	15	75	84	59
	6	17	18	13	74	84	57
	10	16	21	12	74	85	63
Tinaroo	4	20	26	14	75	85	66
	6	19	22	13	73	83	62
	10	19	25	12	73	81	60
NW-Mpwapwa	4	21	23	15	74	85	59
	6	18	20	13	75	73	58
	10	19	26	13	67	79	60
Archer	4	19	27	13	83	87	58
	6	15	22	10	81	86	57
	10	18	26	10	76	87	58
Siratro	4	19	21	15	70	78	60
	6	18	20	15	76	76	57
	10	16	20	13	67	77	61
Mean	4	20	23	15	77	85	62
	6	18	21	13	77	82	61
	10	18	24	13	73	83	62

[1]Verano = *Stylosanthes hamata* cv. Verano; Seca = *S. scabra* cv. Seca; Tinaroo = *Neonotonia wightii* cv. Tinaroo; NW-Mpwapwa = *N. wightii* cv. Mpwapwa; Archer = *Macrotyloma axillare* cv. Archer; and Siratro = *Macroptilium atropurpureum* cv. Siratro.

1973) with Siratro and *Desmodium intortum* cv. Greenleaf. The yields, however, were considerably lower than for the grasses. The best 3 legumes (Verano, Seca and Tinaroo) produced 35% of the yield of the best 4 grasses (CG-Mpwapwa, Gayndah, Biloela and Bambatsi) in the first year, dropping to 22% in the second year. Archer, Siratro and NW-Mpwapwa were doing poorly, whereas Seca seemed to be well adapted to the climate. Selection of species yielding high proportions of leaf, not only in the legumes but also in the grasses, should be of great benefit to the more intensive milk production systems in Tanzania, requiring high quality forages.

The CP concentration and particularly the true IVOMD in grass leaves and stems (Table 5) declined with advancing plant age, while NDF content increased. Crude protein levels in the grasses were comparatively high as a result of the N fertilisation. The variation among species in whole plant digestibility was more evident in the 10–than in the 4-week samples: 50–61% *vs.* 68–74%, respectively. There was a weak negative correlation between yield and IVOMD, varying from 0.11–0.45 for the different cuts. In the legumes (Table 6), CP levels declined only slightly with advancing plant age, results which also have been noted elsewhere (Whiteman 1980; Crowder and Chheda 1982). A higher CP level and IVOMD in leaves compared with stems seen in tropical herbaceous legumes such as Siratro (Crowder and Chheda 1982) was also seen in this study.

In Tanzania, herbaceous legumes and grasses such as Napier and rhodes grass have tended to be used mainly in high potential areas with rainfall >700 mm. Here, crop residues may not be sufficient either in quantity or in quality to sustain medium to high milk production. With increasing population pressure also, an intensification of animal husbandry is occurring in semi-arid areas. More tolerant species may play a role in the future. Management to secure survival of the legumes will be most critical and must involve long defoliation intervals and periods of intensive weed control. Fortunately, the longer cutting intervals did not seem to have as serious an effect on nutritive value in the legumes as in the grasses. The legumes should preferably be grown in pure stands as they do not compete well with grasses. It is possible that weeding may be reduced if legumes are grown together with grasses. This, however, depends on the compatibility between the grasses and the legumes and how aggressive they are to suppress the weeds. Experience in Tanzania has shown that herbaceous legumes disappear in a mixed sward after some years when subjected to grazing. Also, if the optimal harvesting strategy for grasses was used, this would, in most cases, lower the legume yield, and if the optimal harvesting strategy for legumes were used, it would result in a low nutritive value for the grasses.

Conclusions

Under the conditions of this experiment, it can be concluded that the legumes benefit from long and the grasses from intermediate cutting intervals. As the legumes did not decrease in nutritive value to the same extent as the grasses,relatively long cutting intervals seem to be the best alternative. In the grasses, however, it is more difficult to conclude which cutting regime would be optimal. Three cuttings with a frequency of 6–8–6 gave the best yield, but with lower digestibilities than the 4-week cuts. The best yielding grasses were Bambatsi, CG-Mpwapwa and Biloela. They required relatively simple management and were still able to produce well. With 3 cuts per year, they would be valuable basal feeds to lactating dairy cows and goats. The best yielding legumes were Seca, Verano and Tinaroo and should be potential supplements to grasses due to their higher crude protein levels without the need of N fertilisers, but would require more management in the form of weeding.

To fully exploit the use of the forages in this study, species persistence under cutting must be tested further and feeding trials conducted to study the effect of selective feeding on digestibility and intake.

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